Amazon EMR Serverless User Guide

Amazon EMR

Amazon EMR: Amazon EMR Serverless User Guide

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What is Amazon EMR Serverless?

Amazon EMR Serverless is a deployment option for Amazon EMR that provides a serverless runtime environment. This simplifies the operation of analytics applications that use the latest open-source frameworks, such as Apache Spark and Apache Hive. With EMR Serverless, you don’t have to configure, optimize, secure, or operate clusters to run applications with these frameworks.

EMR Serverless helps you avoid over- or under-provisioning resources for your data processing jobs. EMR Serverless automatically determines the resources that the application needs, gets these resources to process your jobs, and releases the resources when the jobs finish. For use cases where applications need a response within seconds, such as interactive data analysis, you can pre-initialize the resources that the application needs when you create the application.

With EMR Serverless, you continue to get the benefits of Amazon EMR, such as open source compatibility, concurrency, and optimized runtime performance for popular frameworks.

EMR Serverless is suitable for customers who want ease in operating applications using open source frameworks. It offers quick job startup, automatic capacity management, and straightforward cost controls.

Concepts

In this section, we cover EMR Serverless terms and concepts that appear throughout our EMR Serverless User Guide.

Release version

An Amazon EMR *release* is a set of open-source applications from the big data ecosystem. Each release includes different big data applications, components, and features that you select for EMR Serverless to deploy and configure so that they can run your applications. When you create an application, specify its release version. Choose the Amazon EMR release version and the open source framework version that you want to use in your application. To learn more about pre-release versions, refer to Amazon EMR Serverless release versions.

Application

With EMR Serverless, you can create one or more EMR Serverless applications that use open source analytics frameworks. To create an application, specify the following attributes:

- The Amazon EMR release version for the open source framework version that you want to use. To determine your release version, refer to Amazon EMR Serverless release versions.
- The specific runtime that you want your application to use, such as Apache Spark or Apache Hive.

After you create an application, submit data-processing jobs or interactive requests to your application.

Each EMR Serverless application runs on a secure Amazon Virtual Private Cloud (VPC) strictly apart from other applications. Additionally, use AWS Identity and Access Management (IAM) policies to define which users and roles can access the application. You can also specify limits to control and track usage costs incurred by the application.

Consider creating multiple applications when you must do the following:

- Use different open source frameworks
- Use different versions of open source frameworks for different use cases
- Perform A/B testing when upgrading from one version to another
- Maintain separate logical environments for test and production scenarios
- Provide separate logical environments for different teams with independent cost controls and usage tracking
- Separate different line-of-business applications

EMR Serverless is a Regional service that simplifies how workloads run across multiple Availability Zones in a Region. To learn more about how to use applications with EMR Serverless, refer to Interact with and configure an EMR Serverless application.

Job run

A *job run* is a request submitted to an EMR Serverless application that the application asychronously executes and tracks through completion. Examples of jobs include a HiveQL query that you submit to an Apache Hive application, or a PySpark data processing script that you submit to an Apache Spark application. When you submit a job, you must specify a runtime role, authored in IAM, that the job uses to access AWS resources, such as Amazon S3 objects. You can submit multiple job run requests to an application, and each job run can use a different runtime role to access AWS resources. An EMR Serverless application starts executing jobs as soon as it receives them and runs multiple job requests concurrently. To learn more about how EMR Serverless runs jobs, refer to Running jobs.

Workers

An EMR Serverless application internally uses *workers* to execute your workloads. The default sizes of these workers are based on your application type and Amazon EMR release version. When you schedule a job run, override these sizes.

When you submit a job, EMR Serverless computes the resources that the application needs for the job and schedules workers. EMR Serverless breaks down your workloads into tasks, downloads images, provisions and sets up workers, and decommissions them when the job finishes. EMR Serverless automatically scales workers up or down based on the workload and parallelism required at every stage of the job. This automatic scaling removes the need for you to estimate the number of workers that the application needs to run your workloads.

Pre-initialized capacity

EMR Serverless provides a *pre-initialized capacity* feature that keeps workers initialized and ready to respond in seconds. This capacity effectively creates a warm pool of workers for an application. To configure this feature for each application, set the `initial-capacity` parameter of an application. When you configure pre-initialized capacity, jobs can start immediately so that you can implement iterative applications and time-sensitive jobs. To learn more about pre-initialized workers, refer to Configuring an application when working with EMR Serverless.

EMR Studio

EMR Studio is the user console for managing your EMR Serverless applications. If an EMR Studio doesn't exist in your account when you create your first EMR Serverless application, we automatically create one for you. Access EMR Studio either from the Amazon EMR console, or turn on federated access from your identity provider (IdP) through IAM or IAM Identity Center. When you do this, users can access Studio and manage EMR Serverless applications without direct access to the Amazon EMR console. To learn more about how EMR Serverless applications works with EMR Studio, refer to Creating an EMR Serverless application from the EMR Studio console and Running jobs from the EMR Studio console.

Prerequisites for getting started with EMR Serverless

This section describes the administrative prerequisites for running EMR Serverless. These include account configuration and permissions management.

Topics

Sign up for an AWS account

If you do not have an AWS account, complete the following steps to create one.

To sign up for an AWS account

1. Open https://portal.aws.amazon.com/billing/signup.
2. Follow the online instructions.

   Part of the sign-up procedure involves receiving a phone call or text message and entering a verification code on the phone keypad.

   When you sign up for an AWS account, an *AWS account root user* is created. The root user has access to all AWS services and resources in the account. As a security best practice, assign administrative access to a user, and use only the root user to perform tasks that require root user access.

AWS sends you a confirmation email after the sign-up process is complete. At any time, you can view your current account activity and manage your account by going to https://aws.amazon.com/ and choosing **My Account**.

Create a user with administrative access

After you sign up for an AWS account, secure your AWS account root user, enable AWS IAM Identity Center, and create an administrative user so that you don't use the root user for everyday tasks.

Secure your AWS account root user

1. Sign in to the AWS Management Console as the account owner by choosing **Root user** and entering your AWS account email address. On the next page, enter your password.

   For help signing in by using root user, see Signing in as the root user in the *AWS Sign-In User Guide*.

2. Turn on multi-factor authentication (MFA) for your root user.

   For instructions, see Enable a virtual MFA device for your AWS account root user (console) in the *IAM User Guide*.

Create a user with administrative access

1. Enable IAM Identity Center.

   For instructions, see Enabling AWS IAM Identity Center in the *AWS IAM Identity Center User Guide*.

2. In IAM Identity Center, grant administrative access to a user.

   For a tutorial about using the IAM Identity Center directory as your identity source, see Configure user access with the default IAM Identity Center directory in the *AWS IAM Identity Center User Guide*.

Sign in as the user with administrative access

- To sign in with your IAM Identity Center user, use the sign-in URL that was sent to your email address when you created the IAM Identity Center user.

  For help signing in using an IAM Identity Center user, see Signing in to the AWS access portal in the *AWS Sign-In User Guide*.

Assign access to additional users

1. In IAM Identity Center, create a permission set that follows the best practice of applying least-privilege permissions.

   For instructions, see Create a permission set in the *AWS IAM Identity Center User Guide*.

2. Assign users to a group, and then assign single sign-on access to the group.

   For instructions, see Add groups in the *AWS IAM Identity Center User Guide*.

Grant permissions

In production environments, we suggest that you use finer-grained policies. For examples of such policies, refer to User access policy examples for EMR Serverless. To learn more about access management, refer to Access management for AWS resources in the IAM User Guide.

For users who need to get started with EMR Serverless in a sandbox environment, use a policy similar to the following:

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "EMRStudioCreate",
      "Effect": "Allow",
      "Action": [
        "elasticmapreduce:CreateStudioPresignedUrl",
        "elasticmapreduce:DescribeStudio",
        "elasticmapreduce:CreateStudio",
        "elasticmapreduce:ListStudios"
      ],
      "Resource": [
        "*"
      ]
    },
    {
      "Sid": "EMRServerlessFullAccess",
      "Effect": "Allow",
      "Action": [
        "emr-serverless:*"
      ],
      "Resource": [
        "*"
      ]
    },
    {
      "Sid": "AllowEC2ENICreationWithEMRTags",
      "Effect": "Allow",
      "Action": [
        "ec2:CreateNetworkInterface"
      ],
      "Resource": [
        "arn:aws:ec2:*:*:network-interface/*"
      ],
      "Condition": {
        "StringEquals": {
          "aws:CalledViaLast": "ops.emr-serverless.amazonaws.com"
        }
      }
    },
    {
      "Sid": "AllowEMRServerlessServiceLinkedRoleCreation",
      "Effect": "Allow",
      "Action": [
        "iam:CreateServiceLinkedRole"
      ],
      "Resource": [
        "arn:aws:iam::*:role/aws-service-role/*"
      ]
    }
  ]
}
```

To provide access, add permissions to your users, groups, or roles:

- Users and groups in AWS IAM Identity Center:

  Create a permission set. Follow the instructions in Create a permission set in the *AWS IAM Identity Center User Guide*.

- Users managed in IAM through an identity provider:

Create a role for identity federation. Follow the instructions in Create a role for a third-party identity provider (federation) in the *IAM User Guide*.

- IAM users:
  - Create a role that your user can assume. Follow the instructions in Create a role for an IAM user in the *IAM User Guide*.
  - (Not recommended) Attach a policy directly to a user or add a user to a user group. Follow the instructions in Adding permissions to a user (console) in the *IAM User Guide*.

Grant programmatic access

Users need programmatic access if they want to interact with AWS outside of the AWS Management Console. The way to grant programmatic access depends on the type of user that's accessing AWS.

To grant users programmatic access, choose one of the following options.

Which user needs programmatic access?	To	By
IAM	(Recommended) Use console credentials as temporary credentials to sign programmatic requests to the AWS CLI, AWS SDKs, or AWS APIs.	Following the instructions for the interface that you want to use. • For the AWS CLI, see Login for AWS local development in the *AWS Command Line Interface User Guide*. • For AWS SDKs, see Login for AWS local development in the *AWS SDKs and Tools Reference Guide*.
Workforce identity (Users managed in IAM Identity Center)	Use temporary credentials to sign programmatic requests to the AWS CLI, AWS SDKs, or AWS APIs.	Following the instructions for the interface that you want to use.

Which user needs programmatic access?	To	By
		- For the AWS CLI, see Configuring the AWS CLI to use AWS IAM Identity Center in the *AWS Command Line Interface User Guide*. - For AWS SDKs, tools, and AWS APIs, see IAM Identity Center authentication in the *AWS SDKs and Tools Reference Guide*.
IAM	Use temporary credentials to sign programmatic requests to the AWS CLI, AWS SDKs, or AWS APIs.	Following the instructions in Using temporary credentials with AWS resources in the *IAM User Guide*.

Which user needs programmatic access?	To	By
IAM	(Not recommended) Use long-term credentials to sign programmatic requests to the AWS CLI, AWS SDKs, or AWS APIs.	Following the instructions for the interface that you want to use. • For the AWS CLI, see Authenticating using IAM user credentials in the *AWS Command Line Interface User Guide*. • For AWS SDKs and tools, see Authenticate using long-term credentials in the *AWS SDKs and Tools Reference Guide*. • For AWS APIs, see Managing access keys for IAM users in the *IAM User Guide*.

Install and configure the AWS CLI

If you want to use EMR Serverless APIs, install the latest version of the AWS Command Line Interface (AWS CLI). You don't need the AWS CLI to use EMR Serverless from the EMR Studio console, and get started without the CLI by following the steps in Getting started with EMR Serverless from the console.

To set up the AWS CLI

1. To install the latest version of the AWS CLI for macOS, Linux, or Windows, refer to Installing or updating the latest version of the AWS CLI.
2. To configure the AWS CLI and secure setup of your access to AWS services, including EMR Serverless, refer to Quick configuration with `aws configure`.
3. To verify the setup, enter the following DataBrew command at the command prompt.

```
aws emr-serverless help
```

AWS CLI commands use the default AWS Region from your configuration, unless you set it with a parameter or a profile. To set your AWS Region with a parameter, add the `--region` parameter to each command.

To set your AWS Region with a profile, first add a named profile in the `~/.aws/config` file or the `%UserProfile%/.aws/config` file (for Microsoft Windows). Follow the steps in Named profiles for the AWS CLI. Next, set your AWS Region and other settings with a command similar to the one in the following example.

```
[profile emr-serverless]
aws_access_key_id = ACCESS-KEY-ID-OF-IAM-USER
aws_secret_access_key = SECRET-ACCESS-KEY-ID-OF-IAM-USER
region = us-east-1
output = text
```

Open the console

Most of the console-oriented topics in this section start from the Amazon EMR console. If you aren't already signed in to your AWS account, sign in, then open the Amazon EMR console and continue to the next section to continue getting started with Amazon EMR.

Getting started with Amazon EMR Serverless

This tutorial helps you get started with EMR Serverless when you deploy a sample Spark or Hive workload. You'll create, run, and debug your own application. We show default options in most parts of this tutorial.

Before you launch an EMR Serverless application, complete the following tasks.

Topics

Grant permissions to use EMR Serverless

To use EMR Serverless, you need a user or IAM role with an attached policy that grants permissions for EMR Serverless. To create a user and attach the appropriate policy to that user, follow the instructions in Grant permissions.

Prepare storage for EMR Serverless

In this tutorial, you'll use an S3 bucket to store output files and logs from the sample Spark or Hive workload that you'll run using an EMR Serverless application. To create a bucket, follow the instructions in Creating a bucket in the *Amazon Simple Storage Service Console User Guide*. Replace any further reference to *amzn-s3-demo-bucket* with the name of the newly created bucket.

Create an EMR Studio to run interactive workloads

If you want to use EMR Serverless to execute interactive queries through notebooks that are hosted in EMR Studio, you need to specify an S3 bucket and the minimum service role for EMR Serverless to create a Workspace. For steps to get set up, see Set up an EMR Studio in the *Amazon EMR*

Management Guide. For more information on interactive workloads, see Run interactive workloads with EMR Serverless through EMR Studio.

Create a job runtime role

Job runs in EMR Serverless use a runtime role that provides granular permissions to specific AWS services and resources at runtime. In this tutorial, a public S3 bucket hosts the data and scripts. The bucket *`amzn-s3-demo-bucket`* stores the output.

To set up a job runtime role, first create a runtime role with a trust policy so that EMR Serverless can use the new role. Next, attach the required S3 access policy to that role. The following steps guide you through the process.

Console

1. Navigate to the IAM console at https://console.aws.amazon.com/iam/.
2. In the left navigation pane, choose **Policies**.
3. Choose **Create Policy**.
4. The **Create policy** page opens on a new tab. Select the **Policy editor** as Json and Paste the policy JSON below.

> **Important**
>
> Replace *`amzn-s3-demo-bucket`* in the policy below with the actual bucket name created in Prepare storage for EMR Serverless. This is a basic policy for S3 access. For more job runtime role examples, see Job runtime roles for Amazon EMR Serverless.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "ReadAccessForEMRSamples",
      "Effect": "Allow",
      "Action": [
        "s3:GetObject",
        "s3:ListBucket"
      ],
      "Resource": [
        "arn:aws:s3:::*.elasticmapreduce",
        "arn:aws:s3:::*.elasticmapreduce/*"
      ]
    },
    {
      "Sid": "FullAccessToOutputBucket",
      "Effect": "Allow",
      "Action": [
        "s3:PutObject",
        "s3:GetObject",
        "s3:ListBucket",
        "s3:DeleteObject"
      ],
      "Resource": [
        "arn:aws:s3:::amzn-s3-demo-bucket",
        "arn:aws:s3:::amzn-s3-demo-bucket/*"
      ]
    },
    {
      "Sid": "GlueCreateAndReadDataCatalog",
      "Effect": "Allow",
      "Action": [
        "glue:GetDatabase",
        "glue:CreateDatabase",
        "glue:GetDataBases",
        "glue:CreateTable",
        "glue:GetTable",
        "glue:UpdateTable",
        "glue:DeleteTable",
        "glue:GetTables",
        "glue:GetPartition",
        "glue:GetPartitions",
        "glue:CreatePartition",
        "glue:BatchCreatePartition",
        "glue:GetUserDefinedFunctions"
      ],
      "Resource": [
        "*"
      ]
    }
```

```
  ]
}
```

5. Choose **Next** to enter a name for your policy, such as `EMRServerlessS3AndGlueAccessPolicy` and **Create policy**

6. In the left navigation pane of IAM console , choose **Roles**.

7. Choose **Create role**.

8. For role type, choose **Custom trust policy** and paste the following trust policy. This allows jobs submitted to your Amazon EMR Serverless applications to access other AWS services on your behalf.

   JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "sts:AssumeRole"
      ],
      "Resource": "arn:aws:iam::123456789012:role/
EMRServerlessExecutionRole",
      "Sid": "AllowSTSAssumerole"
    }
  ]
}
```

9. Choose **Next** to navigate to the **Add permissions** page, then choose **EMRServerlessS3AndGlueAccessPolicy**.

10. In the **Name, review, and create** page, for **Role name**, enter a name for your role, for example, `EMRServerlessS3RuntimeRole`. To create this IAM role, choose **Create role**.

CLI

1. Create a file named `emr-serverless-trust-policy.json` that contains the trust policy to use for the IAM role. The file should contain the following policy.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "EMRServerlessTrustPolicy",
      "Action": [
        "sts:AssumeRole"
      ],
      "Effect": "Allow",
      "Resource": "arn:aws:iam::123456789012:role/
EMRServerlessExecutionRole"
    }
  ]
}
```

2. Create an IAM role named `EMRServerlessS3RuntimeRole`. Use the trust policy that you created in the previous step.

   ```
   aws iam create-role \
       --role-name EMRServerlessS3RuntimeRole \
       --assume-role-policy-document file://emr-serverless-trust-policy.json
   ```

   Note the ARN in the output. You use the ARN of the new role during job submission, referred to after this as the *`job-role-arn`*.

3. Create a file named `emr-sample-access-policy.json` that defines the IAM policy for your workload. This provides read access to the script and data stored in public S3 buckets and read-write access to *`amzn-s3-demo-bucket`*.

   > **Important**
   >
   > Replace *`amzn-s3-demo-bucket`* in the policy below with the actual bucket name created in Prepare storage for EMR Serverless.. This is a basic policy for AWS Glue and S3 access. For more job runtime role examples, see Job runtime roles for Amazon EMR Serverless.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "ReadAccessForEMRSamples",
      "Effect": "Allow",
      "Action": [
        "s3:GetObject",
        "s3:ListBucket"
      ],
      "Resource": [
        "arn:aws:s3:::*.elasticmapreduce",
        "arn:aws:s3:::*.elasticmapreduce/*"
      ]
    },
    {
      "Sid": "FullAccessToOutputBucket",
      "Effect": "Allow",
      "Action": [
        "s3:PutObject",
        "s3:GetObject",
        "s3:ListBucket",
        "s3:DeleteObject"
      ],
      "Resource": [
        "arn:aws:s3:::amzn-s3-demo-bucket",
        "arn:aws:s3:::amzn-s3-demo-bucket/*"
      ]
    },
    {
      "Sid": "GlueCreateAndReadDataCatalog",
      "Effect": "Allow",
      "Action": [
        "glue:GetDatabase",
        "glue:CreateDatabase",
        "glue:GetDataBases",
        "glue:CreateTable",
        "glue:GetTable",
        "glue:UpdateTable",
        "glue:DeleteTable",
        "glue:GetTables",
        "glue:GetPartition",
        "glue:GetPartitions",
        "glue:CreatePartition",
        "glue:BatchCreatePartition",
        "glue:GetUserDefinedFunctions"
      ],
      "Resource": [
        "*"
      ]
    }
  ]
}
```

4. Create an IAM policy named `EMRServerlessS3AndGlueAccessPolicy` with the policy file that you created in **Step 3**. Take note of the ARN in the output, as you will use the ARN of the new policy in the next step.

   ```
   aws iam create-policy \
       --policy-name EMRServerlessS3AndGlueAccessPolicy \
       --policy-document file://emr-sample-access-policy.json
   ```

   Note the new policy's ARN in the output. You'll substitute it for *`policy-arn`* in the next step.

5. Attach the IAM policy `EMRServerlessS3AndGlueAccessPolicy` to the job runtime role `EMRServerlessS3RuntimeRole`.

   ```
   aws iam attach-role-policy \
       --role-name EMRServerlessS3RuntimeRole \
       --policy-arn policy-arn
   ```

Getting started with EMR Serverless from the console

This section describes working with EMR Serverless, including creating an EMR Studio. It also describes how to submit job runs and view logs.

Steps to complete

- Step 1: Create an EMR Serverless application

- Step 2: Submit a job run or interactive workload
- Step 3: View application UI and logs
- Step 4: Clean up

Step 1: Create an EMR Serverless application

Create a new application with EMR Serverless as follows.

1. Sign in to the AWS Management Console and open the Amazon EMR console at https://console.aws.amazon.com/emr.
2. In the left navigation pane, choose **EMR Serverless** to navigate to the EMR Serverless landing page.
3. To create or manage EMR Serverless applications, you need the EMR Studio UI.

   - If you already have an EMR Studio in the AWS Region where you want to create an application, then select **Manage applications** to navigate to your EMR Studio, or select the studio that you want to use.
   - If you don't have an EMR Studio in the AWS Region where you want to create an application, choose **Get started** and then Choose **Create and launch Studio**. EMR Serverless creates a EMR Studio for you so that you can create and manage applications.
4. In the **Create studio** UI that opens in a new tab, enter the name, type, and release version for your application. If you only want to run batch jobs, select **Use default settings for batch jobs only**. For interactive workloads, select **Use default settings for interactive workloads**. You can also run batch jobs on interactive-enabled applications with this option. If you need to, you can change these settings later.

   For more information, see Create a studio.
5. Select **Create application** to create your first application.

Continue to the next section Step 2: Submit a job run or interactive workload to submit a job run or interactive workload.

Step 2: Submit a job run or interactive workload

Spark job run

In this tutorial, we use a PySpark script to compute the number of occurrences of unique words across multiple text files. A public, read-only S3 bucket stores both the script and the dataset.

To run a Spark job

1. Upload the sample script `wordcount.py` into your new bucket with the following command.

   ```
   aws s3 cp s3://us-east-1.elasticmapreduce/emr-containers/samples/wordcount/
   scripts/wordcount.py s3://amzn-s3-demo-bucket/scripts/
   ```

2. Completing Step 1: Create an EMR Serverless application takes you to the **Application details** page in EMR Studio. There, choose the **Submit job** option.
3. On the **Submit job** page, complete the following.
   - In the **Name** field, enter the name that you want to call your job run.
   - In the **Runtime role** field, enter the name of the role that you created in Create a job runtime role.
   - In the **Script location** field, enter `s3://amzn-s3-demo-bucket/scripts/wordcount.py` as the S3 URI.
   - In the **Script arguments** field, enter `["s3://amzn-s3-demo-bucket/emr-serverless-spark/output"]`.
   - In the **Spark properties** section, choose **Edit as text** and enter the following configurations.

     ```
     --conf spark.executor.cores=1 --conf spark.executor.memory=4g --
     conf spark.driver.cores=1 --conf spark.driver.memory=4g --conf
      spark.executor.instances=1
     ```

4. To start the job run, choose **Submit job** .
5. In the **Job runs** tab, you should see your new job run with a **Running** status.

Hive job run

In this part of the tutorial, we create a table, insert a few records, and run a count aggregation query. To run the Hive job, first create a file that contains all Hive queries to run as part of single job, upload the file to S3, and specify this S3 path when starting the Hive job.

To run a Hive job

1. Create a file called `hive-query.ql` that contains all the queries that you want to run in your Hive job.

   ```
   create database if not exists emrserverless;
   use emrserverless;
   create table if not exists test_table(id int);
   drop table if exists Values__Tmp__Table__1;
   insert into test_table values (1),(2),(2),(3),(3),(3);
   select id, count(id) from test_table group by id order by id desc;
   ```

2. Upload `hive-query.ql` to your S3 bucket with the following command.

   ```
   aws s3 cp hive-query.ql s3://amzn-s3-demo-bucket/emr-serverless-hive/query/hive-query.ql
   ```

3. Completing Step 1: Create an EMR Serverless application takes you to the **Application details** page in EMR Studio. There, choose the **Submit job** option.

4. On the **Submit job** page, complete the following.

   - In the **Name** field, enter the name that you want to call your job run.
   - In the **Runtime role** field, enter the name of the role that you created in Create a job runtime role.
   - In the **Script location** field, enter `s3://amzn-s3-demo-bucket/emr-serverless-hive/query/hive-query.ql` as the S3 URI.
   - In the **Hive properties** section, choose **Edit as text**, and enter the following configurations.

     ```
     --hiveconf hive.log.explain.output=false
     ```

   - In the **Job configuration** section, choose **Edit as JSON**, and enter the following JSON.

     ```
     {
     ```

```
   "applicationConfiguration":
   [{
       "classification": "hive-site",
          "properties": {
              "hive.exec.scratchdir": "s3://amzn-s3-demo-bucket/emr-
serverless-hive/hive/scratch",
              "hive.metastore.warehouse.dir": "s3://amzn-s3-demo-bucket/emr-
serverless-hive/hive/warehouse",
              "hive.driver.cores": "2",
              "hive.driver.memory": "4g",
              "hive.tez.container.size": "4096",
              "hive.tez.cpu.vcores": "1"
           }
    }]
}
```

5. To start the job run, choose **Submit job**.
6. In the **Job runs** tab, you should see your new job run with a **Running** status.

Interactive workload

With Amazon EMR 6.14.0 and higher, you can use notebooks that are hosted in EMR Studio to run interactive workloads for Spark in EMR Serverless. For more information including permissions and prerequisites, see Run interactive workloads with EMR Serverless through EMR Studio.

Once you've created your application and set up the required permissions, use the following steps to run an interactive notebook with EMR Studio:

1. Navigate to the **Workspaces** tab in EMR Studio. If you still need to configure an Amazon S3 storage location and EMR Studio service role, select the **Configure studio** button in the banner at the top of the screen.
2. To access a notebook, select a Workspace or create a new Workspace. Use **Quick launch** to open your Workspace in a new tab.
3. Go to the newly opened tab. Select the **Compute** icon from the left navigation. Select EMR Serverless as the **Compute type**.
4. Select the interactive-enabled application that you created in the previous section.

5. In the **Runtime role** field, enter the name of the IAM role that your EMR Serverless application can assume for the job run. To learn more about runtime roles, see Job runtime roles in the *Amazon EMR Serverless User Guide*.
6. Select **Attach**. This may take up to a minute. The page will refresh when attached.
7. Pick a kernel and start a notebook. You can also browse example notebooks on EMR Serverless and copy them to your Workspace. To access the example notebooks, navigate to the **`{...}`** menu in the left navigation and browse through notebooks that have `serverless` in the notebook file name.
8. In the notebook, you can access the driver log link and a link to the Apache Spark UI, a real-time interface that provides metrics to monitor your job. For more information, see Monitoring EMR Serverless applications and jobs in the *Amazon EMR Serverless User Guide*.

When you attach an application to an Studio workspace, the application start triggers automatically if it's not already running. You can also pre-start the application and keep it ready before you attach it to the workspace.

Step 3: View application UI and logs

To view the application UI, first identify the job run. An option for **Spark UI** or **Hive Tez UI** is available in the first row of options for that job run, based on the job type. Select the appropriate option.

If you chose the Spark UI, choose the **Executors** tab to view the driver and executors logs. If you chose the Hive Tez UI, choose the **All Tasks** tab to view the logs.

Once the job run status shows as **Success**, you can view the output of the job in your S3 bucket.

Step 4: Clean up

While the application you created should auto-stop after 15 minutes of inactivity, we still recommend that you release resources that you don't intend to use again.

To delete the application, navigate to the **List applications** page. Select the application that you created and choose **Actions** → **Stop** to stop the application. After the application is in the `STOPPED` state, select the same application and choose **Actions** → **Delete**.

For more examples of running Spark and Hive jobs, see Using Spark configurations when you run EMR Serverless jobs and Using Hive configurations when you run EMR Serverless jobs.

Getting started from the AWS CLI

Get started with EMR Serverless from the AWS CLI with commands to create an application, run jobs, check job run output, and delete your resources.

Step 1: Create an EMR Serverless application

Use the `emr-serverless create-application` command to create your first EMR Serverless application. You need to specify the application type and the the Amazon EMR release label associated with the application version you want to use. The name of the application is optional.

Spark

To create a Spark application, run the following command.

```
aws emr-serverless create-application \
    --release-label emr-6.6.0 \
    --type "SPARK" \
    --name my-application
```

Hive

To create a Hive application, run the following command.

```
aws emr-serverless create-application \
    --release-label emr-6.6.0 \
    --type "HIVE" \
    --name my-application
```

Note the application ID returned in the output. You'll use the ID to start the application and during job submission, referred to after this as the *`application-id`*.

Before you move on to Step 2: Submit a job run to your EMR Serverless application, make sure that your application has reached the CREATED state with the `get-application` API.

```
aws emr-serverless get-application \
    --application-id application-id
```

EMR Serverless creates workers to accommodate your requested jobs. By default, these are created on demand, but you can also specify a pre-initialized capacity by setting the `initialCapacity` parameter when you create the application. You can also limit the total maximum capacity that an application can use with the `maximumCapacity` parameter. To learn more about these options, see Configuring an application when working with EMR Serverless.

Step 2: Submit a job run to your EMR Serverless application

Now your EMR Serverless application is ready to run jobs.

Spark

In this step, we use a PySpark script to compute the number of occurrences of unique words across multiple text files. A public, read-only S3 bucket stores both the script and the dataset. The application sends the output file and the log data from the Spark runtime to `/output` and `/logs` directories in the S3 bucket that you created.

To run a Spark job

1. Use the following command to copy the sample script we will run into your new bucket.

```
aws s3 cp s3://us-east-1.elasticmapreduce/emr-containers/samples/wordcount/
scripts/wordcount.py s3://amzn-s3-demo-bucket/scripts/
```

2. In the following command, substitute *`application-id`* with your application ID. Substitute *`job-role-arn`* with the runtime role ARN you created in Create a job runtime role. Substitute *`job-run-name`* with the name you want to call your job run. Replace all *`amzn-s3-demo-bucket`* strings with the Amazon S3 bucket that you created, and add `/output` to the path. This creates a new folder in your bucket where EMR Serverless can copy the output files of your application.

```
aws emr-serverless start-job-run \
    --application-id application-id \
    --execution-role-arn job-role-arn \
    --name job-run-name \
    --job-driver '{
        "sparkSubmit": {
          "entryPoint": "s3://amzn-s3-demo-bucket/scripts/wordcount.py",
          "entryPointArguments": ["s3://amzn-s3-demo-bucket/emr-serverless-
spark/output"],
          "sparkSubmitParameters": "--conf spark.executor.cores=1
 --conf spark.executor.memory=4g --conf spark.driver.cores=1 --conf
 spark.driver.memory=4g --conf spark.executor.instances=1"
```

```
        }
    }'
```

3. Note the job run ID returned in the output . Replace *job-run-id* with this ID in the following steps.

Hive

In this tutorial, we create a table, insert a few records, and run a count aggregation query. To run the Hive job, first create a file that contains all Hive queries to run as part of single job, upload the file to S3, and specify this S3 path when you start the Hive job.

To run a Hive job

1. Create a file called `hive-query.ql` that contains all the queries that you want to run in your Hive job.

```
create database if not exists emrserverless;
use emrserverless;
create table if not exists test_table(id int);
drop table if exists Values__Tmp__Table__1;
insert into test_table values (1),(2),(2),(3),(3),(3);
select id, count(id) from test_table group by id order by id desc;
```

2. Upload `hive-query.ql` to your S3 bucket with the following command.

```
aws s3 cp hive-query.ql s3://amzn-s3-demo-bucket/emr-serverless-hive/query/hive-query.ql
```

3. In the following command, substitute *application-id* with your own application ID. Substitute *job-role-arn* with the runtime role ARN you created in Create a job runtime role. Replace all *amzn-s3-demo-bucket* strings with the Amazon S3 bucket that you created, and add `/output` and `/logs` to the path. This creates new folders in your bucket, where EMR Serverless can copy the output and log files of your application.

```
aws emr-serverless start-job-run \
    --application-id application-id \
    --execution-role-arn job-role-arn \
    --job-driver '{
        "hive": {
          "query": "s3://amzn-s3-demo-bucket/emr-serverless-hive/query/hive-
query.ql",
          "parameters": "--hiveconf hive.log.explain.output=false"
        }
    }' \
    --configuration-overrides '{
      "applicationConfiguration": [{
        "classification": "hive-site",
          "properties": {
            "hive.exec.scratchdir": "s3://amzn-s3-demo-bucket/emr-serverless-
hive/hive/scratch",
            "hive.metastore.warehouse.dir": "s3://amzn-s3-demo-bucket/emr-
serverless-hive/hive/warehouse",
            "hive.driver.cores": "2",
            "hive.driver.memory": "4g",
            "hive.tez.container.size": "4096",
            "hive.tez.cpu.vcores": "1"
            }
        }],
        "monitoringConfiguration": {
          "s3MonitoringConfiguration": {
            "logUri": "s3://amzn-s3-demo-bucket/emr-serverless-hive/logs"
           }
        }
    }'
```

4. Note the job run ID returned in the output. Replace *job-run-id* with this ID in the following steps.

Step 3: Review your job run's output

The job run should typically take 3-5 minutes to complete.

Spark

You can check for the state of your Spark job with the following command.

```
aws emr-serverless get-job-run \
    --application-id application-id \
    --job-run-id job-run-id
```

With your log destination set to `s3://amzn-s3-demo-bucket/emr-serverless-spark/logs`, you can find the logs for this specific job run under `s3://amzn-s3-demo-bucket/emr-serverless-spark/logs/applications/application-id/jobs/job-run-id`.

For Spark applications, EMR Serverless pushes event logs every 30 seconds to the `sparklogs` folder in your S3 log destination. When your job completes, Spark runtime logs for the driver and executors upload to folders named appropriately by the worker type, such as `driver` or `executor`. The output of the PySpark job uploads to `s3://amzn-s3-demo-bucket/output/`.

Hive

You can check for the state of your Hive job with the following command.

```
aws emr-serverless get-job-run \
    --application-id application-id \
    --job-run-id job-run-id
```

With your log destination set to `s3://amzn-s3-demo-bucket/emr-serverless-hive/logs`, you can find the logs for this specific job run under `s3://amzn-s3-demo-bucket/emr-serverless-hive/logs/applications/application-id/jobs/job-run-id`.

For Hive applications, EMR Serverless continuously uploads the Hive driver to the `HIVE_DRIVER` folder, and Tez tasks logs to the `TEZ_TASK` folder, of your S3 log destination. After the job run reaches the `SUCCEEDED` state, the output of your Hive query becomes available in the Amazon S3 location that you specified in the `monitoringConfiguration` field of `configurationOverrides`.

Step 4: Clean up

When you’re done working with this tutorial, consider deleting the resources that you created. We recommend that you release resources that you don't intend to use again.

Delete your application

To delete an application, use the following command.

```
aws emr-serverless delete-application \
    --application-id application-id
```

Delete your S3 log bucket

To delete your S3 logging and output bucket, use the following command. Replace *amzn-s3-demo-bucket* with the actual name of the S3 bucket created in Prepare storage for EMR Serverless..

```
aws s3 rm s3://amzn-s3-demo-bucket --recursive
aws s3api delete-bucket --bucket amzn-s3-demo-bucket
```

Delete your job runtime role

To delete the runtime role, detach the policy from the role. You can then delete both the role and the policy.

```
aws iam detach-role-policy \
    --role-name EMRServerlessS3RuntimeRole \
    --policy-arn policy-arn
```

To delete the role, use the following command.

```
aws iam delete-role \
    --role-name EMRServerlessS3RuntimeRole
```

To delete the policy that was attached to the role, use the following command.

```
aws iam delete-policy \
    --policy-arn policy-arn
```

For more examples of running Spark and Hive jobs, see Using Spark configurations when you run EMR Serverless jobs and Using Hive configurations when you run EMR Serverless jobs.

Interact with and configure an EMR Serverless application

This section covers how to interact with your Amazon EMR Serverless application with the AWS CLI. It also describes configuration of an application, performing customizations, and defaults for Spark and Hive engines.

Topics

Application states

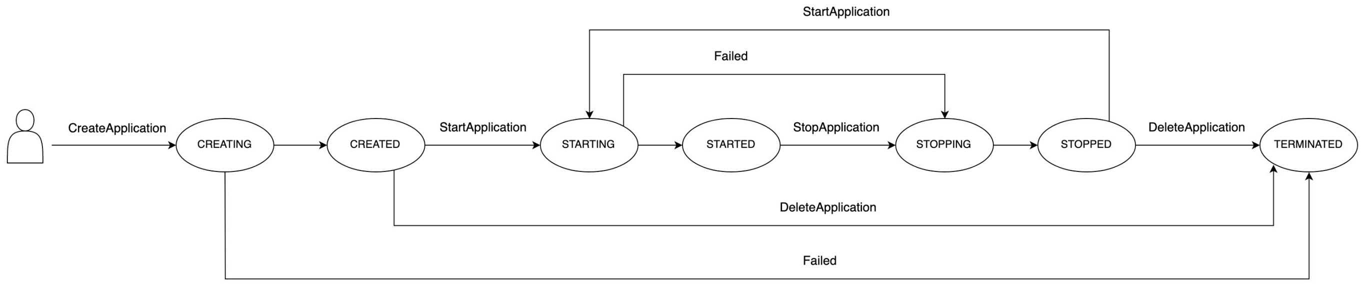
When you create an application with EMR Serverless, the application run enters the `CREATING` state. It then passes through the following states until it succeeds (exits with code `0`) or fails (exits with a non-zero code).

Applications can have the following states:

State	Description
Creating	The application is being prepared and isn't ready to use yet.
Created	The application has been created but hasn't provisioned capacity yet. You can modify the application to change its initial capacity configuration.

State	Description
Starting	The application is starting and is provisioning capacity.
Started	The application is ready to accept new jobs. The application only accepts jobs when it's in this state.
Stopping	All jobs have completed and the application is releasing its capacity.
Stopped	The application is stopped and no resources are running on the application. You can modify the application to change its initial capacity configuration.
Terminated	The application has been terminated and doesn't appear on your application list.

The following diagram illustrates the trajectory of EMR Serverless application states.



Creating an EMR Serverless application from the EMR Studio console

From the EMR Studio console, create, access, and manage EMR Serverless applications. To navigate to the EMR Studio console, follow the instructions in Getting started from the console.

Create an application

With the **Create application** page, create an EMR Serverless application by following these steps.

1. In the **Name** field, enter the name you want to call your application.
2. In the **Type** field, choose Spark or Hive as the type of the application.
3. In the **Release version** field, choose the EMR release number.
4. In the **Architecture** options, choose the instruction set architecture to use. For more information, refer to Amazon EMR Serverless architecture options.

    - **arm64** — 64-bit ARM architecture; to use Graviton processors
    - **x86_64** — 64-bit x86 architecture; to use x86-based processors
5. There are two application setup options for the remaining fields: default settings and custom settings. These fields are optional.

    Default settings — Default settings allow you to create an application quickly with pre-initialized capacity. This includes one driver and one executor for Spark, and one driver and one Tez Task for Hive. The default settings don't enable network connectivity to your VPCs. The application is configured to stop if idle for 15 minutes, and auto-starts on job submission.

    Custom settings — Custom settings allow you to modify the following properties.

    - **Pre-initialized capacity** — The number of drivers and executors or Hive Tez Task workers, and the size of each worker.
    - **Application limits** — The maximum capacity of an application.
    - **Application behavior** — The application's auto-start and auto-stop behavior.
    - **Network connections** — Network connectivity to VPC resources.
    - **Tags** — Custom tags that assign to the application.

    For more information about pre-initialized capacity, application limits, and application behavior, refer to Configuring an application when working with EMR Serverless. For more information about network connectivity, refer to Configuring VPC access for EMR Serverless applications to connect to data.
6. To create the application, choose **Create application** .

List applications from the EMR Studio console

You can access all existing EMR Serverless applications from the **List applications** page. You can choose an application's name to navigate to the **Details** page for that application.

Manage applications from the EMR Studio console

You can perform the following actions on an application from either the **List applications** page or from a specific application's **Details** page.

Start application

Choose this option to manually start an application.

Stop application

Choose this option to manually stop an application. An application must have no running jobs to be stopped. To learn more about application state transitions, refer to Application states.

Configure application

Edit the optional settings for an application from the **Configure application** page. You can change most application settings. For example, change the release label for an application to upgrade it to a different version of Amazon EMR, or switch the architecture from x86_64 to arm64. The other optional settings are the same as those that are in the **Custom settings** section on the **Create application** page. For more information about the application settings, refer to Create an application.

Delete application

Choose this option to manually delete an application. You must stop an application to delete it. To learn more about application state transitions, refer to Application states.

Interacting with your EMR Serverless application on the AWS CLI

From the AWS CLI, create, describe, and delete individual applications. You can also list all of your applications so that access them at a glance. This section describes how to perform these actions. For more application operations, such as starting, stopping, and application updates, refer to the EMR Serverless API Reference. For examples of how to use the EMR Serverless API using the AWS

SDK for Java, refer to Java examples in our GitHub repository. For examples of how to use the EMR Serverless API using the AWS SDK for Python (Boto), refer to Python examples in our GitHub repository.

To create an application, use `create-application`. You must specify `SPARK` or `HIVE` as the application `type`. This command returns the application's ARN, name, and ID.

```
aws emr-serverless create-application \
--name my-application-name \
--type 'application-type' \
--release-label release-version
```

To describe an application, use `get-application` and provide its `application-id`. This command returns the state and capacity-related configurations for your application.

```
aws emr-serverless get-application \
--application-id application-id
```

To list all of your applications, call `list-applications`. This command returns the same properties as `get-application` but includes all of your applications.

```
aws emr-serverless list-applications
```

To delete your application, call `delete-application` and supply your `application-id`.

```
aws emr-serverless delete-application \
--application-id application-id
```

Configuring an application when working with EMR Serverless

With EMR Serverless, configure the applications that you use. For example, set the maximum capacity that an application can scale up to, configure pre-initialized capacity to keep driver and workers ready to respond, and specify a common set of runtime and monitoring configurations at the application level. The following pages describe how to configure applications when you use EMR Serverless.

Topics

- Understanding application behavior in EMR Serverless
- Pre-initialized capacity for working with an application in EMR Serverless
- Default application configuration for EMR Serverless

Understanding application behavior in EMR Serverless

This section describes job submission behavior, capacity configuration for scaling, and worker configuration settings for EMR Serverless.

Default application behavior

Auto-start — An application by default is configured to auto-start on job submission. You can turn this feature off.

Auto-stop — An application by default is configured to auto-stop when idle for 15 minutes. When an application changes to the STOPPED state, it releases any configured pre-initialized capacity. You can modify the amount of idle time before an application auto-stops, or you can turn this feature off.

Maximum capacity

You can configure the maximum capacity that an application can scale up to. You can specify your maximum capacity in terms of CPU, memory (GB), and disk (GB).

> **Note**
>
> It is best practice to configure your maximum capacity to be proportional to your supported worker sizes by multiplying the number of workers by their sizes. For example, if you want to limit your application to 50 workers with 2 vCPUs, 16 GB for memory, and 20 GB for disk, set your maximum capacity to 100 vCPUs, 800 GB for memory, and 1000 GB for disk.

Supported worker configurations

The following table lists supported worker configurations and sizes that can be specified for EMR Serverless. Configure different sizes for drivers and executors based on the need of your workload.

Worker configurations and sizes

CPU	Memory	Default ephemeral storage
1 vCPU	Minimum 2 GB, maximum 8 GB, in 1 GB increments	20 GB - 200 GB
2 vCPU	Minimum 4 GB, maximum 16 GB, in 1 GB increments	20 GB - 200 GB
4 vCPU	Minimum 8 GB, maximum 30 GB, in 1 GB increments	20 GB - 200 GB
8 vCPU	Minimum 16 GB, maximum 60 GB, in 4 GB increments	20 GB - 200 GB
16 vCPU	Minimum 32 GB, maximum 120 GB, in 8 GB increments	20 GB - 200 GB

CPU — Each worker can have 1, 2, 4, 8, or 16 vCPUs.

Memory — Each worker has memory, specified in GB, within the limits listed in the earlier table. Spark jobs have a memory overhead, meaning that the memory they use is more than the specified container sizes. This overhead is specified with the properties `spark.driver.memoryOverhead` and `spark.executor.memoryOverhead`. The overhead has a default value of 10% of container memory, with a minimum of 384 MB. You should consider this overhead when you choose worker sizes.

For example, If you choose 4 vCPUs for your worker instance, and a pre-initialized storage capacity of 30 GB, then set a value of approximately 27 GB as executor memory for your Spark job. This maximizes the utilization of your pre-initialized capacity. Usable memory is 27 GB, plus 10% of 27 GB (2.7 GB), for a total of 29.7 GB.

Disk — You can configure each worker with temporary storage disks with a minimum size of 20 GB and a maximum of 200 GB. You only pay for additional storage beyond 20 GB that you configure per worker.

Pre-initialized capacity for working with an application in EMR Serverless

EMR Serverless provides an optional feature that keeps driver and workers pre-initialized and ready to respond in seconds. This effectively creates a warm pool of workers for an application. This feature is called *pre-initialized capacity*. To configure this feature, set the `initialCapacity` parameter of an application to the number of workers you want to pre-initialize. With pre-initialized worker capacity, jobs start immediately. This is ideal when you want to implement iterative applications and time-sensitive jobs.

Pre-initialized capacity keeps a warm pool of workers ready for jobs and sessions to startup in seconds. You will be paying for provisioned pre-initialized workers even when the application is idle, hence we suggest enabling it for use cases that benefit from the fast start-up time and sizing it for optimal utilization of resources. EMR Serverless applications automatically shut down when idle. We suggest keeping this feature on when using pre-initialized workers to avoid unexpected charges.

When you submit a job, if workers from `initialCapacity` are available, the job uses those resources to start its run. If those workers are already in use by other jobs, or if the job needs more resources than available from `initialCapacity`, then the application requests and gets additional workers, up to the maximum limits on resources set for the application. When a job finishes its run, it releases the workers that it used, and the number of resources available for the application returns to `initialCapacity`. An application maintains the `initialCapacity` of resources even after jobs finish their runs. The application releases excess resources beyond `initialCapacity` when the jobs no longer need them to run.

Pre-initialized capacity is available and ready to use when the application has started. The pre-initialized capacity becomes inactive when the application is stopped. An application moves to the `STARTED` state only if the requested pre-initialized capacity has been created and is ready to use. The whole time that the application is in the `STARTED` state, EMR Serverless keeps the pre-initialized capacity available for use or in use by jobs or interactive workloads. The feature restores capacity for released or failed containers. This maintains the number of workers that the `InitialCapacity` parameter specifies. The state of an application with no pre-initialized capacity can immediately change from `CREATED` to `STARTED`.

You can configure the application to release pre-initialized capacity if it isn't used for a certain period of time, with a default of 15 minutes. A stopped application starts automatically when you submit a new job. You can set these automatic start and stop configurations when you create the application, or change them when the application is in a `CREATED` or `STOPPED` state.

You can change the `InitialCapacity` counts, and specify compute configurations such as CPU, memory, and disk, for each worker. Because you can't make partial modifications, specify all compute configurations when you change values. You can only change configurations when the application is in the `CREATED` or `STOPPED` state.

> **Note**
>
> To optimize your application's use of resources, we suggest aligning your container sizes with your pre-initialized capacity worker sizes. For example, if you configure your Spark executor size to 2 CPUs and your memory to 8 GB, but your pre-initialized capacity worker size is 4 CPUs with 16 GB of memory, then the Spark executors only use half of the workers' resources when they are assigned to this job.

Customizing pre-initialized capacity for Spark and Hive

You can further customize pre-initialized capacity for workloads that run on specific big data frameworks. For example, when a workload runs on Apache Spark, specify how many workers start as drivers and how many start as executors. Similarly, when you use Apache Hive, specify how many workers start as Hive drivers, and how many should run Tez tasks.

Configuring an application running Apache Hive with pre-initialized capacity

The following API request creates an application running Apache Hive based on Amazon EMR release emr-6.6.0. The application starts with 5 pre-initialized Hive drivers, each with 2 vCPU and 4 GB of memory, and 50 pre-initialized Tez task workers, each with 4 vCPU and 8 GB of memory. When Hive queries run on this application, they first use the pre-initialized workers and start executing immediately. If all of the pre-initialized workers are busy and more Hive jobs are submitted, the application can scale to a total of 400 vCPU and 1024 GB of memory. You can optionally omit capacity for either the `DRIVER` or the `TEZ_TASK` worker.

```
aws emr-serverless create-application \
  --type "HIVE" \
  --name my-application-name \
  --release-label emr-6.6.0 \
  --initial-capacity '{
    "DRIVER": {
        "workerCount": 5,
        "workerConfiguration": {
            "cpu": "2vCPU",
            "memory": "4GB"
        }
    },
    "TEZ_TASK": {
        "workerCount": 50,
        "workerConfiguration": {
            "cpu": "4vCPU",
            "memory": "8GB"
        }
    }
  }' \
  --maximum-capacity '{
    "cpu": "400vCPU",
    "memory": "1024GB"
  }'
```

Configuring an application running Apache Spark with pre-initialized capacity

The following API request creates an application that runs Apache Spark 3.2.0 based on Amazon EMR release 6.6.0. The application starts with 5 pre-initialized Spark drivers, each with 2 vCPU and 4 GB of memory, and 50 pre-initialized executors, each with 4 vCPU and 8 GB of memory. When Spark jobs run on this application, they first use the pre-initialized workers and start to execute immediately. If all of the pre-initialized workers are busy and more Spark jobs are submitted, the application can scale to a total of 400 vCPU and 1024 GB of memory. You can optionally omit capacity for either the `DRIVER` or the `EXECUTOR`.

> **Note**
>
> Spark adds a configurable memory overhead, with a 10% default value, to the memory requested for driver and executors. For jobs to use pre-initialized workers, the initial capacity memory configuration should be greater than the memory that the job and the overhead request.

```
aws emr-serverless create-application \
  --type "SPARK" \
  --name my-application-name \
  --release-label emr-6.6.0 \
  --initial-capacity '{
    "DRIVER": {
        "workerCount": 5,
        "workerConfiguration": {
            "cpu": "2vCPU",
            "memory": "4GB"
        }
    },
    "EXECUTOR": {
        "workerCount": 50,
        "workerConfiguration": {
            "cpu": "4vCPU",
            "memory": "8GB"
        }
    }
  }' \
  --maximum-capacity '{
    "cpu": "400vCPU",
    "memory": "1024GB"
  }'
```

Default application configuration for EMR Serverless

You can specify a common set of runtime and monitoring configurations at the application level for all the jobs that you submit under the same application. This reduces the additional overhead that is associated with the need to submit the same configurations for each job.

You can modify the configurations at the following points in time:

- Declare application-level configurations at job submission.
- Override default configurations during job run.

The following sections provide more details and an example for further context.

Declaring configurations at the application level

You can specify application-level logging and runtime configuration properties for the jobs that you submit under the application.

`monitoringConfiguration`

To specify the log configurations for jobs that you submit with the application, use the `monitoringConfiguration` field. For more information on logging for EMR Serverless, refer to Storing logs.

`runtimeConfiguration`

To specify runtime configuration properties such as `spark-defaults`, provide a configuration object in the `runtimeConfiguration` field. This affects the default configurations for all the jobs that you submit with the application. For more information, refer to Hive configuration override parameter and Spark configuration override parameter.

Available configuration classifications vary by specific EMR Serverless release. For example, classifications for custom Log4j `spark-driver-log4j2` and `spark-executor-log4j2` are only available with releases 6.8.0 and higher. For a list of application-specific properties, refer to Spark job properties and Hive job properties.

You can also configure Apache Log4j2 properties, AWS Secrets Manager for data protection, and Java 17 runtime at the application level.

To pass Secrets Manager secrets at the application level, attach the following policy to users and roles that need to create or update EMR Serverless applications with secrets.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "SecretsManagerPolicy",
      "Effect": "Allow",
      "Action": [
        "secretsmanager:GetSecretValue",
        "secretsmanager:DescribeSecret"
      ],
      "Resource": [
        "arn:aws:secretsmanager:us-east-1:123456789012:secret:my-secret-
name-123abc"
      ]
    },
    {
      "Sid": "KMSDecryptPolicy",
      "Effect": "Allow",
      "Action": [
        "kms:Decrypt"
      ],
      "Resource": [
        "arn:aws:kms:us-
east-1:123456789012:key/12345678-1234-1234-1234-123456789012"
      ]
    }
  ]
}
```

For more information on creating custom policies for secrets, refer to Permissions policy examples for AWS Secrets Manager in the *AWS Secrets Manager User Guide*.

> **Note**
>
> The `runtimeConfiguration` that you specify at application level maps to `applicationConfiguration` in the `StartJobRun` API.

Example declaration

The following example shows how to declare default configurations with `create-application`.

```
aws emr-serverless create-application \
    --release-label release-version  \
    --type SPARK \
    --name my-application-name \
    --runtime-configuration '[
        {
            "classification": "spark-defaults",
            "properties": {
                "spark.driver.cores": "4",
                "spark.executor.cores": "2",
                "spark.driver.memory": "8G",
                "spark.executor.memory": "8G",
                "spark.executor.instances": "2",

 "spark.hadoop.javax.jdo.option.ConnectionDriverName":"org.mariadb.jdbc.Driver",
                "spark.hadoop.javax.jdo.option.ConnectionURL":"jdbc:mysql://db-host:db-
port/db-name",
                "spark.hadoop.javax.jdo.option.ConnectionUserName":"connection-user-
name",
                "spark.hadoop.javax.jdo.option.ConnectionPassword":
 "EMR.secret@SecretID"
            }
        },
        {
            "classification": "spark-driver-log4j2",
            "properties": {
                "rootLogger.level":"error",
                "logger.IdentifierForClass.name": "classpathForSettingLogger",
                "logger.IdentifierForClass.level": "info"
            }
        }
    ]' \
    --monitoring-configuration '{
        "s3MonitoringConfiguration": {
            "logUri": "s3://amzn-s3-demo-logging-bucket/logs/app-level"
        },
        "managedPersistenceMonitoringConfiguration": {
            "enabled": false
        }
    }'
```

Overriding configurations during a job run

You can specify configuration overrides for the application configuration and monitoring configuration with the `StartJobRun` API. EMR Serverless then merges the configurations that you specify at the application level and the job level to determine the configurations for the job execution.

The granularity level when the merge occurs is as follows:

- **`ApplicationConfiguration`** - Classification type, for example `spark-defaults`.
- **`MonitoringConfiguration`** - Configuration type, for example `s3MonitoringConfiguration`.

Note

The priority of configurations that you provide at `StartJobRun` supersede the configurations that you provide at the application level.

For more information priority rankings, refer to Hive configuration override parameter and Spark configuration override parameter.

When you start a job, if you don’t specify a particular configuration, it will be inherited from the application. If you declare the configurations at job level, you can perform the following operations:

- **Override an existing configuration** - Provide the same configuration parameter in the `StartJobRun` request with your override values.
- **Add an additional configuration** - Add the new configuration parameter in the `StartJobRun` request with the values that you want to specify.
- **Remove an existing configuration** - To remove an application *runtime configuration*, provide the key for the configuration that you want to remove, and pass an empty declaration `{}` for the configuration. We don't recommend removing any classifications that contain parameters that are required for a job run. For example, if you try to remove the required properties for a Hive job, the job will fail.

  To remove an application *monitoring configuration*, use the appropriate method for the relevant configuration type:

  - **`cloudWatchLoggingConfiguration`** - To remove `cloudWatchLogging`, pass the enabled flag as `false`.
  - **`managedPersistenceMonitoringConfiguration`** - To remove managed persistence settings and fall back to the default enabled state, pass an empty declaration `{}` for the configuration.
  - **`s3MonitoringConfiguration`** - To remove `s3MonitoringConfiguration`, pass an empty declaration `{}` for the configuration.

Example override

The following example shows different operations you can perform during job submission at `start-job-run`.

```
aws emr-serverless start-job-run \
    --application-id your-application-id \
    --execution-role-arn your-job-role-arn \
    --job-driver '{
        "sparkSubmit": {
            "entryPoint": "s3://us-east-1.elasticmapreduce/emr-containers/samples/
wordcount/scripts/wordcount.py",
            "entryPointArguments": ["s3://amzn-s3-demo-destination-bucket1/
wordcount_output"]
        }
    }' \
    --configuration-overrides '{
        "applicationConfiguration": [
            {
                // Override existing configuration for spark-defaults in the
 application
                "classification": "spark-defaults",
                "properties": {
                    "spark.driver.cores": "2",
                    "spark.executor.cores": "1",
                    "spark.driver.memory": "4G",
                    "spark.executor.memory": "4G"
                }
            },
            {
                // Add configuration for spark-executor-log4j2
                "classification": "spark-executor-log4j2",
                "properties": {
                    "rootLogger.level": "error",
                    "logger.IdentifierForClass.name": "classpathForSettingLogger",
                    "logger.IdentifierForClass.level": "info"
                }
            },
            {
                // Remove existing configuration for spark-driver-log4j2 from the
 application
                "classification": "spark-driver-log4j2",
                "properties": {}
            }
        ],
        "monitoringConfiguration": {
            "managedPersistenceMonitoringConfiguration": {
                // Override existing configuration for managed persistence
                "enabled": true
            },
            "s3MonitoringConfiguration": {
                // Remove configuration of S3 monitoring
            },
            "cloudWatchLoggingConfiguration": {
                // Add configuration for CloudWatch logging
                "enabled": true
            }
        }
    }'
```

At the time of job execution, the following classifications and configurations will apply based on the priority override ranking described in Hive configuration override parameter and Spark configuration override parameter.

- The classification `spark-defaults` will be updated with the properties specified at the job level. Only the properties included in `StartJobRun` is considered for this classification.
- The classification `spark-executor-log4j2` will be added in the existing list of classifications.
- The classification `spark-driver-log4j2` will be removed.
- The configurations for `managedPersistenceMonitoringConfiguration` will be updated with configurations at job level.
- The configurations for `s3MonitoringConfiguration` will be removed.
- The configurations for `cloudWatchLoggingConfiguration` will be added to existing monitoring configurations.

Customizing an EMR Serverless image

Starting with Amazon EMR 6.9.0, use custom images to package application dependencies and runtime environments into a single container with Amazon EMR Serverless. This simplifies how you manage workload dependencies and makes your packages more portable. When you customize your EMR Serverless image, it provides the following benefits:

- Installs and configures packages that are optimized to your workloads. These packages are not widely available in the public distribution of Amazon EMR runtime environments.
- Integrates EMR Serverless with current established build, test, and deployment processes within your organization, including local development and testing.

- Applies established security processes, such as image scanning, that meet compliance and governance requirements within your organization.
- Lets you use your own versions of JDK and Python for your applications.

EMR Serverless provides images that use as your base when you create your own images. The base image provides the essential jars, configuration, and libraries for the image to interact with EMR Serverless. You can find the base image in the Amazon ECR Public Gallery. Use the image that matches your application type (Spark or Hive) and release version. For example, if you create an application on Amazon EMR release 6.9.0, use the following images.

Type	Image
Spark	`public.ecr.aws/emr-serverless/spark/emr-6.9.0:latest`
Hive	`public.ecr.aws/emr-serverless/hive/emr-6.9.0:latest`

Prerequisites

Before you create an EMR Serverless custom image, complete these prerequisites.

1. Create an Amazon ECR repository in the same AWS Region that you use to launch EMR Serverless applications. To create an Amazon ECR private repository, refer to Creating a private repository.
2. To grant users access to your Amazon ECR repository, add the following policies to users and roles that create or update EMR Serverless applications with images from this repository.

   JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "ECRRepositoryListGetPolicy",
      "Effect": "Allow",
      "Action": [
        "ecr:GetDownloadUrlForLayer",
        "ecr:BatchGetImage",
        "ecr:DescribeImages"
      ],
      "Resource": [
        "arn:aws:ecr:*:123456789012:repository/my-repo"
      ]
    }
  ]
}
```

For more examples of Amazon ECR identity-based policies, refer to Amazon Elastic Container Registry identity-based policy examples.

Step 1: Create a custom image from EMR Serverless base images

First, create a Dockerfile that begins with a FROM instruction that uses your preferred base image. After the FROM instruction, include any modification that you want to make to the image. The base image automatically sets the USER to hadoop. This setting does not have permissions for all the modifications you include. As a workaround, set the USER to root, modify your image, and then set the USER back to hadoop:hadoop. To refer to samples for common use cases, refer to Using custom images with EMR Serverless.

```
# Dockerfile
FROM public.ecr.aws/emr-serverless/spark/emr-6.9.0:latest

USER root
# MODIFICATIONS GO HERE

# EMRS runs the image as hadoop
USER hadoop:hadoop
```

After you have the Dockerfile, build the image with the following command.

```
# build the docker image
docker build . -t aws-account-id.dkr.ecr.region.amazonaws.com/my-
repository[:tag]or[@digest]
```

Step 2: Validate image locally

EMR Serverless provides an offline tool that can statically check your custom image to validate basic files, environment variables, and correct image configurations. For information on how to install and run the tool, refer to the Amazon EMR Serverless Image CLI GitHub.

After you install the tool, run the following command to validate an image:

```
amazon-emr-serverless-image \
validate-image -r emr-6.9.0 -t spark \
-i aws-account-id.dkr.ecr.region.amazonaws.com/my-repository:tag/@digest
```

The output appears similar to the following.

```
Amazon EMR Serverless - Image CLI
Version: 0.0.1
... Checking if docker cli is installed
... Checking Image Manifest
[INFO] Image ID: 9e2f4359cf5beb466a8a2ed047ab61c9d37786c555655fc122272758f761b41a
[INFO] Created On: 2022-12-02T07:46:42.586249984Z
[INFO] Default User Set to hadoop:hadoop : PASS
[INFO] Working Directory Set to  : PASS
[INFO] Entrypoint Set to /usr/bin/entrypoint.sh : PASS
[INFO] HADOOP_HOME is set with value: /usr/lib/hadoop : PASS
[INFO] HADOOP_LIBEXEC_DIR is set with value: /usr/lib/hadoop/libexec : PASS
[INFO] HADOOP_USER_HOME is set with value: /home/hadoop : PASS
[INFO] HADOOP_YARN_HOME is set with value: /usr/lib/hadoop-yarn : PASS
[INFO] HIVE_HOME is set with value: /usr/lib/hive : PASS
[INFO] JAVA_HOME is set with value: /etc/alternatives/jre : PASS
[INFO] TEZ_HOME is set with value: /usr/lib/tez : PASS
[INFO] YARN_HOME is set with value: /usr/lib/hadoop-yarn : PASS
[INFO] File Structure Test for hadoop-files in /usr/lib/hadoop: PASS
[INFO] File Structure Test for hadoop-jars in /usr/lib/hadoop/lib: PASS
[INFO] File Structure Test for hadoop-yarn-jars in /usr/lib/hadoop-yarn: PASS
[INFO] File Structure Test for hive-bin-files in /usr/bin: PASS
[INFO] File Structure Test for hive-jars in /usr/lib/hive/lib: PASS
[INFO] File Structure Test for java-bin in /etc/alternatives/jre/bin: PASS
[INFO] File Structure Test for tez-jars in /usr/lib/tez: PASS
-----------------------------------------------------------------
Overall Custom Image Validation Succeeded.
-----------------------------------------------------------------
```

Step 3: Upload the image to your Amazon ECR repository

Push your Amazon ECR image to your Amazon ECR repository with the following commands. Ensure you have the correct IAM permissions to push the image to your repository. For more information, refer to Pushing an image in the *Amazon ECR User Guide*.

```
# login to ECR repo
aws ecr get-login-password --region region | docker login --username AWS --password-
stdin aws-account-id.dkr.ecr.region.amazonaws.com

# push the docker image
docker push aws-account-id.dkr.ecr.region.amazonaws.com/my-repository:tag/@digest
```

Step 4: Create or update an application with custom images

Choose the AWS Management Console tab or AWS CLI tab according to how you want to launch your application, then complete the following steps.

Console

1. Sign in to the EMR Studio console at https://console.aws.amazon.com/emr. Navigate to your application, or create a new application with the instructions in Create an application.
2. To specify custom images when you create or update an EMR Serverless application, select **Custom settings** in the application setup options.
3. In the **Custom image settings** section, select the **Use the custom image with this application** check box.
4. Paste the Amazon ECR image URI into the **Image URI** field. EMR Serverless uses this image for all worker types for the application. Alternatively, you can choose **Different custom images** and paste different Amazon ECR image URIs for each worker type.

CLI

- Create an application with the `image-configuration` parameter. EMR Serverless applies this setting to all worker types.

```
aws emr-serverless create-application \
--release-label emr-6.9.0 \
--type SPARK \
--image-configuration '{
    "imageUri": "aws-account-id.dkr.ecr.region.amazonaws.com/my-repository:tag/
@digest"
}'
```

To create an application with different image settings for each worker type, use the `worker-type-specifications` parameter.

```
aws emr-serverless create-application \
--release-label emr-6.9.0 \
--type SPARK \
--worker-type-specifications '{
    "Driver": {
        "imageConfiguration": {
            "imageUri": "aws-account-id.dkr.ecr.region.amazonaws.com/my-
repository:tag/@digest"
        }
    },
    "Executor" : {
        "imageConfiguration": {
            "imageUri": "aws-account-id.dkr.ecr.region.amazonaws.com/my-
repository:tag/@digest"
        }
    }
}'
```

To update an application, use the `image-configuration` parameter. EMR Serverless applies this setting to all worker types.

```
aws emr-serverless update-application \
--application-id application-id \
--image-configuration '{
    "imageUri": "aws-account-id.dkr.ecr.region.amazonaws.com/my-repository:tag/
@digest"
}'
```

Step 5: Allow EMR Serverless to access the custom image repository

Add the following resource policy to the Amazon ECR repository to allow the EMR Serverless service principal to use the `get`, `describe`, and `download` requests from this repository.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "EmrServerlessCustomImageSupport",
      "Effect": "Allow",
      "Action": [
        "ecr:BatchGetImage",
        "ecr:DescribeImages",
        "ecr:GetDownloadUrlForLayer"
      ],
      "Resource": "arn:aws:ecr:*:123456789012:repository/my-repo",
      "Condition": {
        "ArnLike": {
          "aws:SourceArn": "arn:aws:emr-serverless:*:123456789012:/applications/
*"
        }
      }
    }
  ]
}
```

As a security best practice, add an `aws:SourceArn` condition key to the repository policy. The IAM global condition key `aws:SourceArn` ensures that EMR Serverless uses the repository only for an application ARN. For more information on Amazon ECR repository policies, refer to Creating a private repository.

Considerations and limitations

When you work with custom images, consider the following:

- Use the correct base image that matches the type (Spark or Hive) and release label (for example, `emr-6.9.0`) for your application.
- EMR Serverless ignores `[CMD]` or `[ENTRYPOINT]` instructions in the Docker file. Use common instructions in the Docker file, such as `[COPY]`, `[RUN]`, and `[WORKDIR]`.
- Do not modify environment variables `JAVA_HOME`, `SPARK_HOME`, `HIVE_HOME`, `TEZ_HOME` when you create a custom image.

- Custom images can't exceed 10 GB in size.
- If you modify binaries or jars in the Amazon EMR base images, this can cause application or job launch failures.
- The Amazon ECR repository must be in the same AWS Region that you use to launch EMR Serverless applications.

Configuring VPC access for EMR Serverless applications to connect to data

You can configure EMR Serverless applications to connect to your data stores within your VPC, such as Amazon Redshift clusters, Amazon RDS databases or Amazon S3 buckets with VPC endpoints. Your EMR Serverless application has outbound connectivity to the data stores within your VPC. By default, EMR Serverless blocks both inbound access to your applications and outbound internet access to enhance security.

> **Note**
>
> You must configure VPC access if you want to use an external Hive metastore database for your application. For information about how to configure an external Hive metastore, refer to Metastore configuration.

Create application

On the **Create application** page, choose custom settings and specify the VPC, subnets and security groups that EMR Serverless applications can use.

VPCs

Choose the name of the virtual private cloud (VPC) that contains your data stores. The **Create application** page lists all VPCs for your chosen AWS Region.

Subnets

Choose the subnets within the VPC that contains your data store. The **Create application** page lists all subnets for the data stores in your VPC. Both public and private subnets are supported. You can pass either private or public subnets to your applications. The choice of whether to have a public or private subnet has a few associated considerations to be aware of.

For private subnets:

- The associated route tables must not have internet gateways.
- For outbound connectivity to the internet, if needed, configure outbound routes using a NAT Gateway. To configure a NAT Gateway, refer to NAT gateways.
- For Amazon S3 connectivity, configure either a NAT Gateway or a VPC endpoint. To configure an S3 VPC endpoint, refer to Create a gateway endpoint.
- If you configure an S3 VPC endpoint and you attach an endpoint policy to control access, follow the instructions in Logging for EMR Serverless with managed storage to provide permissions for EMR Serverless to store and serve application logs.
- For connectivity to other AWS services outside the VPC, such as to Amazon DynamoDB, configure either VPC endpoints or a NAT gateway. To configure VPC endpoints for AWS services, refer to Work with VPC endpoints.

> **Note**
>
> When you set up an Amazon EMR Serverless application in a private subnet, we suggest that you also set up VPC endpoints for Amazon S3. If your EMR Serverless application is in a private subnet without VPC endpoints for Amazon S3, you incur additional NAT gateway charges that are associated with S3 traffic. This is because the traffic between your EMR application and Amazon S3 will not stay within your VPC when VPC endpoints aren't configured.

For public subnets:

- These have a route to an Internet Gateway.
- You must ensure proper security group configurations to control outbound traffic.

Workers can connect to the data stores within your VPC through outbound traffic. By default, EMR Serverless blocks inbound access to workers. This is to improve security.

When you use AWS Config, EMR Serverless creates an elastic network interface item record for every worker. To avoid costs related to this resource, consider turning off `AWS::EC2::NetworkInterface` in AWS Config.

> **Note**
>
> We suggest that you select multiple subnets across multiple Availability Zones. This is because the subnets that you choose determine the Availability Zones available for an EMR Serverless application to launch. Each worker consumes an IP address on the subnet where it is launched. Please ensure that the specified subnets have sufficient IP addresses for the number of workers you plan to launch. For more information on subnet planning, refer to the section called "Best practices for subnet planning".

Considerations and limitations for subnets

- EMR Serverless with public subnets does not support AWS Lake Formation.
- Inbound traffic isn't supported for public subnets.

Security groups

Choose one or more security groups that can communicate with your data stores. The **Create application** page lists all security groups in your VPC. EMR Serverless associates these security groups with elastic network interfaces that are attached to your VPC subnets.

> **Note**
>
> We suggest that you create a separate security group for EMR Serverless applications. EMR Serverless does not allow you to **Create/Update/Start application** if security groups have ports open to the public internet on **0.0.0.0/0** or the **::/0** range. This provides enhanced security, isolation, and makes managing network rules more efficient. For example, this blocks unexpected traffic to workers with public IP addresses. To communicate with Amazon Redshift clusters, for instance, define the traffic rules between Redshift and EMR Serverless security groups, as demonstrated in the example in the following section.

Example — Communication with Amazon Redshift clusters

1. Add a rule for inbound traffic to the Amazon Redshift security group from one of the EMR Serverless security groups.

Type	Protocol	Port range	Source
All TCP	TCP	5439	`emr-serverless-security-group`

2. Add a rule for outbound traffic from one of the EMR Serverless security groups. Do this in one of two ways. First, open outbound traffic to all ports.

Type	Protocol	Port range	Destination
All traffic	TCP	ALL	0.0.0.0/0

Alternatively, you can restrict outbound traffic to Amazon Redshift clusters. This is useful only when the application must communicate with Amazon Redshift clusters and nothing else.

Type	Protocol	Port range	Source
All TCP	TCP	5439	`redshift-security-group`

Configure application

You can change the network configuration for an existing EMR Serverless application from the **Configure application** page.

Access job run details

On the **Job run detail** page, access the subnet used by your job for a specific run. Note that a job runs only in one subnet selected from the specified subnets.

Best practices for subnet planning

AWS resources are created in a subnet which is a subset of available IP addresses in an Amazon VPC. For example, a VPC with a /16 netmask has up to 65,536 available IP addresses which can be broken into multiple smaller networks using subnet masks. As an example, you can split this range into two subnets with each using /17 mask and 32,768 available IP addresses. A subnet resides within an Availability Zone and cannot span across zones.

The subnets should be designed keeping in mind your EMR Serverless application scaling limits. For example, if you have an application requesting 4 vCpu workers and can scale up to 4,000 vCpu, then your application requires at most 1,000 workers for a total of 1,000 network interfaces. We suggest that you create subnets across multiple Availability Zones. This allows EMR Serverless to retry your job or provision pre-initialized capacity in a different Availability Zone in an unlikely event when an Availability Zone fails. Therefore, each subnet in at least two Availability Zones should have more than 1,000 available IP addresses.

You need subnets with mask size lower than or equal to 22 to provision 1,000 network interfaces. Any mask greater than 22 does not meet the requirement. For example, a subnet mask of /23 provides 512 IP addresses, while a mask of /22 provides 1024 and a mask of /21 provides 2048 IP addresses. Below is an example of 4 subnets with /22 mask in a VPC of /16 netmask that can be allocated to different Availability Zones. There is a difference of five between available and usable IP addresses because first four IP addresses and last IP address in each subnet is reserved by AWS.

Subnet ID	Subnet Address	Subnet Mask	IP Address Range	Available IP Addresses	Usable IP Addresses
1	10.0.0.0	255.255.252.0/22	10.0.0.0 - 10.0.3.255	1,024	1,019
2	10.0.4.0	255.255.252.0/22	10.0.4.0 - 10.0.7.255	1,024	1,019
3	10.0.8.0	255.255.252.0/22	10.0.8.0 - 10.0.11.255	1,024	1,019
4	10.0.12.0	255.255.252.0/22	10.0.12.0 - 10.0.15.255	1,024	1,019

You should evaluate if your workload is best suited for larger worker sizes. Using larger worker sizes requires fewer network interfaces. For example, using 16vCpu workers with an application scaling limit of 4,000 vCpu requires at most 250 workers for a total of 250 available IP addresses to provision network interfaces. You need subnets in multiple Availability Zones with mask size lower than or equal to 24 to provision 250 network interfaces. Any mask size greater than 24 offers less than 250 IP addresses.

If you share subnets across multiple applications, each subnet should be designed keeping in mind collective scaling limits of all your applications. For example, if you have 3 applications requesting 4 vCpu workers and each can scale up to 4000 vCpu with 12,000 vCpu account-level service based quota, each subnet requires 3000 available IP addresses. If the VPC that you want to use doesn't have a sufficient number of IP addresses, try to increase the number of available IP addresses. You can do this by associating additional Classless Inter-Domain Routing (CIDR) blocks with your VPC. For more information, refer to Associate additional IPv4 CIDR blocks with your VPC in the *Amazon VPC User Guide*.

You can use one of the many tools available online to quickly generate subnet definitions and review their available range of IP addresses.

Amazon EMR Serverless architecture options

The instruction set architecture of your Amazon EMR Serverless application determines the type of processors that the application uses to run the job. Amazon EMR provides two architecture options for your application: **x86_64** and **arm64**. EMR Serverless automatically updates to the latest generation of instances as they become available, so your applications can use the newer instances without requiring additional effort from you.

Topics

Using x86_64 architecture

The **x86_64** architecture is also known as x86 64-bit or x64. **x86_64** is the default option for EMR Serverless applications. This architecture uses x86-based processors and is compatible with most third-party tools and libraries.

Most applications are compatible with the x86 hardware platform and can run successfully on the default **x86_64** architecture. However, if your application is compatible with 64-bit ARM, then switch to **arm64** to use Graviton processors for improved performance, compute power, and memory. It costs less to run instances on arm64 architecture than when you run instances of equal size on x86 architecture.

Using arm64 architecture (Graviton)

AWS Graviton processors are custom designed by AWS with 64-bit ARM Neoverse cores and leverage the arm64 architecture (also known as Arch64 or 64-bit ARM). The AWS Graviton line of processors available on EMR Serverless include Graviton3 and Graviton2 processors. These processors deliver superior price-performance for Spark and Hive workloads compared to equivalent workloads that run on the x86_64 architecture. EMR Serverless automatically uses the latest generation of processors when available without any effort from your side to upgrade to the latest generation of processors.

Launching new applications with Graviton support

Use one of the following methods to launch an application that uses the **arm64** architecture.

AWS CLI

To launch an application using Graviton processors from AWS CLI, specify `ARM64` as the `architecture` parameter in the `create-application` API. Provide the appropriate values for your application in the other parameters.

```
aws emr-serverless create-application \
 --name my-graviton-app \
 --release-label emr-6.8.0 \
 --type "SPARK" \
 --architecture "ARM64" \
 --region us-west-2
```

EMR Studio

To launch an application using Graviton processors from EMR Studio, choose **arm64** as the **Architecture** option when you create or update an application.

Configuring existing applications to use Graviton

You can configure your existing Amazon EMR Serverless applications to use the Graviton (arm64) architecture with the SDK, AWS CLI, or EMR Studio.

To convert an existing application from x86 to arm64

1. Confirm that you are using the latest major version of the AWS CLI/SDK that supports the `architecture` parameter.
2. Confirm that there are no jobs running and then stop the application.

```
aws emr-serverless stop-application \
 --application-id application-id \
 --region us-west-2
```

3. To update the application to use Graviton, specify `ARM64` for the `architecture` parameter in the `update-application` API.

```
aws emr-serverless update-application \
 --application-id application-id \
 --architecture 'ARM64' \
 --region us-west-2
```

4. To verify that the CPU architecture of the application is now ARM64, use the `get-application` API.

```
aws emr-serverless get-application \
 --application-id application-id \
 --region us-west-2
```

5. When you're ready, restart the application.

```
aws emr-serverless start-application \
 --application-id application-id \
 --region us-west-2
```

Considerations when using Graviton

Before you launch an EMR Serverless application using arm64 for Graviton support, confirm the following.

Library compatibility

When you select Graviton (arm64) as an architecture option, ensure that third-party packages and libraries are compatible with the 64-bit ARM architecture. For information on how to package Python libraries into a Python virtual environment that is compatible with your selected architecture, refer to Using Python libraries with EMR Serverless.

To learn more, refer to the AWS Graviton Getting Started repository on GitHub. This repository contains essential resources that can help you get started with the ARM-based Graviton.

Job concurrency and queuing for an EMR Serverless application

Starting with Amazon EMR version 7.0.0 and later, specify job run queue timeout and concurrency configuration for your application. When you specify this configuration, Amazon EMR Serverless starts by queuing your job and begins execution based on concurrency utilization on your application. For example, if your job run concurrency is 10, only ten jobs are run at a time on your application. Remaining jobs are queued until one of the running jobs terminates. If queue timeout is reached earlier, your job times out. For more information, refer to Job run states.

Key benefits of concurrency and queuing

Job concurrency and queuing provides the following benefits when many job submissions are required:

- It helps control concurrent executing jobs to efficiently use your application level capacity limits.
- The queue can contain a sudden burst of job submissions, with a configurable timeout setting.

Getting started with concurrency and queuing

The following procedures demonstrate a couple different ways to implement concurrency and queuing.

Using the AWS CLI

1. Create an Amazon EMR Serverless application with queue timeout and concurrent job runs:

   ```
   aws emr-serverless create-application \
   --release-label emr-7.0.0 \
   --type SPARK \
   --scheduler-configuration '{"maxConcurrentRuns": 1, "queueTimeoutMinutes": 30}'
   ```

2. Update an application to change the job queue timeout and concurrency:

   ```
   aws emr-serverless update-application \
   --application-id application-id \
   --scheduler-configuration '{"maxConcurrentRuns": 5, "queueTimeoutMinutes": 30}'
   ```

   > **Note**
   >
   > You can update your existing application to enable job concurrency and queuing. To do this, the application must have a release label *emr-7.0.0* or later.

Using the AWS Management Console

The following steps demonstrate how to get started with job concurrency and queuing, using the AWS Management Console:

1. Go to EMR Studio and choose to create an application with release label EMR-7.0.0 or higher.
2. Under **Application setup options**, select the option **Use custom settings**.
3. Under **Additional configurations** there is a section for **Job Run Settings**. Select the option **Enable job concurrency** to enable the feature.
4. After selection, select **Concurrent job runs** and **Queue timeout** to configure the number of concurrent job runs and queue timeout, respectively. If you do not enter values for these settings, the default values are used.
5. Choose **Create Application** and the application will be created with this feature enabled. To verify, go to the dashboard, select your application and check under properties tab to determine if the feature is enabled.

Following configuration, submit jobs with this feature enabled.

Considerations for concurrency and queuing

Take the following into consideration when you implement concurrency and queuing:

- Job concurrency and queuing is supported on Amazon EMR release 7.0.0 and higher.
- Job concurrency and queuing is enabled by default on Amazon EMR release 7.3.0 and higher.
- You cannot update concurrency for an application in the **STARTED** state.
- The valid range for `maxConcurrentRuns` is 1 to 1000, and for `queueTimeoutMinutes` it is 15 to 720.
- A maximum of 2000 jobs can be in the **QUEUED** state for an account.
- Concurrency and queuing applies to batch and streaming jobs. It cannot be used for interactive jobs. For more information, refer to Run interactive workloads with EMR Serverless through EMR Studio.

Get data into S3 Express One Zone with EMR Serverless

With Amazon EMR releases 7.2.0 and higher, use EMR Serverless with the Amazon S3 Express One Zone storage class for improved performance when you run jobs and workloads. S3 Express One Zone is a a high-performance, single-zone Amazon S3 storage class that delivers consistent, single-digit millisecond data access for most latency-sensitive applications. At the time of its release, S3 Express One Zone delivers the lowest latency and highest performance cloud object storage in Amazon S3.

Prerequisites

- S3 Express One Zone permissions – When S3 Express One Zone initially performs an action like `GET`, `LIST`, or PUT on an S3 object, the storage class calls `CreateSession` on your behalf. Your IAM policy must allow the `s3express:CreateSession` permission so that the S3A connector can invoke the `CreateSession` API. For an example policy with this permission, refer to Getting started with S3 Express One Zone.
- S3A connector – To configure Spark to access data from an Amazon S3 bucket that uses the S3 Express One Zone storage class, use the Apache Hadoop connector S3A. To use the connector, ensure all S3 URIs use the `s3a` scheme. If they don't, change the filesystem implementation that you use for `s3` and `s3n` schemes.

To change the `s3` scheme, specify the following cluster configurations:

```
[
  {
    "Classification": "core-site",
    "Properties": {
      "fs.s3.impl": "org.apache.hadoop.fs.s3a.S3AFileSystem",
      "fs.AbstractFileSystem.s3.impl": "org.apache.hadoop.fs.s3a.S3A"
    }
  }
]
```

To change the `s3n` scheme, specify the following cluster configurations:

```
[
  {
    "Classification": "core-site",
    "Properties": {
      "fs.s3n.impl": "org.apache.hadoop.fs.s3a.S3AFileSystem",
      "fs.AbstractFileSystem.s3n.impl": "org.apache.hadoop.fs.s3a.S3A"
    }
  }
]
```

Getting started with S3 Express One Zone

Follow these steps to get started with S3 Express One Zone.

1. Create a VPC endpoint. Add the endpoint `com.amazonaws.us-west-2.s3express` to the VPC endpoint.
2. Follow Getting started with Amazon EMR Serverless to create an application with Amazon EMR release label 7.2.0 or higher.
3. Configure your application to use the newly created VPC endpoint, a private subnet group, and a security group.
4. Add the `CreateSession` permission to your job execution role.

   JSON

   ```
   {
     "Version":"2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Resource": [
           "*"
         ],
         "Action": [
           "s3express:CreateSession"
         ],
         "Sid": "AllowS3EXPRESSCreatesession"
       }
     ]
   }
   ```

5. Run your job. Note that use the S3A scheme to access S3 Express One Zone buckets.

```
aws emr-serverless start-job-run \
--application-id <application-id> \
--execution-role-arn <job-role-arn> \
--name <job-run-name> \
--job-driver '{
 "sparkSubmit": {


 "entryPoint": "s3a://<DOC-EXAMPLE-BUCKET>/scripts/wordcount.py",
 "entryPointArguments":["s3a://<DOC-EXAMPLE-BUCKET>/emr-serverless-spark/output"],
 "sparkSubmitParameters": "--conf spark.executor.cores=4
 --conf spark.executor.memory=8g --conf spark.driver.cores=4
 --conf spark.driver.memory=8g --conf spark.executor.instances=2
 --conf spark.hadoop.fs.s3a.change.detection.mode=none
 --conf spark.hadoop.fs.s3a.endpoint.region={<AWS_REGION>}
 --conf spark.hadoop.fs.s3a.select.enabled=false
 --conf spark.sql.sources.fastS3PartitionDiscovery.enabled=false
 }'
```

Running jobs

After you provision your application, submit jobs to the application. This section covers how to use the AWS CLI to run these jobs. This section also identifies the default values for each type of application that is available on EMR Serverless.

Topics

Job run states

When you submit a job run to an Amazon EMR Serverless job queue, the job run enters the `SUBMITTED` state. A job state's passes from `SUBMITTED` through `RUNNING` until it reaches `FAILED`, `SUCCESS`, or `CANCELLING`.

Job runs can have the following states:

State	Description
Submitted	The initial job state when you submit a job run to EMR Serverless. The job waits to be scheduled for the application. EMR Serverless begins to prioritize and schedule the job run.
Queued	The job run waits in this state when application level job run concurrency is fully occupied. For more information about queuing and concurrency, refer to Job concurrency and queuing for an EMR Serverless application.
Pending	The scheduler is evaluating the job run to prioritize and schedule the run for the application.
Scheduled	EMR Serverless has scheduled the job run for the application, and is allocating resources to execute the job.
Running	EMR Serverless has allocated the resources that the job initially needs, and the job is running in the application. In Spark applications, this means that the Spark driver process is in the `running` state.
Failed	EMR Serverless failed to submit the job run to the application, or it completed unsuccessfully. Refer to `StateDetails` for additional information about this job failure.
Success	The job run has completed successfully.
Cancelling	The `CancelJobRun` API has requested job run cancellation, or the job run has timed out. EMR Serverless is trying to cancel the job in the application and release the resources.

State	Description
Cancelled	The job run was cancelled successfully, and the resources that it used have been released.

EMR Serverless job run cancellation with grace period

In data processing systems, abrupt terminations can lead to resource waste, incomplete operations, and potential data inconsistencies. Amazon EMR Serverless allows you to specify a grace period when canceling job runs. This feature allows time for proper cleanup and completion of in-progress work before job termination.

When cancelling a job run, specify a grace period (in seconds) using the parameter `shutdownGracePeriodInSeconds` during which the job can perform cleanup operations prior to final termination. The behavior and default settings vary between batch and streaming jobs.

Grace Period For batch jobs

For batch jobs, EMR Serverless allows you to implement custom cleanup operations that execute during the grace period. You can register these cleanup operations as part of the JVM shutdown hook in your application code.

Default behavior

The default behavior for shutdown is to have no grace period. It consists of the following two actions:

- Immediate termination
- Resources are released immediately

Configuration options

You can specify settings that result in graceful shutdown:

- Valid Range for Shutdown Grace period: 15-1800 seconds (optional)
- Immediate termination (without any grace period): 0 second

Enable graceful shutdown

To implement graceful shutdown for batch jobs, follow these steps:

1. Add shutdown hook in your application code containing custom shutdown logic.

   Example in Scala

   ```
   import org.apache.hadoop.util.ShutdownHookManager

   // Register shutdown hook with priority (second argument)
   // Higher priority hooks run first
   ShutdownHookManager.get().addShutdownHook(() => {
       logger.info("Performing cleanup operations...")
   }, 100)
   ```

   Using ShutdownHookManager

   Example in PySpark

   ```
   import atexit

   def cleanup():
       # Your cleanup logic here
       print("Performing cleanup operations...")

   # Register the cleanup function
   atexit.register(cleanup)
   ```

2. Specify a grace period when canceling the job to allow time for the hooks added previously to execute

   Example

   ```
   # Default (immediate termination)
   aws emr-serverless cancel-job-run \
     --application-id APPLICATION_ID \
     --job-run-id JOB_RUN_ID

   # With 5-minute grace period
   aws emr-serverless cancel-job-run \
     --application-id APPLICATION_ID \
     --job-run-id JOB_RUN_ID \
   ```

```
    --shutdown-grace-period-in-seconds 300
```

Grace Period For Streaming Jobs

In Spark Structured Streaming, where computations involve reading from or writing to external data sources, abrupt shutdowns can lead to unwanted results. Streaming jobs process data in micro-batches, and interrupting these operations mid-way can result in duplicate processing in subsequent attempts. This happens when the latest checkpoint from the previous micro-batch was not written, causing the same data to be processed again when the streaming job restarts. Such duplicate processing not only wastes computing resources but can also impact business operations, making it crucial to avoid abrupt shutdowns.

EMR Serverless provides built-in support for graceful shutdown through a streaming query listener. This ensures proper completion of ongoing micro-batches before job termination. The service automatically manages graceful shutdown between micro-batches for streaming applications, ensuring that the current micro-batch completes processing, checkpoints are properly written, and the streaming context is terminated cleanly without ingesting new data during the shutdown process.

Default behavior

- 120-second grace period enabled by default.
- Built-in streaming query listener manages graceful shutdown.

Configuration options

- Valid Range for Shutdown Grace period: 15-1800 seconds (optional)
- Immediate Termination: 0 second

Enable Graceful Shutdown

To implement graceful shutdown for streaming jobs:

Specify a grace period when canceling the job to allow time for the ongoing micro batch to get completed.

Example

```
# Default graceful shutdown (120 seconds)
aws emr-serverless cancel-job-run \
  --application-id APPLICATION_ID \
  --job-run-id JOB_RUN_ID

# Custom grace period (e.g. 300 seconds)
aws emr-serverless cancel-job-run \
  --application-id APPLICATION_ID \
  --job-run-id JOB_RUN_ID \
  --shutdown-grace-period-in-seconds 300

# Immediate Termination
aws emr-serverless cancel-job-run \
  --application-id APPLICATION_ID \
  --job-run-id JOB_RUN_ID \
  --shutdown-grace-period-in-seconds 0
```

Add custom shutdown hooks (optional)

While EMR Serverless manages graceful shutdown by default through its built-in streaming query listener, you can optionally implement custom shutdown logic for individual streaming queries. EMR Serverless registers its graceful shutdown listener with priority 60 (using ShutdownHookManager). Since higher priority hooks run first, you can register your custom cleanup operations with a priority greater than 60 to ensure they execute before EMR Serverless' shutdown process begins.

In order to add a custom hook, refer to the first example in this topic that shows how to add a shutdown hook in your application code. Here, 100 is the priority, which is greater than 60. Hence such a shutdown hook runs first.

> **Note**
>
> Custom shutdown hooks are optional and not required for graceful shutdown functionality, which is handled automatically by EMR Serverless.

Grace Period Charges and Batch Duration

If the default value for grace period (120 seconds) is used:

- If your batch duration is less than 120 seconds, you'll only be charged for the actual time needed to complete the batch.
- If your batch duration exceeds 120 seconds, you'll be charged for the maximum grace period (120 seconds), but the query may not shutdown gracefully as it will be forcefully terminated.

To optimize costs and ensure graceful shutdown:

- For batch durations > 120 seconds: Consider increasing the grace period to match your batch duration
- For batch durations < 120 seconds: No need to adjust the grace period as you'll only be charged for the actual processing time

Considerations

Grace Period Behavior

- The grace period provides time for your registered shutdown hooks to complete.
- Job terminates as soon as the shutdown hook finishes even if it is well before grace period.
- If cleanup operations exceed the grace period, the job will be forcefully terminated.

Service Behavior

- Grace period shutdown is only available for jobs in RUNNING state.
- Subsequent cancel requests during the CANCELLING state are ignored.
- If EMR Serverless fails to initiate grace period shutdown due to internal service errors:
  - The service will retry for up to 2 minutes.
  - If retries are unsuccessful, the job will be forcefully terminated.

Billing

Jobs are billed for the compute resources used until the job completely shuts down, including any time taken during the grace period.

Running jobs from the EMR Studio console

You can submit job runs to EMR Serverless applications and access the jobs from the EMR Studio console. To create or navigate to your EMR Serverless application on the EMR Studio console, follow the instructions in Getting started from the console.

Submit a job

On the **Submit job** page, submit a job to an EMR Serverless application as follows.

Spark

1. In the **Name** field, enter a name for your job run.
2. In the **Runtime role** field, enter the name of the IAM role that your EMR Serverless application can assume for the job run. To learn more about runtime roles, refer to Job runtime roles for Amazon EMR Serverless.
3. In the **Script location** field, enter the Amazon S3 location for the script or JAR that you want to run. For Spark jobs, the script can be a Python (`.py`) file or a JAR (`.jar`) file.
4. If your script location is a JAR file, enter the class name that is the entry point for the job in the **Main class** field.
5. (Optional) Enter values for the remaining fields.

   - **Script arguments** — Enter any arguments that you want to pass to your main JAR or Python script. Your code reads these parameters. Separate each argument in the array by a comma.
   - **Spark properties** — Expand the Spark properties section and enter any Spark configuration parameters in this field.

   > **Note**
   >
   > If you specify Spark driver and executor sizes, take memory overhead into account. Specify memory overhead values in the properties `spark.driver.memoryOverhead` and `spark.executor.memoryOverhead`. Memory overhead has a default value of 10% of container memory, with a minimum of 384 MB. The executor memory and the memory overhead together can't exceed the worker memory. For example, the maximum `spark.executor.memory` on a 30 GB worker must be 27 GB.

   - **Job configuration** — Specify any job configuration in this field. You can use these job configurations to override the default configurations for applications.
   - **Additional settings** — Active or deactivate the AWS Glue Data Catalog as a metastore and modify application log settings. To learn more about metastore configurations, refer to Metastore configuration for EMR Serverless. To learn more about application logging options, refer to Storing logs.
   - **Tags** — Assign custom tags to the application.

6. Choose **Submit job**.

Hive

1. In the **Name** field, enter a name for your job run.
2. In the **Runtime role** field, enter the name of the IAM role that your EMR Serverless application can assume for the job run.
3. In the **Script location** field, enter the Amazon S3 location for the script or JAR that you want to run. For Hive jobs, the script must be a Hive (`.sql`) file.
4. (Optional) Enter values for the remaining fields.

   - **Initialization script location** – Enter the location of the script that initializes tables before the Hive script runs.
   - **Hive properties** – Expand the Hive properties section and enter any Hive configuration parameters in this field.
   - **Job configuration** – Specify any job configuration. You can use these job configurations to override the default configurations for applications. For Hive jobs, `hive.exec.scratchdir` and `hive.metastore.warehouse.dir` are required properties in the `hive-site` configuration.

```
{
    "applicationConfiguration": [
        {
            "classification": "hive-site",
            "configurations": [],
            "properties": {
                "hive.exec.scratchdir": "s3://DOC-EXAMPLE_BUCKET/hive/
scratch",
                "hive.metastore.warehouse.dir": "s3://DOC-EXAMPLE_BUCKET/hive/
warehouse"
```

```
            }
        }
    ],
    "monitoringConfiguration": {}
}
```

    - **Additional settings** — Activate or deactivate the AWS Glue Data Catalog as a metastore and modify application log settings. To learn more about metastore configurations, refer to Metastore configuration for EMR Serverless. To learn more about application logging options, refer to Storing logs.
    - **Tags** — Assign any custom tags to the application.

5. Choose **Submit job**.

Access job runs

From the **Job runs** tab on an application's **Details** page, access job runs and perform the following actions for job runs.

Cancel job — To cancel a job run that is in the `RUNNING` state, choose this option. To learn more about job run transitions, refer to Job run states.

Clone job — To clone a previous job run and resubmit it, choose this option.

Running jobs from the AWS CLI

You can create, describe, and delete individual jobs on the AWS CLI. You can also list all of your jobs to access them at a glance.

To submit a new job, use `start-job-run`. Provide the ID of the application that you want to run, along with job-specific properties. For Spark examples, refer to Using Spark configurations when you run EMR Serverless jobs. For Hive examples, refer to Using Hive configurations when you run EMR Serverless jobs. This command returns your `application-id`, ARN, and new `job-id`.

Each job run has a set timeout duration. If the job run exceeds this duration, EMR Serverless will automatically cancel it. The default timeout is 12 hours. When you start your job run, configure this timeout setting to a value that meets your job requirements. Configure the value with the `executionTimeoutMinutes` property.

```
aws emr-serverless start-job-run \
  --application-id application-id \
  --execution-role-arn job-role-arn \
  --execution-timeout-minutes 15 \
  --job-driver '{
    "hive": {
        "query": "s3://amzn-s3-demo-bucket/scripts/create_table.sql",
        "parameters": "--hiveconf hive.exec.scratchdir=s3://amzn-s3-demo-bucket/
hive/scratch --hiveconf hive.metastore.warehouse.dir=s3://amzn-s3-demo-bucket/hive/
warehouse"
    }
   }' \
  --configuration-overrides '{
    "applicationConfiguration": [{
        "classification": "hive-site",
        "properties": {
            "hive.client.cores": "2",
            "hive.client.memory": "4GIB"
        }
    }]
}'
```

To describe a job, use `get-job-run`. This command returns job-specific configurations and the set capacity for your new job.

```
aws emr-serverless get-job-run \
--job-run-id job-id \
--application-id application-id
```

To list your jobs, use `list-job-runs`. This command returns an abbreviated set of properties that includes job type, state, and other high-level attributes. If you don't want to access all of your jobs, specify the maximum number of jobs you want to access, up to 50. The following example specifies that you want to access your two last job runs.

```
aws emr-serverless list-job-runs \
--max-results 2 \
--application-id application-id
```

To cancel a job, use `cancel-job-run`. Provide the `application-id` and the `job-id` of the job that you want to cancel.

```
aws emr-serverless cancel-job-run \
--job-run-id job-id \
--application-id application-id
```

For more information on how to run jobs from the AWS CLI, refer to the EMR Serverless API Reference.

Execution IAM policy

You can specify an Execution IAM Policy, in addition to an Execution Role, when submitting job runs on EMR Serverless. The resulting permissions assumed by the job run is the intersection of the permissions in the Execution Role and the specified Execution IAM Policy.

Getting Started

Steps to use Execution IAM policy::

Create an `emr-serverless` application or use an existing one and then run the following aws cli to start a job run with an inline IAM policy:

```
aws emr-serverless start-job-run --region us-west-2 \
      --application-id application-id \
      --execution-role-arn execution-role-arn \
      --job-driver job-driver-options \
      --execution-iam-policy '{"policy": "inline-policy"}'
```

CLI command examples

If we have the following policy stored in the `policy.json` file on the machine:

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "s3:GetObject",
        "s3:ListBucket"
      ],
      "Resource": [
        "arn:aws:s3:::my-test-bucket",
        "arn:aws:s3:::my-test-bucket/*"
      ],
      "Sid": "AllowS3Getobject"
    }
  ]
}
```

Then we can start a job with this policy using the following AWS CLI command:

```
aws emr-serverless start-job-run --region us-west-2 \
      --application-id application-id \
      --execution-role-arn execution-role-arn \
      --job-driver job-driver-options
      --execution-iam-policy '{
          "policy": '$(jq -c '. | @json' policy.json)'
      }'
```

You can also use both AWS and Customer managed policies, specifying them through their ARNs:

```
aws emr-serverless start-job-run --region us-west-2 \
      --application-id application-id \
      --execution-role-arn execution-role-arn \
      --job-driver job-driver-options
      --execution-iam-policy '{
          "policyArns": [
          "arn:aws:iam::aws:policy/AmazonS3FullAccess",
          "arn:aws:iam::aws:policy/CloudWatchLogsFullAccess"
          ]
    }'
```

It's possible to specify both an inline IAM policy and managed policy ARNs in the same request as well:

```
aws emr-serverless start-job-run --region us-west-2 \
      --application-id application-id \
      --execution-role-arn execution-role-arn \
      --job-driver job-driver-options
      --execution-iam-policy '{
          "policy": '$(jq -c '. | @json' policy.json)',
          "policyArns": [
          "arn:aws:iam::aws:policy/AmazonS3FullAccess",
          "arn:aws:iam::aws:policy/CloudWatchLogsFullAccess"
          ]
      }'
```

Important Notes

- The `execution-role-policy`'s `policy` field can have a maximum length of 2048 chars.
- The inline IAM policy string specified in the `execution-iam-policy`'s `policy` field has to conform to the json string standard, with no newlines and quotes escaped as in the preceding example.
- A list of up to 10 managed policy ARNs can be specified as a value to the `execution-iam-policy`'s `policyArns` field.
- Managed policy ARNs must be a list of valid AWS or Customer managed policy ARN, when a Customer managed policy ARN is specified, the policy must belong to the same AWS account of the EMR-S JobRun.
- When both inline IAM policy and managed policies are used, the plaintext that you use for the inline and managed policies combined can't exceed 2,048 characters.
- The resulting permissions assumed by the JobRun is the intersection of the permissions in the Execution Role and the specified Execution IAM Policy.

Policy Intersection

The resulting permissions assumed by the job run is the intersection of the permissions in the Execution Role and the specified Execution IAM Policy. Which means any required permission will have to be specified in both places in order for JobRun to work. However, it's possible to specify an additional blanket allow statement in the inline policy for any permissions that you don't intend to update or overwrite.

Example

Given the following execution IAM role policy:

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "s3:*"
      ],
      "Resource": [
        "*"
      ],
      "Sid": "AllowS3"
    },
    {
      "Effect": "Allow",
      "Action": [
        "logs:DescribeLogGroups"
      ],
      "Resource": [
        "arn:aws:logs:us-west-2:123456789012:log-group::log-stream"
      ],
      "Sid": "AllowLOGSDescribeloggroups"
    },
    {
      "Effect": "Allow",
      "Action": [
        "dynamodb:DescribeTable"
      ],
      "Resource": [
        "arn:aws:dynamodb:*:*:table/MyCompany1table"
      ],
      "Sid": "AllowDYNAMODBDescribetable"
    }
  ]
}
```

And the following inline IAM policy:

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "s3:GetObject",
        "s3:ListBucket"
      ],
      "Resource": [
        "arn:aws:s3:::my-test-bucket/tenant1",
        "arn:aws:s3:::my-test-bucket/tenant1/*"
      ],
      "Sid": "AllowS3Getobject"
    },
    {
      "Effect": "Allow",
      "Action": [
        "logs:*",
        "dynamodb:*"
      ],
      "Resource": [
        "*"
      ],
      "Sid": "AllowLOGS"
    }
  ]
}
```

The resulting permissions assumed by the JobRun is::

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "s3:GetObject",
        "s3:ListBucket"
      ],
      "Resource": [
        "arn:aws:s3:::my-test-bucket/tenant1",
        "arn:aws:s3:::my-test-bucket/tenant1/*"
      ],
      "Sid": "AllowS3Getobject"
    },
    {
      "Effect": "Allow",
      "Action": [
        "logs:DescribeLogGroups"
      ],
      "Resource": [
        "arn:aws:logs:us-west-2:123456789012:log-group::log-stream"
      ],
      "Sid": "AllowLOGSDescribeloggroups"
    },
    {
      "Effect": "Allow",
      "Action": [
        "dynamodb:DescribeTable"
      ],
      "Resource": [
        "arn:aws:dynamodb:*:*:table/MyCompany1table"
      ],
      "Sid": "AllowDYNAMODBDescribetable"
    }
  ]
}
```

Using shuffle-optimized disks

With Amazon EMR releases 7.1.0 and higher, use shuffle-optimized disks when you run Apache Spark or Hive jobs to improve performance for I/O-intensive workloads. Compared to standard disks, shuffle-optimized disks provide higher IOPS (I/O operations per second) for faster data movement and reduced latency during shuffle operations. Shuffle-optimized disks let you attach disk sizes of up to 2 TB per worker, so configure the appropriate capacity for your workload requirements.

Key benefits

Shuffle-optimized disks provide the following benefits.

- **High IOPS performance –** shuffle-optimized disks provide higher IOPS than standard disks, leading to more efficient and rapid data shuffling during Spark and Hive jobs and other shuffle-intensive workloads.

- **Larger disk size** – Shuffle-optimized disks support disk sizes from 20GB to 2TB per worker, so choose the appropriate capacity based on your workloads.

Getting started

See the following steps to use shuffle-optimized disks in your workflows.

Spark

1. Create an EMR Serverless release 7.1.0 application with the following command.

```
aws emr-serverless create-application \
  --type "SPARK" \
  --name my-application-name \
  --release-label emr-7.1.0 \
  --region <AWS_REGION>
```

2. Configure your Spark job to include the parameters `spark.emr-serverless.driver.disk.type` and/or `spark.emr-serverless.executor.disk.type` to run with shuffle-optimized disks. You can use either one or both parameters, depending on your use case.

```
aws emr-serverless start-job-run \
    --application-id application-id \
    --execution-role-arn job-role-arn \
    --job-driver '{
        "sparkSubmit": {
            "entryPoint": "/usr/lib/spark/examples/jars/spark-examples.jar",
            "entryPointArguments": ["1"],
            "sparkSubmitParameters": "--class org.apache.spark.examples.SparkPi
            --conf spark.executor.cores=4
            --conf spark.executor.memory=20g
            --conf spark.driver.cores=4
            --conf spark.driver.memory=8g
            --conf spark.executor.instances=1
            --conf spark.emr-serverless.executor.disk.type=shuffle_optimized"
        }
    }'
```

For more information, refer to Spark job properties.

Hive

1. Create an EMR Serverless release 7.1.0 application with the following command.

```
aws emr-serverless create-application \
  --type "HIVE" \
  --name my-application-name \
  --release-label emr-7.1.0 \
  --region <AWS_REGION>
```

2. Configure your Hive job to include the parameters `hive.driver.disk.type` and/or `hive.tez.disk.type` to run with shuffle-optimized disks. You can use either one or both parameters, depending on your use case.

```
aws emr-serverless start-job-run \
    --application-id application-id \
    --execution-role-arn job-role-arn \
    --job-driver '{
        "hive": {
            "query": "s3://<DOC-EXAMPLE-BUCKET>/emr-serverless-hive/query/hive-
query.ql",
            "parameters": "--hiveconf hive.log.explain.output=false"
        }
    }' \
    --configuration-overrides '{
        "applicationConfiguration": [{
            "classification": "hive-site",
            "properties": {
                "hive.exec.scratchdir": "s3://<DOC-EXAMPLE-BUCKET>/emr-
serverless-hive/hive/scratch",
                "hive.metastore.warehouse.dir": "s3://<DOC-EXAMPLE-BUCKET>/emr-
serverless-hive/hive/warehouse",
                "hive.driver.cores": "2",
                "hive.driver.memory": "4g",
                "hive.tez.container.size": "4096",
                "hive.tez.cpu.vcores": "1",
                "hive.driver.disk.type": "shuffle_optimized",
                "hive.tez.disk.type": "shuffle_optimized"
            }
        }]
    }'
```

For more information, Hive job properties.

Configuring an application with pre-initialized capacity

See the following examples to create applications based on Amazon EMR release 7.1.0. These applications have the following properties:

- 5 pre-initialized Spark drivers, each with 2 vCPU, 4 GB of memory, and 50 GB of shuffle-optimized disk.
- 50 pre-initialized executors, each with 4 vCPU, 8 GB of memory, and 500 GB of shuffle-optimized disk.

When this application runs Spark jobs, it first consumes the pre-initialized workers and then scales the on-demand workers up to the maximum capacity of 400 vCPU and 1024 GB of memory. Optionally, you can omit capacity for either `DRIVER` or `EXECUTOR`.

Spark

```
aws emr-serverless create-application \
  --type "SPARK" \
  --name <my-application-name> \
  --release-label emr-7.1.0 \
  --initial-capacity '{
    "DRIVER": {
        "workerCount": 5,
        "workerConfiguration": {
            "cpu": "2vCPU",
            "memory": "4GB",
            "disk": "50GB",
            "diskType": "SHUFFLE_OPTIMIZED"
        }
    },
    "EXECUTOR": {
        "workerCount": 50,
        "workerConfiguration": {
            "cpu": "4vCPU",
            "memory": "8GB",
            "disk": "500GB",
            "diskType": "SHUFFLE_OPTIMIZED"
        }
    }
  }' \
  --maximum-capacity '{
    "cpu": "400vCPU",
    "memory": "1024GB"
  }'
```

Hive

```
aws emr-serverless create-application \
  --type "HIVE" \
  --name <my-application-name> \
  --release-label emr-7.1.0 \
  --initial-capacity '{
    "DRIVER": {
        "workerCount": 5,
        "workerConfiguration": {
            "cpu": "2vCPU",
            "memory": "4GB",
            "disk": "50GB",
            "diskType": "SHUFFLE_OPTIMIZED"
        }
    },
    "EXECUTOR": {
        "workerCount": 50,
        "workerConfiguration": {
            "cpu": "4vCPU",
            "memory": "8GB",
            "disk": "500GB",
            "diskType": "SHUFFLE_OPTIMIZED"
        }
    }
  }' \
  --maximum-capacity '{
    "cpu": "400vCPU",
    "memory": "1024GB"
  }'
```

Using serverless storage for Amazon EMR Serverless

With Amazon EMR releases 7.12 and higher, use serverless storage when you run Apache Spark jobs to eliminate local disk provisioning and reduce data processing costs, and prevent job failures from disk capacity constraints. Serverless storage automatically handles shuffle, disk spill, and disk caching operations for your jobs without requiring capacity configuration and stores intermediate data at no cost. Amazon EMR Serverless stores intermediate data in a fully managed serverless storage that scales automatically based on workload demands and enables Spark to release compute workers immediately when idle, reducing compute costs.

Key benefits

Serverless storage for EMR Serverless provides the following benefits.

- **Zero-configuration storage** – Serverless storage eliminates the need to configure local disk type and size for each application or job. EMR Serverless automatically manages intermediate data operations without capacity planning.
- **Prevents job failures through automatic scaling** – Storage capacity scales automatically based on workload demand, preventing job failures from insufficient disk capacity.
- **Reduced data processing costs** – Serverless storage reduces processing costs through two mechanisms. First, intermediate data storage is provided at no cost—you pay only for compute and memory resources. Second, decoupled storage with Spark's dynamic resource allocation enables Spark to release workers immediately when idle rather than retaining them to preserve intermediate data on local disks. This enables faster scale-out and scale-in per Spark stage, reducing compute costs for jobs where later stages need fewer workers than initial stages.
- **Encrypted storage with job-level isolation** – All intermediate data is encrypted in transit and at rest with strict job-level isolation.
- **Fine-grained access control support** – Serverless storage supports fine-grained access control through AWS Lake Formation integration.

Getting started

See the following steps to use serverless storage for EMR Serverless in your Spark workflows.

1. **Create an EMR Serverless application**

   Create an EMR Serverless release 7.12 (or later) application with serverless storage enabled by setting the spark property `spark.aws.serverlessStorage.enabled` to **true** in the spark-defaults classification.

   ```
   aws emr-serverless create-application \
   ```

```
  --type "SPARK" \
  --name my-application \
  --release-label emr-7.12.0 \
  --runtime-configuration '[{
      "classification": "spark-defaults",
        "properties": {
          "spark.aws.serverlessStorage.enabled": "true"
        }
    }]' \
  --region <AWS_REGION>
```

2. **Start a Spark job**

   Start a job run on your application. Serverless storage for EMR Serverless automatically handles intermediate data operation such as shuffle for your job.

```
aws emr-serverless start-job-run \
  --application-id <application-id> \
  --execution-role-arn <job-role-arn> \
  --job-driver '{
    "sparkSubmit": {
      "entryPoint": "s3://<bucket>/script.py",
      "sparkSubmitParameters": "--conf spark.executor.cores=4
        --conf spark.executor.memory=20g
        --conf spark.driver.cores=4
        --conf spark.driver.memory=8g
        --conf spark.executor.instances=10"
    }
  }'
```

   You can also enable serverless storage for EMR Serverless at the job level even when it is not enabled at the application level. This will launch worker nodes enabled with serverless storage to process your jobs. You can also disable serverless storage for a specific job by setting the same Spark property `spark.aws.serverlessStorage.enabled` to **false**.

```
# Turn on serverless storage for EMR serverless for a specific job
aws emr-serverless start-job-run \
    --application-id <application-id> \
    --execution-role-arn <job-role-arn> \
    --job-driver '{
"sparkSubmit": {
"entryPoint": "/usr/lib/spark/examples/jars/spark-examples.jar",
            "entryPointArguments": ["1"],
            "sparkSubmitParameters": "--class org.apache.spark.examples.SparkPi
            --conf spark.aws.serverlessStorage.enabled": "true"
        }
    }'
```

> **Note**
>
> To continue using traditional local disk provisioning, omit the `spark.aws.serverlessStorage.enabled` configuration or set it to **false**.

Considerations and limitations

- **Release version** – Serverless storage is supported on Amazon EMR release 7.12 and later.
- **Data volume limits** – Each job can read and write up to a total of 200 GB of intermediate data per job run. Jobs exceeding this limit will fail with an error message indicating that serverless storage limit was reached.
- **Job execution timeout** – Serverless storage supports jobs with execution timeouts up to 24 hours. Jobs configured for longer execution timeouts will fail with an error message.
- **Pre-initialized capacity** – Pre-initialized capacity workers do not support serverless storage. When you configure pre-initialized capacity, it will only be utilized by jobs that explicitly disable serverless storage at the job level. Jobs with serverless storage enabled will always provision new workers on demand and will not use any pre-initialized capacity, regardless of the configuration in application level.
- **Workload types** – Serverless storage is not supported for streaming and interactive jobs.
- **Worker configuration** – Serverless storage is not supported for workers with 1 or 2 vCPUs.

Supported AWS Regions

EMR Serverless support serverless storage in the following regions:

- US East (N. Virginia)
- US West (Oregon)
- Europe (Ireland)

Streaming jobs for processing continuously streamed data

A streaming job in EMR Serverless is a job mode that lets you analyze and process streaming data in near real-time. These long-running jobs poll streaming data and continuously process results as data arrives. Streaming jobs are best suited for tasks that require real-time data processing, such as near real-time analytics, fraud detection, and recommendations engines. EMR Serverless streaming jobs provide optimizations, such as built-in job resiliency, real-time monitoring, enhanced log management, and integration with streaming connectors.

The following are some use cases with streaming jobs:

- **Near real-time analytics –** streaming jobs in Amazon EMR Serverless let you process streaming data in near real-time, so you can perform real-time analytics on continuous data streams, such as log data, sensor data, or clickstream data to derive insights and make timely decisions based on the latest information.
- **Fraud detection –** use streaming jobs to run near real-time fraud detection in financial transactions, credit card operations, or online activities when you analyze data streams and identify suspicious patterns or anomalies as they occur.
- **Recommendation engines –** streaming jobs can process user-activity data and update recommendations models. Doing so opens up possibilities for personalized and real-time recommendations based on behaviors and preferences.
- **Social media analytics –** streaming jobs can process social media data, such as tweets, comments, and posts, so organizations can monitor trends, sentiment analysis, and manage brand reputation in near real-time.
- **Internet of Things (IoT) analytics –** streaming jobs can handle and analyze high-velocity streams of data from IoT devices, sensors, and connected machinery, so run anomaly detection, predictive maintenance, and other IoT analytics use cases.
- **Clickstream analysis –** streaming jobs can process and analyze clickstream data from websites or mobile applications. Businesses that use such data can run analytics to learn more about user behavior, personalize user experiences, and optimize marketing campaigns.
- **Log monitoring and analysis –** streaming jobs can also process log data from servers, applications, and network devices. This provides you with anomaly detection, troubleshooting, and system health and performance.

Key benefits

Streaming jobs in EMR Serverless automatically provide *job-resiliency*, which is a combination of the following factors:

- **Auto-retry** – EMR Serverless automatically retries any jobs that failed without any manual input from you.
- **Availability Zone (AZ) resiliency** – EMR Serverless automatically switches streaming jobs to a healthy AZ if the original AZ experiences issues.
- **Log management:**
  - **Log rotation** – for more efficient disk storage management, EMR Serverless periodically rotates logs for long streaming jobs. Doing so prevents log accumulation that might consume all of the disk space.
  - **Log compaction** – helps you efficiently manage and optimize log files in managed-persistence. Compaction also improves the debug experience when you use the managed spark history server.

Supported data sources and data sinks

EMR Serverless works with a number of input data sources and output data sinks:

- Supported input data sources – Amazon Kinesis Data Streams, Amazon Managed Streaming for Apache Kafka, and self-managed Apache Kafka clusters. By default, Amazon EMR releases 7.1.0 and higher include the Amazon Kinesis Data Streams connector, so you don't need to build or download any additional packages.
- Supported output data sinks – AWS Glue Data Catalog tables, Amazon S3, Amazon Redshift, MySQL, PostgreSQL Oracle, Oracle, Microsoft SQL, Apache Iceberg, Delta Lake, and Apache Hudi.

Considerations and limitations

When you use streaming jobs, keep in mind the following considerations and limitations.

- Streaming jobs are supported with Amazon EMR releases 7.1.0 and higher.
- EMR Serverless expects streaming jobs to run for a long time, so you can't set execution timeout to limit the runtime of the job.
- Streaming jobs are only compatible with the Spark engine, which is built on the structured streaming framework.

- EMR Serverless indefinitely retries streaming jobs, and you can't customize the number of maximum attempts. Thrash prevention is automatically included to stop the job retry if the amount of failed attempts has surpassed a threshold set over an hourly window. The default threshold is five failed attempts over one hour. You can configure this threshold to be between 1 and 10 attempts. For more information, refer to Job resiliency.
- Streaming jobs have checkpoints to save runtime state and progress, so EMR Serverless can resume the streaming job from the latest checkpoint. For more information, refer to Recovering from failures with Checkpointing in the Apache Spark documentation.

Getting started streaming jobs

See the following instructions to learn how to get started with streaming jobs.

1. Follow Getting started with Amazon EMR Serverless to create an application. Note that your application must run Amazon EMR release 7.1.0 or higher.
2. Once your application is ready, set the `mode` parameter to `STREAMING` to submit a streaming job, similar to the following AWS CLI example.

```
aws emr-serverless start-job-run \
--application-id <APPPLICATION_ID> \
--execution-role-arn <JOB_EXECUTION_ROLE> \
--mode 'STREAMING' \
--job-driver '{
    "sparkSubmit": {
        "entryPoint": "s3://<streaming script>",
        "entryPointArguments": ["s3://<DOC-EXAMPLE-BUCKET-OUTPUT>/output"],
        "sparkSubmitParameters": "--conf spark.executor.cores=4
            --conf spark.executor.memory=16g
            --conf spark.driver.cores=4
            --conf spark.driver.memory=16g
            --conf spark.executor.instances=3"
    }
}'
```

Supported streaming connectors

Streaming connectors facilitate reading data from a streaming source and can also write data to a streaming sink.

The following are the supported streaming connectors:

Amazon Kinesis Data Streams connector

The Amazon Kinesis Data Streams connector for Apache Spark enables building streaming applications and pipelines that consume data from and write data to Amazon Kinesis Data Streams. The connector supports enhanced fan-out consumption with a dedicated read throughput rate of up to 2MB/second per shard. By default, Amazon EMR Serverless 7.1.0 and higher includes the connector, so you don't need to build or download any additional packages. For more information about the connector, refer to the spark-sql-kinesis-connector page on GitHub.

The following is an example of how to start a job run with the Kinesis Data Streams connector dependency.

```
aws emr-serverless start-job-run \
--application-id <APPLICATION_ID> \
--execution-role-arn <JOB_EXECUTION_ROLE> \
--mode 'STREAMING' \
--job-driver '{
    "sparkSubmit": {
        "entryPoint": "s3://<Kinesis-streaming-script>",
        "entryPointArguments": ["s3://<DOC-EXAMPLE-BUCKET-OUTPUT>/output"],
        "sparkSubmitParameters": "--conf spark.executor.cores=4
                --conf spark.executor.memory=16g
                --conf spark.driver.cores=4
                --conf spark.driver.memory=16g
                --conf spark.executor.instances=3
                --jars /usr/share/aws/kinesis/spark-sql-kinesis/lib/spark-streaming-
sql-kinesis-connector.jar"
    }
}'
```

To connect to Kinesis Data Streams, configure the EMR Serverless application with VPC access and use a VPC endpoint to allow private access. or use a NAT Gateway to get public access. For more information, refer to Configuring VPC access. You must also make sure that your job runtime role has the necessary read and write permissions to access the required data streams. To learn more about how to configure a job runtime role, refer to Job runtime roles for Amazon EMR Serverless. For a full list of all of the required permissions, refer to the spark-sql-kinesis-connector page on GitHub.

Apache Kafka connector

The Apache Kafka connector for Spark structured streaming is an open-source connector from the Spark community and is available in a Maven repository. This connector facilitates Spark structured streaming applications to read data from and write data to self-managed Apache Kafka and Amazon Managed Streaming for Apache Kafka. For more information about the connector, refer to the Structured Streaming + Kafka Integration Guide in the Apache Spark documentation.

The following example demonstrates how to include the Kafka connector in your job run request.

```
aws emr-serverless start-job-run \
--application-id <APPLICATION_ID> \
--execution-role-arn <JOB_EXECUTION_ROLE> \
--mode 'STREAMING' \
--job-driver '{
    "sparkSubmit": {
        "entryPoint": "s3://<Kafka-streaming-script>",
        "entryPointArguments": ["s3://<DOC-EXAMPLE-BUCKET-OUTPUT>/output"],
        "sparkSubmitParameters": "--conf spark.executor.cores=4
                --conf spark.executor.memory=16g
                --conf spark.driver.cores=4
                --conf spark.driver.memory=16g
                --conf spark.executor.instances=3
                --packages org.apache.spark:spark-sql-
kafka-0-10_2.12:<KAFKA_CONNECTOR_VERSION>"
    }
}'
```

The Apache Kafka connector version depends on your EMR Serverless release version and corresponding Spark version. To find the correct Kafka version, see the refer to the Structured Streaming + Kafka Integration Guide.

To use Amazon Managed Streaming for Apache Kafka with IAM authentication, include another dependency to enable the Kafka connector to connect to Amazon MSK with IAM. For more information, refer to the aws-msk-iam-auth repository on GitHub. You must also make sure that the job runtime role has the necessary IAM permissions. The following example demonstrates how to use the connector with IAM authentication.

```
aws emr-serverless start-job-run \
--application-id <APPLICATION_ID> \
--execution-role-arn <JOB_EXECUTION_ROLE> \
--mode 'STREAMING' \
--job-driver '{
    "sparkSubmit": {
        "entryPoint": "s3://<Kafka-streaming-script>",
        "entryPointArguments": ["s3://<DOC-EXAMPLE-BUCKET-OUTPUT>/output"],
        "sparkSubmitParameters": "--conf spark.executor.cores=4
                --conf spark.executor.memory=16g
                --conf spark.driver.cores=4
                --conf spark.driver.memory=16g
                --conf spark.executor.instances=3
                --packages org.apache.spark:spark-sql-
kafka-0-10_2.12:<KAFKA_CONNECTOR_VERSION>,software.amazon.msk:aws-msk-iam-
auth:<MSK_IAM_LIB_VERSION>"
    }
}'
```

To use the Kafka connector and the IAM authentication library from Amazon MSK configure the EMR Serverless application with VPC access. Your subnets must have Internet access and use a NAT Gateway to access the the Maven dependencies. For more information, refer to Configuring VPC access. The subnets must have network connectivity to access the Kafka cluster. This is true regardless of whether your Kafka cluster is self-managed or if you use Amazon Managed Streaming for Apache Kafka.

Streaming job log management

Streaming jobs support log rotation for Spark application logs and event logs, and log compaction for Spark event logs. This helps you manage your resources effectively.

Log rotation

Streaming jobs support log rotation for Spark application logs and event logs. Log rotation prevents long streaming jobs from generating large log files that might take up all of your available disk space. Log rotation helps you save disk storage and prevents job failures because of low disk space. For more information, refer to Rotating logs.

Log compaction

Streaming jobs also support log compaction for Spark event logs whenever managed logging is available. For more details about managed logging, refer to Logging with managed storage. Streaming jobs can run for a long time, and the amount of event data can build up over time and significantly increase log file sizes. The Spark History Server reads and loads these events into memory for the Spark application UI. This process can cause high latencies and costs, especially if event logs stored in Amazon S3 are very large.

Log compaction reduces the event log size, so the Spark History Server does not need to load more than 1 GB of event logs at any time. For more information, refer to Monitoring and Instrumentation in the Apache Spark documentation.

Using Spark configurations when you run EMR Serverless jobs

You can run Spark jobs on an application with the `type` parameter set to `SPARK`. Jobs must be compatible with the Spark version compatible with the Amazon EMR release version. For example, when you run jobs with Amazon EMR release 6.6.0, your job must be compatible with Apache Spark 3.2.0. For information on the application versions for each release, refer to Amazon EMR Serverless release versions.

Spark job parameters

When you use the `StartJobRun` API to run a Spark job, specify the following parameters.

Required parameters

- Spark job runtime role
- Spark job driver parameter
- Spark configuration override parameter
- Spark dynamic resource allocation optimization

Spark job runtime role

Use **`executionRoleArn`** to specify the ARN for the IAM role that your application uses to execute Spark jobs. This role must contain the following permissions:

- Read from S3 buckets or other data sources where your data resides
- Read from S3 buckets or prefixes where your PySpark script or JAR file resides
- Write to S3 buckets where you intend to write your final output
- Write logs to a S3 bucket or prefix that `S3MonitoringConfiguration`specifies
- Access to KMS keys if you use KMS keys to encrypt data in your S3 bucket
- Access to the AWS Glue Data Catalog if you use SparkSQL

If your Spark job reads or writes data to or from other data sources, specify the appropriate permissions in this IAM role. If you don't provide these permissions to the IAM role, the job might fail. For more information, refer to Job runtime roles for Amazon EMR Serverless and Storing logs.

Spark job driver parameter

Use **`jobDriver`** to provide input to the job. The job driver parameter accepts only one value for the job type that you want to run. For a Spark job, the parameter value is `sparkSubmit`. You can use this job type to run Scala, Java, PySpark, and any other supported jobs through Spark submit. Spark jobs have the following parameters:

- **`sparkSubmitParameters`** – These are the additional Spark parameters that you want to send to the job. Use this parameter to override default Spark properties such as driver memory or number of executors, like those defined in the `--conf` or `--class` arguments.
- **`entryPointArguments`** – This is an array of arguments that you want to pass to your main JAR or Python file. You should handle reading these parameters using your entrypoint code. Separate each argument in the array by a comma.
- **`entryPoint`** – This is the reference in Amazon S3 to the main JAR or Python file that you want to run. If you are running a Scala or Java JAR, specify the main entry class in the `SparkSubmitParameters` using the `--class` argument.

For additional information, refer to Launching Applications with spark-submit.

Spark configuration override parameter

Use **`configurationOverrides`** to override monitoring-level and application-level configuration properties. This parameter accepts a JSON object with the following two fields:

- **`monitoringConfiguration`** - Use this field to specify the Amazon S3 URL (`s3MonitoringConfiguration`) where you want the EMR Serverless job to store logs of your Spark job. Make sure you've created this bucket with the same AWS account that hosts your application, and in the same AWS Region where your job is running.
- **`applicationConfiguration`** – To override the default configurations for applications, you can provide a configuration object in this field. You can use a shorthand syntax to provide the configuration, or you can reference the configuration object in a JSON file. Configuration objects consist of a classification, properties, and optional nested configurations. Properties consist of the settings that you want to override in that file. You can specify multiple classifications for multiple applications in a single JSON object.

> **Note**
>
> Available configuration classifications vary by specific EMR Serverless release. For example, classifications for custom Log4j `spark-driver-log4j2` and `spark-executor-log4j2` are only available with releases 6.8.0 and higher.

If you use the same configuration in an application override and in Spark submit parameters, the Spark submit parameters take priority. Configurations rank in priority as follows, from highest to lowest:

- Configuration that EMR Serverless provides when it creates `SparkSession`.
- Configuration that you provide as part of `sparkSubmitParameters` with the `--conf` argument.
- Configuration that you provide as part of your application overrides when you start a job.
- Configuration that you provide as part of your `runtimeConfiguration` when you create an application.
- Optimized configurations that Amazon EMR uses for the release.
- Default open source configurations for the application.

For more information on declaring configurations at the application level, and overriding configurations during job run, refer to [Default application configuration for EMR Serverless](#).

Spark dynamic resource allocation optimization

Use `dynamicAllocationOptimization` to optimize resource usage in EMR Serverless. Setting this property to `true` in your Spark configuration classification indicates to EMR Serverless to optimize executor resource allocation to better align the rate at which Spark requests and cancels executors with the rate at which EMR Serverless creates and releases workers. By doing so, EMR Serverless more optimally reuses workers across stages, resulting in lower cost when running jobs with multiple stages while maintaining the same performance.

This property is available in all Amazon EMR release versions.

The following is a sample configuration classification with `dynamicAllocationOptimization`.

```
[
  {
    "Classification": "spark",
    "Properties": {
      "dynamicAllocationOptimization": "true"
    }
  }
]
```

Consider the following if you're using dynamic allocation optimization:

- This optimization is available for the Spark jobs for which you enabled dynamic resource allocation.
- To achieve the best cost efficiency, we suggest configuration of an upper scaling bound on workers using either the job-level setting `spark.dynamicAllocation.maxExecutors` or the application-level maxium capacity setting based on your workload.
- You might not notice cost improvement in simpler jobs. For example, if your job runs on a small dataset or finishes running in one stage, Spark might not need a larger number of executors or multiple scaling events.
- Jobs with a sequence of a large stage, smaller stages, and then a large stage again might experience regression in job runtime. As EMR Serverless uses resources more efficiently, it might lead to fewer available workers for larger stages, leading to longer runtime.

Spark job properties

The following table lists optional Spark properties and their default values that you can override when you submit a Spark job.

Optional Spark properties and default values

Key	Description	Default value
`spark.archives`	A comma-separated list of archives that Spark extracts into each executor's working directory. Supported file types include `.jar`, `.tar.gz`, `.tgz` and `.zip`. To specify the directory name	`NULL`

Key	Description	Default value
	to extract, add # after the file name that you want to extract. For example, `file.zip#directory` .	
`spark.authenticate`	Option that turns on authentication of Spark's internal connections.	`TRUE`
`spark.driver.cores`	The number of cores that the driver uses.	4
`spark.driver.extraJavaOptions`	Extra Java options for the Spark driver.	`NULL`
`spark.driver.memory`	The amount of memory that the driver uses.	14G
`spark.dynamicAllocation.enabled`	Option that turns on dynamic resource allocation. This option scales up or down the number of executors registere d with the application, based on the workload.	`TRUE`
`spark.dynamicAllocation.executorIdleTimeout`	The length of time that an executor can remain idle before Spark removes it. This only applies if you turn on dynamic allocation.	60s
`spark.dynamicAllocation.initialExecutors`	The initial number of executors to run if you turn on dynamic allocation.	3

Key	Description	Default value
`spark.dynamicAllocation.maxExecutors`	The upper bound for the number of executors if you turn on dynamic allocation.	For 6.10.0 and higher, `infinity` For 6.9.0 and lower, `100`
`spark.dynamicAllocation.minExecutors`	The lower bound for the number of executors if you turn on dynamic allocation.	`0`
`spark.emr-serverless.allocation.batch.size`	The number of containers to request in each cycle of executor allocation. There is a one-second gap between each allocation cycle.	20
`spark.emr-serverless.driver.disk`	The Spark driver disk.	20G
`spark.emr-serverless.driverEnv. [KEY]`	Option that adds environment variables to the Spark driver.	NULL
`spark.emr-serverless.executor.disk`	The Spark executor disk.	20G
`spark.emr-serverless.memoryOverheadFactor`	Sets the memory overhead to add to the driver and executor container memory.	0.1
`spark.emr-serverless.driver.disk.type`	The disk type attached to Spark driver.	Standard
`spark.emr-serverless.executor.disk.type`	The disk type attached to Spark executors.	Standard

Key	Description	Default value
`spark.executor.cores`	The number of cores that each executor uses.	4
`spark.executor.extraJavaOptions`	Extra Java options for the Spark executor.	`NULL`
`spark.executor.instances`	The number of Spark executor containers to allocate.	3
`spark.executor.memory`	The amount of memory that each executor uses.	14G
`spark.executorEnv. *[KEY]*`	Option that adds environment variables to the Spark executors.	`NULL`
`spark.files`	A comma-separated list of files to go in the working directory of each executor. You can access the file paths of these files in the executor with `SparkFiles.get( *fileName*)`.	`NULL`
`spark.hadoop.hive.metastore.client.factory.class`	The Hive metastore implementation class.	`NULL`
`spark.jars`	Additional jars to add to the runtime classpath of the driver and executors.	`NULL`

Key	Description	Default value
spark.network.crypto.enabled	Option that turns on AES-based RPC encryption. This includes the authentication protocol added in Spark 2.2.0.	FALSE
spark.sql.warehouse.dir	The default location for managed databases and tables.	The value of $PWD/spark-warehouse
spark.submit.pyFiles	A comma-separated list of .zip, .egg, or .py files to place in the PYTHONPATH for Python apps.	NULL

The following table lists the default Spark submit parameters.

Default Spark submit parameters

Key	Description	Default value
archives	A comma-separated list of archives that Spark extracts into each executor's working directory.	NULL
class	The application's main class (for Java and Scala apps).	NULL
conf	An arbitrary Spark configuration property.	NULL
driver-cores	The number of cores that the driver uses.	4
driver-memory	The amount of memory that the driver uses.	14G

Key	Description	Default value
`executor-cores`	The number of cores that each executor uses.	4
`executor-memory`	The amount of memory that the executor uses.	14G
`files`	A comma-separated list of files to place in the working directory of each executor. You can access the file paths of these files in the executor with `SparkFiles.get( fileName )`.	`NULL`
`jars`	A comma-separated list of jars to include on the driver and executor classpaths.	`NULL`
`num-executors`	The number of executors to launch.	3
`py-files`	A comma-separated list of `.zip`, `.egg`, or `.py` files to place on the `PYTHONPATH` for Python apps.	`NULL`
`verbose`	Option that turns on additional debug output.	`NULL`

Resource configuration best practices

Configuring driver and executor resources via the StartJobRun API

Note

Spark driver and executor cores and memory properties, if specified, must be directly specified in the StartJobRun API request.

Configuring your resources in this manner ensures that EMR Serverless can allocate the correct resources before running the job. This is in contrast to settings provided in the user script, such as in the .py or .jar file, which are evaluated too late, as driver and executor workers are sometimes pre-provisioned before script execution begins. There are two supported ways to configure these resources during job submission:

Option 1: Use sparkSubmitParameters

```
"jobDriver": {
 "sparkSubmit": {
    "entryPoint": "s3://your-script-path.py",
    "sparkSubmitParameters": "–conf spark.driver.memory=4g \
    –conf spark.driver.cores=2 \
    –conf spark.executor.memory=8g \
    –conf spark.executor.cores=4"
  }
 }
```

Option 2: Use configurationOverrides for the spark-defaults classification

```
"configurationOverrides": {
 "applicationConfiguration": [
 {
 "classification": "spark-defaults",
 "properties": {
     "spark.driver.memory": "4g",
     "spark.driver.cores": "2",
     "spark.executor.memory": "8g",
     "spark.executor.cores": "4"
      }
```

```
    }
  ]
 }
```

Spark examples

The following example shows how to use the `StartJobRun` API to run a Python script. For an end-to-end tutorial that uses this example, refer to Getting started with Amazon EMR Serverless. You can find additional examples of how to run PySpark jobs and add Python dependencies in the EMR Serverless Samples GitHub repository.

```
aws emr-serverless start-job-run \
    --application-id application-id \
    --execution-role-arn job-role-arn \
    --job-driver '{
        "sparkSubmit": {
            "entryPoint": "s3://us-east-1.elasticmapreduce/emr-containers/samples/
wordcount/scripts/wordcount.py",
            "entryPointArguments": ["s3://amzn-s3-demo-destination-bucket/
wordcount_output"],
            "sparkSubmitParameters": "--conf spark.executor.cores=1 --conf
 spark.executor.memory=4g --conf spark.driver.cores=1 --conf spark.driver.memory=4g --
conf spark.executor.instances=1"
        }
    }'
```

The following example shows how to use the `StartJobRun` API to run a Spark JAR.

```
aws emr-serverless start-job-run \
    --application-id application-id \
    --execution-role-arn job-role-arn \
    --job-driver '{
        "sparkSubmit": {
            "entryPoint": "/usr/lib/spark/examples/jars/spark-examples.jar",
            "entryPointArguments": ["1"],
            "sparkSubmitParameters": "--class org.apache.spark.examples.SparkPi --conf
 spark.executor.cores=4 --conf spark.executor.memory=20g --conf spark.driver.cores=4 --
conf spark.driver.memory=8g --conf spark.executor.instances=1"
        }
    }'
```

Using Hive configurations when you run EMR Serverless jobs

You can run Hive jobs on an application with the `type` parameter set to `HIVE`. Jobs must be compatible with the Hive version compatible with the Amazon EMR release version. For example, when you run jobs on an application with Amazon EMR release 6.6.0, your job must be compatible with Apache Hive 3.1.2. For information on the application versions for each release, refer to Amazon EMR Serverless release versions.

Hive job parameters

When you use the `StartJobRun` API to run a Hive job, specify the following parameters.

Required parameters

- Hive job runtime role
- Hive job driver parameter
- Hive configuration override parameter

Hive job runtime role

Use **`executionRoleArn`** to specify the ARN for the IAM role that your application uses to execute Hive jobs. This role must contain the following permissions:

- Read from S3 buckets or other data sources where your data resides
- Read from S3 buckets or prefixes where your Hive query file and init query file reside
- Read and write to S3 buckets where your Hive Scratch directory and Hive Metastore warehouse directory reside
- Write to S3 buckets where you intend to write your final output
- Write logs to an S3 bucket or prefix that `S3MonitoringConfiguration` specifies
- Access to KMS keys if you use KMS keys to encrypt data in your S3 bucket
- Access to the AWS Glue Data Catalog

If your Hive job reads or writes data to or from other data sources, specify the appropriate permissions in this IAM role. If you don't provide these permissions to the IAM role, your job might fail. For more information, refer to Job runtime roles for Amazon EMR Serverless.

Hive job driver parameter

Use **`jobDriver`** to provide input to the job. The job driver parameter accepts only one value for the job type that you want to run. When you specify `hive` as the job type, EMR Serverless passes a Hive query to the `jobDriver` parameter. Hive jobs have the following parameters:

- **`query`** – This is the reference in Amazon S3 to the Hive query file that you want to run.
- **`parameters`** – These are the additional Hive configuration properties that you want to override. To override properties, pass them to this parameter as `--hiveconf` *`property=value`*. To override variables, pass them to this parameter as `--hivevar` *`key=value`*.
- **`initQueryFile`** – This is the init Hive query file. Hive runs this file prior to your query and can use it to initialize tables.

Hive configuration override parameter

Use **`configurationOverrides`** to override monitoring-level and application-level configuration properties. This parameters accepts a JSON object with the following two fields:

- **`monitoringConfiguration`** – Use this field to specify the Amazon S3 URL (`s3MonitoringConfiguration`) where you want the EMR Serverless job to store logs of your Hive job. Make sure that you create this bucket with the same AWS account that hosts your application, and in the same AWS Region where your job is running.
- **`applicationConfiguration`** – You can provide a configuration object in this field to override the default configurations for applications. You can use a shorthand syntax to provide the configuration, or you can reference the configuration object in a JSON file. Configuration objects consist of a classification, properties, and optional nested configurations. Properties consist of the settings that you want to override in that file. You can specify multiple classifications for multiple applications in a single JSON object.

  > **Note**
  >
  > Available configuration classifications vary by specific EMR Serverless release. For example, classifications for custom Log4j `spark-driver-log4j2` and `spark-executor-log4j2` are only available with releases 6.8.0 and higher.

If you pass the same configuration in an application override and in Hive parameters, the Hive parameters take priority. The following list ranks configurations from highest priority to lowest priority.

- Configuration that you provide as part of Hive parameters with `--hiveconf` *`property=value`*.
- Configuration that you provide as part of your application overrides when you start a job.
- Configuration that you provide as part of your `runtimeConfiguration` when you create an application.
- Optimized configurations that Amazon EMR assigns for the release.
- Default open-source configurations for the application.

For more information on declaring configurations at the application level, and overriding configurations during job run, refer to Default application configuration for EMR Serverless.

Hive job properties

The following table lists the mandatory properties that configure when you submit a Hive job.

Mandatory Hive job properties

Setting	Description
`hive.exec.scratchdir`	The Amazon S3 location where EMR Serverles s creates temporary files during the Hive job execution.
`hive.metastore.warehouse.dir`	The Amazon S3 location of databases for managed tables in Hive.

The following table lists the optional Hive properties and their default values that you can override when you submit a Hive job.

Optional Hive properties and default values

Setting	Description	Default value
`fs.s3.customAWSCredentialsProvider`	The AWS Credentials provider you want to use.	com.amazonaws.auth.DefaultAWSCredentialsProviderChain
`fs.s3a.aws.credentials.provider`	The AWS Credentials provider you want to use with a S3A file system.	com.amazonaws.auth.DefaultAWSCredentialsProviderChain
`hive.auto.convert.join`	Option that turns on auto-conversion of common joins into mapjoins, based on the input file size.	TRUE
`hive.auto.convert.join.noconditionaltask`	Option that turns on optimization when Hive converts a common join into a mapjoin based on the input file size.	TRUE
`hive.auto.convert.join.noconditionaltask.size`	A join converts directly to a mapjoin below this size.	Optimal value is calculated based on Tez task memory
`hive.cbo.enable`	Option that turns on cost-based optimizations with the Calcite framework.	TRUE
`hive.cli.tez.session.async`	Option to start a background Tez session while your Hive query compiles. When set to `false`, Tez AM launches after your Hive query compiles.	TRUE
`hive.compute.query.using.stats`	Option that activates Hive to answer certain queries	TRUE

Setting	Description	Default value
	with statistics stored in the metastore. For basic statistics, set `hive.stats.autogather` to `TRUE`. For a more advanced collection of queries, run `analyze table queries`.	
`hive.default.fileformat`	The default file format for `CREATE TABLE` statements. You can explicitly override this if you specify `STORED AS [FORMAT]` in your `CREATE TABLE` command.	`TEXTFILE`
`hive.driver.cores`	The number of cores to use for the Hive driver process.	2
`hive.driver.disk`	The disk size for the Hive driver.	20G
`hive.driver.disk.type`	The disk type for the Hive driver.	Standard
`hive.tez.disk.type`	The disk size for the tez workers.	Standard
`hive.driver.memory`	The amount of memory to use per Hive driver process. The Hive CLI and Tez Application Master share this memory equally with 20% of headroom.	6G

Setting	Description	Default value
`hive.emr-serverless.launch.env.[` *`KEY`*`]`	Option to set the *KEY* environment variable in all Hive-specific processes, such as your Hive driver, Tez AM, and Tez task.	
`hive.exec.dynamic.partition`	Options that turns on dynamic partitions in DML/DDL.	TRUE
`hive.exec.dynamic.partition.mode`	Option that specifies whether you want to use strict mode or non-strict mode. In strict mode, specify at least one static partition in case you accidentally overwrite all partitions. In non-strict mode, all partitions are allowed to be dynamic.	`strict`
`hive.exec.max.dynamic.partitions`	The maximum number of dynamic partitions that Hive creates in total.	1000
`hive.exec.max.dynamic.partitions.pernode`	Maximum number of dynamic partitions that Hive creates in each mapper and reducer node.	100

Setting	Description	Default value
hive.exec.orc.split.strategy	Expects one of the following values: BI, ETL, or HYBRID. This isn't a user-level configuration. BI specifies that you want to spend less time in split generation as opposed to query execution . ETL specifies that you want to spend more time in split generation. HYBRID specifies a choice of the preceding strategies based on heuristics.	HYBRID
hive.exec.reducers.bytes.per.reducer	The size per reducer. The default is 256 MB. If the input size is 1G, the job uses 4 reducers.	256000000
hive.exec.reducers.max	The maximum number of reducers.	256
hive.exec.stagingdir	The name of the directory that stores temporary files that Hive creates inside table locations and in the scratch directory location specified in the hive.exec.scratchdir property.	.hive-staging
hive.fetch.task.conversion	Expects one of the following values: NONE, MINIMAL, or MORE. Hive can convert select queries to a single FETCH task. This minimizes latency.	MORE

Setting	Description	Default value
hive.groupby.position.alias	Option that causes Hive to use a column position alias in GROUP BY statements.	FALSE
hive.input.format	The default input format. Set to HiveInputFormat if you encounter problems with CombineHiveInputFormat .	org.apache.hadoop.hive.ql.io.CombineHiveInputFormat
hive.log.explain.output	Option that turns on explanations of extended output for any query in your Hive log.	FALSE
hive.log.level	The Hive logging level.	INFO
hive.mapred.reduce.tasks.speculative.execution	Option that turns on speculative launch for reducers. Only supported with Amazon EMR 6.10.x and lower.	TRUE
hive.max-task-containers	The maximum number of concurrent containers. The configured mapper memory is multiplied by this value to determine available memory that split computation and task preemption use.	1000
hive.merge.mapfiles	Option that causes small files to merge at the end of a map-only job.	TRUE
hive.merge.size.per.task	The size of merged files at the end of the job.	256000000

Setting	Description	Default value
`hive.merge.tezfiles`	Option that turns on a merge of small files at the end of a Tez DAG.	`FALSE`
`hive.metastore.client.factory.class`	The name of the factory class that produces objects that implement the `IMetaStoreClient` interface.	`com.amazonaws.glue.catalog.metastore.AWSGlueDataCatalogHiveClientFactory`
`hive.metastore.glue.catalogid`	If the AWS Glue Data Catalog acts as a metastore but runs in a different AWS account than the jobs, the ID of the AWS account where the jobs are running.	`NULL`
`hive.metastore.uris`	The thrift URI that the metastore client uses to connect to remote metastore.	`NULL`
`hive.optimize.ppd`	Option that turns on predicate pushdown.	`TRUE`
`hive.optimize.ppd.storage`	Option that turns on predicate pushdown to storage handlers.	`TRUE`
`hive.orderby.position.alias`	Option that causes Hive to use a column position alias in `ORDER BY` statements.	`TRUE`
`hive.prewarm.enabled`	Option that turns on container prewarm for Tez.	`FALSE`
`hive.prewarm.numcontainers`	The number of containers to pre-warm for Tez.	10

Setting	Description	Default value
`hive.stats.autogather`	Option that causes Hive to gather basic statistics automatically during the `INSERT OVERWRITE` command.	`TRUE`
`hive.stats.fetch.column.stats`	Option that turns off the fetch of column statistics from the metastore. A fetch of column statistics can be expensive when the number of columns is high.	`FALSE`
`hive.stats.gather.num.threads`	The number of threads that the `partialscan` and `noscan` analyze commands use for partitioned tables. This only applies to file formats that implement `StatsProvidingRecordReader` (like ORC).	10
`hive.strict.checks.cartesian.product`	Options that turns on strict Cartesian join checks. These checks disallow a Cartesian product (a cross join).	`FALSE`
`hive.strict.checks.type.safety`	Option that turns on strict type safety checks and turns off comparison of `bigint` with both `string` and `double`.	`TRUE`

Setting	Description	Default value
`hive.support.quoted.identifiers`	Expects value of `NONE` or `COLUMN`. `NONE` implies only alphanumeric and underscore characters are valid in identifiers. `COLUMN` implies column names can contain any character.	`COLUMN`
`hive.tez.auto.reducer.parallelism`	Option that turns on the Tez auto-reducer parallelism feature. Hive still estimates data sizes and sets parallelism estimates. Tez samples the output sizes of source vertices and adjusts the estimates at runtime as necessary.	`TRUE`
`hive.tez.container.size`	The amount of memory to use per Tez task process.	6144
`hive.tez.cpu.vcores`	The number of cores to use for each Tez task.	2
`hive.tez.disk.size`	The disk size for each task container.	20G
`hive.tez.input.format`	The input format for splits generation in the Tez AM.	`org.apache.hadoop.hive.ql.io.HiveInputFormat`
`hive.tez.min.partition.factor`	Lower limit of reducers that Tez specifies when you turn on auto-reducer parallelism.	0.25

Setting	Description	Default value
`hive.vectorized.execution.enabled`	Option that turns on vectorized mode of query execution.	`TRUE`
`hive.vectorized.execution.reduce.enabled`	Option that turns on vectorized mode of a query execution's reduce-side.	`TRUE`
`javax.jdo.option.ConnectionDriverName`	The driver class name for a JDBC metastore.	`org.apache.derby.jdbc.EmbeddedDriver`
`javax.jdo.option.ConnectionPassword`	The password associated with a metastore database.	`NULL`
`javax.jdo.option.ConnectionURL`	The JDBC connect string for a JDBC metastore.	`jdbc:derby:;databaseName=metastore_db;create=true`
`javax.jdo.option.ConnectionUserName`	The user name associated with a metastore database.	`NULL`
`mapreduce.input.fileinputformat.split.maxsize`	The maximum size of a split during split computation when your input format is `org.apache.hadoop.hive.ql.io.CombineHiveInputFormat` . A value of 0 indicates no limit.	`0`
`tez.am.dag.cleanup.on.completion`	Option that turns on cleanup of shuffle data when DAG completes.	`TRUE`

Setting	Description	Default value
`tez.am.emr-serverless.launch.env.[ *KEY*]`	Option to set the *KEY* environment variable in the Tez AM process. For Tez AM, this value overrides the `hive.emr-serverless.launch.env.[ *KEY*]` value.	
`tez.am.log.level`	The root logging level that EMR Serverless passes to the Tez app primary.	`INFO`
`tez.am.sleep.time.before.exit.millis`	EMR Serverless should push ATS events after this period of time following AM shutdown request.	`0`
`tez.am.speculation.enabled`	Option that causes speculative launch of slower tasks. This can help reduce job latency when some tasks are running slower due bad or slow machines. Only supported with Amazon EMR 6.10.x and lower.	`FALSE`
`tez.am.task.max.failed.attempts`	The maximum number of attempts that can fail for a particular task before the task fails. This number doesn't count manually terminated attempts.	`3`

Setting	Description	Default value
`tez.am.vertex.cleanup.height`	A distance at which, if all dependent vertices are complete, Tez AM will delete vertex shuffle data. This feature is turned off when the value is 0. Amazon EMR versions 6.8.0 and later support this feature.	0
`tez.client.asynchronous-stop`	Option that causes EMR Serverless to push ATS events before it ends the Hive driver.	`FALSE`
`tez.grouping.max-size`	The upper size limit (in bytes) of a grouped split. This limit prevents excessively large splits.	1073741824
`tez.grouping.min-size`	The lower size limit (in bytes) of a grouped split. This limit prevents too many small splits.	16777216
`tez.runtime.io.sort.mb`	The size of the soft buffer when Tez sorts the output is sorted.	Optimal value is calculated based on Tez task memory
`tez.runtime.unordered.output.buffer.size-mb`	The size of the buffer to use if Tez doesn't write directly to disk.	Optimal value is calculated based on Tez task memory

Setting	Description	Default value
`tez.shuffle-vertex-manager.max-src-fraction`	The fraction of source tasks that must complete before EMR Serverless schedules all tasks for the current vertex (in case of a `ScatterGather` connection). The number of tasks ready for scheduling on the current vertex scales linearly between `min-fraction` and `max-fraction` . This defaults the default value or `tez.shuffle-vertex-manager.min-src-fraction` , whichever is greater.	0.75
`tez.shuffle-vertex-manager.min-src-fraction`	The fraction of source tasks that must complete before EMR Serverless schedules tasks for the current vertex (in case of a `ScatterGather` connection).	0.25
`tez.task.emr-serverless.launch.env.[` *`KEY`*`]`	Option to set the *KEY* environment variable in the Tez task process. For Tez tasks, this value overrides the `hive.emr-serverless.launch.env.[` *`KEY`*`]` value.	
`tez.task.log.level`	The root logging level that EMR Serverless passes to the Tez tasks.	`INFO`

Setting	Description	Default value
`tez.yarn.ats.event.flush.timeout.millis`	The maximum amount of time that AM should wait for events to be flushed before shutting down.	300000

Hive job examples

The following code example shows how to run a Hive query with the `StartJobRun` API.

```
aws emr-serverless start-job-run \
    --application-id application-id \
    --execution-role-arn job-role-arn \
    --job-driver '{
        "hive": {
            "query": "s3://amzn-s3-demo-bucket/emr-serverless-hive/query/hive-
query.ql",
            "parameters": "--hiveconf hive.log.explain.output=false"
        }
    }' \
    --configuration-overrides '{
        "applicationConfiguration": [{
            "classification": "hive-site",
            "properties": {
                "hive.exec.scratchdir": "s3://amzn-s3-demo-bucket/emr-serverless-hive/
hive/scratch",
                "hive.metastore.warehouse.dir": "s3://amzn-s3-demo-bucket/emr-
serverless-hive/hive/warehouse",
                "hive.driver.cores": "2",
                "hive.driver.memory": "4g",
                "hive.tez.container.size": "4096",
                "hive.tez.cpu.vcores": "1"
            }
        }]
    }'
```

You can find additional examples of how to run Hive jobs in the EMR Serverless Samples GitHub repository.

EMR Serverless Job resiliency

EMR Serverless releases 7.1.0 and higher include support for job resiliency, so it automatically retries any failed jobs without any manual input from you. Another benefit of job resiliency is that EMR Serverless moves job runs to different Availability Zone (AZ) should an AZ experience any issues.

To enable job resiliency for a job, set the retry policy for your job. A retry policy makes sure that EMR Serverless automatically restarts a job if it fails at any point. Retry policies are supported for batch and streaming jobs, so customize job resiliency according to your use case. The following table compares the behaviors and differences of job resiliency across batch and streaming jobs.

	Batch jobs	Streaming jobs
Default behavior	Doesn't rerun the job.	Always retries running the job as the application creates checkpoints while running the job.
Retry point	Batch jobs don't have checkpoints, so EMR Serverles s always re-runs the job from the beginning.	Streaming jobs support checkpoints, so configure the streaming query to save runtime state and progress to a checkpoint location in Amazon S3. EMR Serverless resumes the job run from the checkpoint. For more information, refer to Recovering from failures with Checkpointing in the Apache Spark documentation.
Maximum of retry attempts	Allows for a maximum of 10 retries.	Streaming jobs have built-in thrash prevention control, so the application stops retrying jobs if they continue failing after one hour. The default number of retries within one

	Batch jobs	Streaming jobs
		hour is five attempts. You can configure this number of retries to be between 1 or 10. You can't customize the number of maximum attempts. A value of 1 indicates no retries.

When EMR Serverless attempts to rerun a job, it also indexes the job with an attempt number, so track the lifecycle of a job across its attempts.

Use the EMR Serverless API operations or the AWS CLI to change job resiliency or access information related to job resiliency. For more information, refer to the EMR Serverless API guide.

By default, EMR Serverless doesn't rerun batch jobs. To enable retries for batch jobs, configure the `maxAttempts` parameter when starting a batch job run. The `maxAttempts` parameter is applicable only to batch jobs. The default is 1, which means to not rerun the job. Accepted values are 1 to 10, inclusive.

The following example demonstrates how to specify a max number of 10 attempts when starting a job run.

```
aws emr-serverless start-job-run
 --application-id <APPLICATION_ID> \
 --execution-role-arn <JOB_EXECUTION_ROLE> \
 --mode 'BATCH' \
 --retry-policy '{
    "maxAttempts": 10
 }' \
 --job-driver '{
    "sparkSubmit": {
         "entryPoint": "/usr/lib/spark/examples/jars/spark-examples-does-not-
exist.jar",
         "entryPointArguments": ["1"],
         "sparkSubmitParameters": "--class org.apache.spark.examples.SparkPi"
     }
}'
```

EMR Serverless indefinitely retries streaming jobs if they fail. To prevent thrashing because of repeated unrecoverable failures, use the `maxFailedAttemptsPerHour` to configure thrash prevention control for streaming job retries. This parameter lets you specify the maximum number of failed attempts allowed with an hour before EMR Serverless stops retrying. The default is five. Accepted values are 1 to 10, inclusive.

```
aws emr-serverless start-job-run
 --application-id <APPPLICATION_ID> \
 --execution-role-arn <JOB_EXECUTION_ROLE> \
 --mode 'STREAMING' \
 --retry-policy '{
    "maxFailedAttemptsPerHour": 7
 }' \
 --job-driver '{
    "sparkSubmit": {
         "entryPoint": "/usr/lib/spark/examples/jars/spark-examples-does-not-
exist.jar",
         "entryPointArguments": ["1"],
         "sparkSubmitParameters": "--class org.apache.spark.examples.SparkPi"
     }
}'
```

You can also use the other job run API operations get information about jobs. For example, use the `attempt` parameter with the `GetJobRun` operation to get details about a specific job attempt. If you don't include the `attempt` parameter, the operation returns information about the latest attempt.

```
aws emr-serverless get-job-run \
    --job-run-id job-run-id \
    --application-id application-id \
    --attempt 1
```

The `ListJobRunAttempts` operation returns information about all attempts related to a job run.

```
aws emr-serverless list-job-run-attempts \
  --application-id application-id \
  --job-run-id job-run-id
```

The `GetDashboardForJobRun` operation creates and returns a URL that use to access the application UIs for a job run. The `attempt` parameter lets you get a URL for a specific attempt.

If you don't include the `attempt` parameter, the operation returns information about the latest attempt.

```
aws emr-serverless get-dashboard-for-job-run \
    --application-id application-id \
    --job-run-id job-run-id \
    --attempt 1
```

Monitoring a job with a retry policy

Job resiliency support also adds the new event **EMR Serverless job run retry**. EMR Serverless publishes this event on every retry of the job. You can use this notification to track retries of the job. For more information about events, refer to Amazon EventBridge events.

Logging with retry policy

Every time EMR Serverless retries a job, the attempt generates its own set of logs. To ensure that EMR Serverless can successfully deliver these logs to Amazon S3 and Amazon CloudWatch without overwriting any, EMR Serverless adds a prefix to the format of the S3 log path and CloudWatch log stream name to include the attempt number of the job.

The following is an example of what the format looks like.

```
'/applications/<applicationId>/jobs/<jobId>/attempts/<attemptNumber>/'.
```

This format ensures EMR Serverless publishes all of the logs for each attempt of the job to its own designated location in Amazon S3 and CloudWatch. For more details, refer to Storing logs.

> **Note**
>
> EMR Serverless only uses this prefix format with all streaming jobs and any batch jobs that have retry enabled.

Metastore configuration for EMR Serverless

A *Hive metastore* is a centralized location that stores structural information about your tables, including schemas, partition names, and data types. With EMR Serverless, persist this table metadata in a metastore that has access to your jobs.

You have two options for a Hive metastore:

- The AWS Glue Data Catalog
- An external Apache Hive metastore

Using the AWS Glue Data Catalog as a metastore

You can configure your Spark and Hive jobs to use the AWS Glue Data Catalog as its metastore. We recommend this configuration when you require a persistent metastore or a metastore shared by different applications, services, or AWS accounts. For more information about the Data Catalog, refer to Populating the AWS Glue Data Catalog. For information about AWS Glue pricing, refer to AWS Glue pricing.

You can configure your EMR Serverless job to use the AWS Glue Data Catalog either in the same AWS account as your application, or in a different AWS account.

Configure the AWS Glue Data Catalog

To configure the Data Catalog, choose which type of EMR Serverless application that you want to use.

Spark

When you use EMR Studio to run your jobs with EMR Serverless Spark applications, the AWS Glue Data Catalog is the default metastore.

When you use SDKs or AWS CLI, set the `spark.hadoop.hive.metastore.client.factory.class` configuration to `com.amazonaws.glue.catalog.metastore.AWSGlueDataCatalogHiveClientFactory` in the `sparkSubmit` parameters of your job run. The following example shows how to configure the Data Catalog with the AWS CLI.

```
aws emr-serverless start-job-run \
    --application-id application-id \
    --execution-role-arn job-role-arn \
    --job-driver '{
        "sparkSubmit": {
            "entryPoint": "s3://amzn-s3-demo-bucket/code/pyspark/
extreme_weather.py",
            "sparkSubmitParameters": "--conf
 spark.hadoop.hive.metastore.client.factory.class=com.amazonaws.glue.catalog.metastore.AWSGl
 --conf spark.driver.cores=1 --conf spark.driver.memory=3g --conf
 spark.executor.cores=4 --conf spark.executor.memory=3g"
        }
    }'
```

Alternatively, you can set this configuration when you create a new `SparkSession` in your Spark code.

```
from pyspark.sql import SparkSession

spark = (
    SparkSession.builder.appName("SparkSQL")
    .config(
        "spark.hadoop.hive.metastore.client.factory.class",
        "com.amazonaws.glue.catalog.metastore.AWSGlueDataCatalogHiveClientFactory",
    )
    .enableHiveSupport()
    .getOrCreate()
)

# we can query tables with SparkSQL
spark.sql("SHOW TABLES").show()

# we can also them with native Spark
print(spark.catalog.listTables())
```

Hive

For EMR Serverless Hive applications, the Data Catalog is the default metastore. That is, when you run jobs on a EMR Serverless Hive application, Hive records metastore information in the Data Catalog in the same AWS account as your application. You don't need a virtual private cloud (VPC) to use the Data Catalog as your metastore.

To access the Hive metastore tables, add the required AWS Glue policies outlined in Setting up IAM Permissions for AWS Glue.

Configure cross-account access for EMR Serverless and AWS Glue Data Catalog

To set up cross-account access for EMR Serverless, first sign in to the following AWS accounts:

- `AccountA` – An AWS account where you have created an EMR Serverless application.
- `AccountB` – An AWS account that contains a AWS Glue Data Catalog that you want your EMR Serverless job runs to access.

1. Make sure an administrator or other authorized identity in `AccountB` attaches a resource policy to the Data Catalog in `AccountB`. This policy grants `AccountA` specific cross-account permissions to perform operations on resources in the `AccountB` catalog.

   JSON

   ```
   {
     "Version":"2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Action": [
           "glue:GetDatabase",
           "glue:CreateDatabase",
           "glue:GetDataBases",
           "glue:CreateTable",
           "glue:GetTable",
           "glue:UpdateTable",
           "glue:DeleteTable",
           "glue:GetTables",
           "glue:GetPartition",
           "glue:GetPartitions",
           "glue:CreatePartition",
           "glue:BatchCreatePartition",
           "glue:GetUserDefinedFunctions"
         ],
         "Resource": [
           "arn:aws:glue:*:123456789012:catalog"
         ],
         "Sid": "AllowGLUEGetdatabase"
       }
     ]
   }
   ```

2. Add an IAM policy to the EMR Serverless job runtime role in `AccountA` so that role can access Data Catalog resources in `AccountB`.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "glue:GetDatabase",
        "glue:CreateDatabase",
        "glue:GetDataBases",
        "glue:CreateTable",
        "glue:GetTable",
        "glue:UpdateTable",
        "glue:DeleteTable",
        "glue:GetTables",
        "glue:GetPartition",
        "glue:GetPartitions",
        "glue:CreatePartition",
        "glue:BatchCreatePartition",
        "glue:GetUserDefinedFunctions"
      ],
      "Resource": [
        "arn:aws:glue:*:123456789012:catalog"
      ],
      "Sid": "AllowGLUEGetdatabase"
    }
  ]
}
```

3. Start your job run. This step is slightly different depending on `AccountA`'s EMR Serverless application type.

   Spark

   Pass the `spark.hadoop.hive.metastore.glue.catalogid` property in the `sparkSubmitParameters` as shown in the following example. Replace *`AccountB-catalog-id`* with the ID of the Data Catalog in `AccountB`.

```
aws emr-serverless start-job-run \
--application-id "application-id" \
--execution-role-arn "job-role-arn" \
--job-driver '{
    "sparkSubmit": {
        "entryPoint": "s3://amzn-s3-demo-bucket/scripts/test.py",
         "sparkSubmitParameters": "--conf
 spark.hadoop.hive.metastore.client.factory.class=com.amazonaws.glue.catalog.metastore.A
 --conf spark.hadoop.hive.metastore.glue.catalogid=AccountB-catalog-
id --conf spark.executor.cores=1 --conf spark.executor.memory=1g
 --conf spark.driver.cores=1 --conf spark.driver.memory=1g --conf
 spark.executor.instances=1"
    }
  }' \
--configuration-overrides '{
    "monitoringConfiguration": {
    "s3MonitoringConfiguration": {
    "logUri": "s3://amzn-s3-demo-bucket/logs/"
    }
  }
}'
```

Hive

Set the `hive.metastore.glue.catalogid` property in the `hive-site` classification as shown in the following example. Replace *`AccountB-catalog-id`* with the ID of the Data Catalog in `AccountB`.

```
aws emr-serverless start-job-run \
--application-id "application-id" \
--execution-role-arn "job-role-arn" \
--job-driver '{
    "hive": {
    "query": "s3://amzn-s3-demo-bucket/hive/scripts/create_table.sql",
    "parameters": "--hiveconf hive.exec.scratchdir=s3://amzn-s3-demo-bucket/
hive/scratch --hiveconf hive.metastore.warehouse.dir=s3://amzn-s3-demo-bucket/
hive/warehouse"
    }
}' \
--configuration-overrides '{
    "applicationConfiguration": [{
        "classification": "hive-site",
        "properties": {
            "hive.metastore.glue.catalogid": "AccountB-catalog-id"
        }
    }]
}'
```

Considerations when using the AWS Glue Data Catalog

You can add auxiliary JARs with `ADD JAR` in your Hive scripts. For additional considerations, refer to Considerations when using AWS Glue Data Catalog.

Using an external Hive metastore

You can configure your EMR Serverless Spark and Hive jobs to connect to an external Hive metastore, such as Amazon Aurora or Amazon RDS for MySQL. This section describes how to set up an Amazon RDS Hive metastore, configure your VPC, and configure your EMR Serverless jobs to use an external metastore.

Create an external Hive metastore

1. Create an Amazon Virtual Private Cloud (Amazon VPC) with private subnets by following the instructions in Create a VPC.
2. Create your EMR Serverless application with your new Amazon VPC and private subnets. When you configure your EMR Serverless application with a VPC, it first provisions an elastic network interface for each subnet that you specify. It then attaches your specified security group to that network interface. This gives your application access control. For more details about how to set up your VPC, refer to Configuring VPC access for EMR Serverless applications to connect to data.
3. Create a MySQL or Aurora PostgreSQL database in a private subnet in your Amazon VPC. For information about how to create an Amazon RDS database, refer to Creating an Amazon RDS DB instance.
4. Modify the security group of your MySQL or Aurora database to allow JDBC connections from your EMR Serverless security group by following the steps in Modifying an Amazon RDS DB instance. Add a rule for inbound traffic to the RDS security group from one of your EMR Serverless security groups.

Type	Protocol	Port range	Source
All TCP	TCP	3306	`emr-serverless-security-group`

Configure Spark options

Using JDBC

To configure your EMR Serverless Spark application to connect to a Hive metastore based on an Amazon RDS for MySQL or Amazon Aurora MySQL instance, use a JDBC connection. Pass the `mariadb-connector-java.jar` with `--jars` in the `spark-submit` parameters of your job run.

```
aws emr-serverless start-job-run \
  --application-id "application-id" \
  --execution-role-arn "job-role-arn" \
  --job-driver '{
        "sparkSubmit": {
            "entryPoint": "s3://amzn-s3-demo-bucket/scripts/spark-jdbc.py",
            "sparkSubmitParameters": "--jars s3://amzn-s3-demo-bucket/mariadb-
connector-java.jar
            --conf
 spark.hadoop.javax.jdo.option.ConnectionDriverName=org.mariadb.jdbc.Driver
            --conf spark.hadoop.javax.jdo.option.ConnectionUserName=<connection-user-
name>
            --conf spark.hadoop.javax.jdo.option.ConnectionPassword=<connection-
password>
            --conf spark.hadoop.javax.jdo.option.ConnectionURL=<JDBC-Connection-
string>
            --conf spark.driver.cores=2
            --conf spark.executor.memory=10G
            --conf spark.driver.memory=6G
            --conf spark.executor.cores=4"
        }
    }' \
    --configuration-overrides '{
        "monitoringConfiguration": {
        "s3MonitoringConfiguration": {
            "logUri": "s3://amzn-s3-demo-bucket/spark/logs/"
        }
    }
}'
```

The following code example is a Spark entrypoint script that interacts with a Hive metastore on Amazon RDS.

```
from os.path import expanduser, join, abspath
from pyspark.sql import SparkSession
from pyspark.sql import Row
# warehouse_location points to the default location for managed databases and tables
warehouse_location = abspath('spark-warehouse')
spark = SparkSession \
    .builder \
    .config("spark.sql.warehouse.dir", warehouse_location) \
    .enableHiveSupport() \
    .getOrCreate()
spark.sql("SHOW DATABASES").show()
spark.sql("CREATE EXTERNAL TABLE `sampledb`.`sparknyctaxi`(`dispatching_base_num`
 string, `pickup_datetime` string, `dropoff_datetime` string, `pulocationid` bigint,
 `dolocationid` bigint, `sr_flag` bigint) STORED AS PARQUET LOCATION 's3://<s3 prefix>/
nyctaxi_parquet/'")
spark.sql("SELECT count(*) FROM sampledb.sparknyctaxi").show()
spark.stop()
```

Using the thrift service

You can configure your EMR Serverless Hive application to connect to a Hive metastore based on an Amazon RDS for MySQL or Amazon Aurora MySQL instance. To do this, run a thrift server on the primary node of an existing Amazon EMR cluster. This option is ideal if you already have an Amazon EMR cluster with a thrift server that you want to use to simplify your EMR Serverless job configurations.

```
aws emr-serverless start-job-run \
  --application-id "application-id" \
  --execution-role-arn "job-role-arn" \
  --job-driver '{
        "sparkSubmit": {
            "entryPoint": "s3://amzn-s3-demo-bucket/thriftscript.py",
            "sparkSubmitParameters": "--jars s3://amzn-s3-demo-bucket/mariadb-
connector-java.jar
            --conf spark.driver.cores=2
            --conf spark.executor.memory=10G
            --conf spark.driver.memory=6G
            --conf spark.executor.cores=4"
        }
    }' \
    --configuration-overrides '{
        "monitoringConfiguration": {
        "s3MonitoringConfiguration": {
            "logUri": "s3://amzn-s3-demo-bucket/spark/logs/"
        }
    }
}'
```

The following code example is an entrypoint script (`thriftscript.py`) that uses thrift protocol to connect to a Hive metastore. Note that the `hive.metastore.uris` property needs to be set to read from an external Hive metastore.

```
from os.path import expanduser, join, abspath
from pyspark.sql import SparkSession
from pyspark.sql import Row
# warehouse_location points to the default location for managed databases and tables
warehouse_location = abspath('spark-warehouse')
spark = SparkSession \
    .builder \
    .config("spark.sql.warehouse.dir", warehouse_location) \
    .config("hive.metastore.uris","thrift://thrift-server-host:thift-server-port") \
    .enableHiveSupport() \
    .getOrCreate()
spark.sql("SHOW DATABASES").show()
spark.sql("CREATE EXTERNAL TABLE sampledb.`sparknyctaxi`( `dispatching_base_num`
 string, `pickup_datetime` string, `dropoff_datetime` string, `pulocationid` bigint,
 `dolocationid` bigint, `sr_flag` bigint) STORED AS PARQUET LOCATION 's3://<s3 prefix>/
nyctaxi_parquet/'")
spark.sql("SELECT * FROM sampledb.sparknyctaxi").show()
spark.stop()
```

Configure Hive options

Using JDBC

If you want to specify an external Hive database location on either an Amazon RDS MySQL or Amazon Aurora instance, you can override the default metastore configuration.

Note

In Hive, you can perform multiple writes to metastore tables at the same time. If you share metastore information between two jobs, make sure that you don't write to the same metastore table simultaneously unless you write to different partitions of the same metastore table.

Set the following configurations in the `hive-site` classification to activate the external Hive metastore.

```
{
    "classification": "hive-site",
    "properties": {
        "hive.metastore.client.factory.class":
 "org.apache.hadoop.hive.ql.metadata.SessionHiveMetaStoreClientFactory",
        "javax.jdo.option.ConnectionDriverName": "org.mariadb.jdbc.Driver",
        "javax.jdo.option.ConnectionURL": "jdbc:mysql://db-host:db-port/db-name",
        "javax.jdo.option.ConnectionUserName": "username",
        "javax.jdo.option.ConnectionPassword": "password"
    }
}
```

Using a thrift server

You can configure your EMR Serverless Hive application to connect to a Hive metastore based on an Amazon RDS for MySQL or Amazon Aurora MySQLinstance. To do this, run a thrift server on the main node of an existing Amazon EMR cluster. This option is ideal if you already have an Amazon EMR cluster that runs a thrift server and you want to use your EMR Serverless job configurations.

Set the following configurations in the `hive-site` classification so that EMR Serverless can access the remote thrift metastore. Note that you must set the `hive.metastore.uris` property to read from an external Hive metastore.

```
{
    "classification": "hive-site",
    "properties": {
        "hive.metastore.client.factory.class":
 "org.apache.hadoop.hive.ql.metadata.SessionHiveMetaStoreClientFactory",
        "hive.metastore.uris": "thrift://thrift-server-host:thirft-server-port"
    }
}
```

Working with AWS Glue multi-catalog hierarchy on EMR Serverless

You can configure your EMR Serverless applications to work with the AWS Glue multi-catalog hierarchy. The following example shows how to use EMR-S Spark with the AWS Glue multi-catalog hierarchy.

To learn more about multi-catalog hierarchy, refer to Working with a multi-catalog hierarchy in AWS Glue Data Catalog with Spark on Amazon EMR.

Using Redshift Managed Storage (RMS) with Iceberg and AWS Glue Data Catalog

The following demonstrates how to configure Spark for integration with an AWS Glue Data Catalog with Iceberg:

```
aws emr-serverless start-job-run \
    --application-id application-id \
    --execution-role-arn job-role-arn \
    --job-driver '{
        "sparkSubmit": {
            "entryPoint": "s3://amzn-s3-demo-bucket/myscript.py",
            "sparkSubmitParameters": "--conf spark.sql.catalog.nfgac_rms = 
 org.apache.iceberg.spark.SparkCatalog
             --conf spark.sql.catalog.rms.type=glue
             --conf spark.sql.catalog.rms.glue.id=Glue RMS catalog ID
             --conf spark.sql.defaultCatalog=rms
             --conf 
 spark.sql.extensions=org.apache.iceberg.spark.extensions.IcebergSparkSessionExtensions"
        }
    }'
```

A sample query from a table in the catalog, following integration:

```
SELECT * FROM my_rms_schema.my_table
```

Using Redshift Managed Storage (RMS) with Iceberg REST API and AWS Glue Data Catalog

The following demonstrates how to configure Spark to work with Iceberg REST catalog:

```
aws emr-serverless start-job-run \
--application-id application-id \
--execution-role-arn job-role-arn \
--job-driver '{
"sparkSubmit": {
"entryPoint": "s3://amzn-s3-demo-bucket/myscript.py",
    "sparkSubmitParameters": "
    --conf spark.sql.catalog.rms=org.apache.iceberg.spark.SparkCatalog
    --conf spark.sql.catalog.rms.type=rest
    --conf spark.sql.catalog.rms.warehouse=Glue RMS catalog ID
    --conf spark.sql.catalog.rms.uri=Glue endpoint URI/iceberg
    --conf spark.sql.catalog.rms.rest.sigv4-enabled=true
    --conf spark.sql.catalog.rms.rest.signing-name=glue
    --conf
 spark.sql.extensions=org.apache.iceberg.spark.extensions.IcebergSparkSessionExtensions"
    }
  }'
```

A sample query from a table in the catalog:

```
SELECT * FROM my_rms_schema.my_table
```

Considerations when using an external metastore

- You can configure databases that are compatible with MariaDB JDBC as your metastore. Examples of these databases are RDS for MariaDB, MySQL, and Amazon Aurora.
- Metastores aren't auto-initialized. If your metastore isn't initialized with a schema for your Hive version, use the Hive Schema Tool.
- EMR Serverless doesn't support Kerberos authentication. You can't use a thrift metastore server with Kerberos authentication with EMR Serverless Spark or Hive jobs.
- You must configure VPC access to use the multi-catalog hierarchy.

Accessing S3 data in another AWS account from EMR Serverless

You can run Amazon EMR Serverless jobs from one AWS account and configure them to access data in Amazon S3 buckets that belong to another AWS account. This page describes how to configure cross-account access to S3 from EMR Serverless.

Jobs that run on EMR Serverless can use an S3 bucket policy or an assumed role to access data in Amazon S3 from a different AWS account.

Prerequisites

To set up cross-account access for Amazon EMR Serverless, complete tasks while signed in to two AWS accounts:

- **`AccountA`** – This is the AWS account where you have created an Amazon EMR Serverless application. Before you set up cross-account access, have the following ready in this account:
  - An Amazon EMR Serverless application where you want to run jobs.
  - A job execution role that has the required permissions to run jobs in the application. For more information, refer to Job runtime roles for Amazon EMR Serverless.
- **`AccountB`** – This is the AWS account that contains the S3 bucket that you want your Amazon EMR Serverless jobs to access.

Use an S3 bucket policy to access cross-account S3 data

To access the S3 bucket in account B from account A, attach the following policy to the S3 bucket in account B.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "ExamplePermissions1",
      "Effect": "Allow",
      "Action": [
        "s3:ListBucket"
      ],
      "Resource": [
        "arn:aws:s3:::my-bucket-name"
      ]
    },
    {
      "Sid": "ExamplePermissions2",
      "Effect": "Allow",
      "Action": [
        "s3:PutObject",
        "s3:GetObject",
        "s3:DeleteObject"
      ],
      "Resource": [
        "arn:aws:s3:::my-bucket-name/*"
      ]
    }
  ]
}
```

For more information about S3 cross-account access with S3 bucket policies, refer to Example 2: Bucket owner granting cross-account bucket permissions in the *Amazon Simple Storage Service User Guide*.

Use an assumed role to access cross-account S3 data

Another way to set up cross-account access for Amazon EMR Serverless is with the `AssumeRole` action from the AWS Security Token Service (AWS STS). AWS STS is a global web service that lets you request temporary, limited-privilege credentials for users. You can make API calls to EMR Serverless and Amazon S3 with the temporary security credentials that you create with `AssumeRole`.

The following steps illustrate how to use an assumed role to access cross-account S3 data from EMR Serverless:

1. Create an Amazon S3 bucket, *`cross-account-bucket`*, in `AccountB`. For more information, refer to Creating a bucket in the *Amazon Simple Storage Service User Guide*. If you want to have cross-account access to DynamoDB, also create a DynamoDB table in `AccountB`. For more information, refer to Creating a DynamoDB table in the *Amazon DynamoDB Developer Guide*.
2. Create a `Cross-Account-Role-B` IAM role in `AccountB` that can access the *`cross-account-bucket`*.
   a. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.
   b. Choose **Roles** and create a new role: `Cross-Account-Role-B`. For more information about how to create IAM roles, refer to Creating IAM roles in the IAM User Guide.

c. Create an IAM policy that specifies the permissions for `Cross-Account-Role-B` to access the *`cross-account-bucket`* S3 bucket, as the following policy statement demonstrates. Then attach the IAM policy to `Cross-Account-Role-B`. For more information, refer to Creating IAM policies in the *IAM User Guide*.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "s3:*"
      ],
      "Resource": [
        "arn:aws:s3:::cross-account-bucket",
        "arn:aws:s3:::cross-account-bucket/*"
      ],
      "Sid": "AllowS3"
    }
  ]
}
```

If you require DynamoDB access, create an IAM policy that specifies permissions to access the cross-account DynamoDB table. Then attach the IAM policy to `Cross-Account-Role-B`. For more information, refer to Amazon DynamoDB: Allows access to a specific table in the *IAM User Guide*.

The following is a policy to allow access to the DynamoDB table `CrossAccountTable`.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "dynamodb:*"
      ],
      "Resource": [
        "arn:aws:dynamodb:*:123456789012:table/CrossAccountTable"
      ],
      "Sid": "AllowDYNAMODB"
    }
  ]
}
```

3. Edit the trust relationship for the `Cross-Account-Role-B` role.

    a. To configure the trust relationship for the role, choose the **Trust Relationships** tab in the IAM console for the role `Cross-Account-Role-B` that you created in Step 2.

    b. Select **Edit Trust Relationship**.

    c. Add the following policy document. This allows `Job-Execution-Role-A` in `AccountA` to assume the `Cross-Account-Role-B` role.

    JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "sts:AssumeRole"
      ],
      "Resource": "arn:aws:iam::123456789012:role/Job-Execution-Role-A",
      "Sid": "AllowSTSAssumerole"
    }
  ]
}
```

4. Grant `Job-Execution-Role-A` in `AccountA` the AWS STS `AssumeRole` permission to assume `Cross-Account-Role-B`.

    a. In the IAM console for AWS account `AccountA`, select `Job-Execution-Role-A`.

    b. Add the following policy statement to the `Job-Execution-Role-A` to allow the `AssumeRole` action on the `Cross-Account-Role-B` role.

    JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "sts:AssumeRole"
      ],
      "Resource": [
        "arn:aws:iam::123456789012:role/Cross-Account-Role-B"
      ],
      "Sid": "AllowSTSAssumerole"
    }
  ]
}
```

Assumed role examples

Use a single assumed role to access all S3 resources in an account, or with Amazon EMR 6.11 and higher, configure multiple IAM roles to assume when you access different cross-account S3 buckets.

Topics

Access S3 resources with one assumed role

> **Note**
>
> When you configure a job to use a single assumed role, all S3 resources throughout the job use that role, including the `entryPoint` script.

If you want to use a single assumed role to access all S3 resources in account B, specify the following configurations:

1. Specify EMRFS configuration `fs.s3.customAWSCredentialsProvider` to `com.amazonaws.emr.AssumeRoleAWSCredentialsProvider`.
2. For Spark, use `spark.emr-serverless.driverEnv.ASSUME_ROLE_CREDENTIALS_ROLE_ARN` and

spark.executorEnv.ASSUME_ROLE_CREDENTIALS_ROLE_ARN to specify the environment variables on driver and executors.

3. For Hive, use hive.emr-serverless.launch.env.ASSUME_ROLE_CREDENTIALS_ROLE_ARN, tez.am.emr-serverless.launch.env.ASSUME_ROLE_CREDENTIALS_ROLE_ARN, and tez.task.emr-serverless.launch.env.ASSUME_ROLE_CREDENTIALS_ROLE_ARN to specify the environment variables on Hive driver, Tez application primary, and Tez task containers.

The following examples demonstrate how to use an assumed role to start an EMR Serverless job run with cross-account access.

Spark

The following example shows how to use an assumed role to start an EMR Serverless Spark job run with cross-account access to S3.

```
aws emr-serverless start-job-run \
    --application-id application-id \
    --execution-role-arn job-role-arn \
    --job-driver '{
        "sparkSubmit": {
            "entryPoint": "entrypoint_location",
            "entryPointArguments": [":argument_1:", ":argument_2:"],
            "sparkSubmitParameters": "--conf spark.executor.cores=4 --conf
 spark.executor.memory=20g --conf spark.driver.cores=4 --conf spark.driver.memory=8g
 --conf spark.executor.instances=1"
        }
    }' \
     --configuration-overrides '{
        "applicationConfiguration": [{
            "classification": "spark-defaults",
            "properties": {
                "spark.hadoop.fs.s3.customAWSCredentialsProvider":
 "com.amazonaws.emr.AssumeRoleAWSCredentialsProvider",
                "spark.emr-serverless.driverEnv.ASSUME_ROLE_CREDENTIALS_ROLE_ARN":
 "arn:aws:iam::AccountB:role/Cross-Account-Role-B",
                "spark.executorEnv.ASSUME_ROLE_CREDENTIALS_ROLE_ARN":
 "arn:aws:iam::AccountB:role/Cross-Account-Role-B"
            }
        }]
    }'
```

Hive

The following example shows how to use an assumed role to start an EMR Serverless Hive job run with cross-account access to S3.

```
aws emr-serverless start-job-run \
    --application-id application-id \
    --execution-role-arn job-role-arn \
    --job-driver '{
        "hive": {
            "query": "query_location",
            "parameters": "hive_parameters"
        }
    }' \
    --configuration-overrides '{
        "applicationConfiguration": [{
            "classification": "hive-site",
            "properties": {
                "fs.s3.customAWSCredentialsProvider":
 "com.amazonaws.emr.serverless.credentialsprovider.AssumeRoleAWSCredentialsProvider",
                "hive.emr-serverless.launch.env.ASSUME_ROLE_CREDENTIALS_ROLE_ARN":
 "arn:aws:iam::AccountB:role/Cross-Account-Role-B",
                "tez.am.emr-serverless.launch.env.ASSUME_ROLE_CREDENTIALS_ROLE_ARN":
 "arn:aws:iam::AccountB:role/Cross-Account-Role-B",
                "tez.task.emr-
serverless.launch.env.ASSUME_ROLE_CREDENTIALS_ROLE_ARN":
 "arn:aws:iam::AccountB:role/Cross-Account-Role-B"
            }
        }]
    }'
```

Access S3 resources with multiple assumed roles

With EMR Serverless releases 6.11.0 and higher, configure multiple IAM roles to assume when you access different cross-account buckets. If you want to access different S3 resources with different assumed roles in account B, use following configurations when you start the job run:

1. Specify EMRFS configuration `fs.s3.customAWSCredentialsProvider` to `com.amazonaws.emr.serverless.credentialsprovider.BucketLevelAssumeRoleCredenti`

2. Specify EMRFS configuration `fs.s3.bucketLevelAssumeRoleMapping` to define the mapping from S3 bucket name to the IAM role in account B to assume. The value should be in format of `bucket1->role1;bucket2->role2`.

For example, use `arn:aws:iam::`*`AccountB`*`:role/Cross-Account-Role-B-1` to access bucket `bucket1`, and use `arn:aws:iam::`*`AccountB`*`:role/Cross-Account-Role-B-2` to access bucket `bucket2`. The following examples demonstrate how to start an EMR Serverless job run with cross-account access through multiple assumed roles.

Spark

The following example shows how to use multiple assumed roles to create an EMR Serverless Spark job run.

```
aws emr-serverless start-job-run \
    --application-id application-id \
    --execution-role-arn job-role-arn \
    --job-driver '{
        "sparkSubmit": {
            "entryPoint": "entrypoint_location",
            "entryPointArguments": [":argument_1:", ":argument_2:"],
            "sparkSubmitParameters": "--conf spark.executor.cores=4 --conf
 spark.executor.memory=20g --conf spark.driver.cores=4 --conf spark.driver.memory=8g
 --conf spark.executor.instances=1"
        }
    }' \
     --configuration-overrides '{
        "applicationConfiguration": [{
            "classification": "spark-defaults",
            "properties": {
                "spark.hadoop.fs.s3.customAWSCredentialsProvider":
 "com.amazonaws.emr.serverless.credentialsprovider.BucketLevelAssumeRoleCredentialsProvider",
                "spark.hadoop.fs.s3.bucketLevelAssumeRoleMapping":
 "bucket1->arn:aws:iam::AccountB:role/Cross-Account-Role-B-1;bucket2-
>arn:aws:iam::AccountB:role/Cross-Account-Role-B-2"
            }
        }]
    }'
```

Hive

The following examples demonstrate how to use multiple assumed roles to create an EMR Serverless Hive job run.

```
aws emr-serverless start-job-run \
    --application-id application-id \
    --execution-role-arn job-role-arn \
    --job-driver '{
        "hive": {
            "query": "query_location",
            "parameters": "hive_parameters"
        }
    }' \
    --configuration-overrides '{
        "applicationConfiguration": [{
            "classification": "hive-site",
            "properties": {
                "fs.s3.customAWSCredentialsProvider":
 "com.amazonaws.emr.serverless.credentialsprovider.AssumeRoleAWSCredentialsProvider",
                "fs.s3.bucketLevelAssumeRoleMapping": "bucket1-
>arn:aws:iam::AccountB:role/Cross-Account-Role-B-1;bucket2-
>arn:aws:iam::AccountB:role/Cross-Account-Role-B-2"
            }
        }]
    }'
```

Troubleshooting errors in EMR Serverless

Use the following information to help diagnose and fix common issues that occur when working with Amazon EMR Serverless.

Topics

- Error: S3 access is denied. Please check S3 access permissions of the job runtime role on the required S3 resources.
- Error: ModuleNotFoundError: No module named <module>. Please refer to the user guide on how to use python libraries with EMR Serverless.
- Error: Could not assume execution role <role name> because it does not exist or is not set up with the required trust relationship.

Error: Job failed as account has reached the service limit on the maximum vCPU it can use concurrently.

This error indicates that EMR Serverless couldn't submit the job as the account has exceeded the maximum capacity. Increase the maximum capacity for the account. Check your service limits at EMR Serverless service quotas.

Error: Job failed as application has exceeded maximumCapacity settings.

This error indicates that EMR Serverless couldn't submit the job as the application has exceeded the configured maximum capacity. Increase the maximum capacity for the application.

Error: Job failed due to Worker could not be allocated as the application has exceeded maximumCapacity.

This error indicates that the job couldn't complete. Workers couldn't be allocated because the application has exceeded maximumCapacity settings.

Error: S3 access is denied. Please check S3 access permissions of the job runtime role on the required S3 resources.

This error indicates that your job doesn't have access to your S3 resources. Verify that the job runtime role has permission to access the S3 resources that the job needs to use. To learn more about runtime roles, refer to Job runtime roles for Amazon EMR Serverless.

Error: ModuleNotFoundError: No module named <module>. Please refer to the user guide on how to use python libraries with EMR Serverless.

This error indicates that a Python module wasn't available for the Spark job. Check that the dependent Python libraries are available to the job. For more information on how to package Python libraries, refer to Using Python libraries with EMR Serverless.

Error: Could not assume execution role <role name> because it does not exist or is not set up with the required trust relationship.

This error indicates that the job runtime role that you specified for the job doesn't exist, or that the role doesn't have a trust relationship for EMR Serverless permissions. To verify that the IAM role exists and validate that you have set up the role’s trust policy properly, see the instructions in Job runtime roles for Amazon EMR Serverless.

Enabling Job Level Cost Allocation

Job level cost allocation enables granular billing attribution for EMR Serverless at the individual job run level, rather than aggregating all costs at the application level. When enabled, you can filter and track costs in AWS Cost Explorer and Cost and Usage Reports by specific job run IDs and tags associated with job runs, providing better visibility into charges for job runs submitted.

Default behavior

Job-level cost allocation is not enabled by default.

How to enable or disable the feature

You can configure job-level cost allocation during application creation or update it for existing applications.

Specify the `jobLevelCostAllocation` parameter when creating a new application:

```
# Enable job-level cost allocation:
aws emr-serverless create-application \
    --name "my-application" \
    --release-label "emr-7.12.0" \
    --type "SPARK" \
    --job-level-cost-allocation-configuration '{
        "enabled": true
    }'

# Disable job-level cost allocation:
aws emr-serverless create-application \
    --name "my-application" \
    --release-label "emr-7.12.0" \
    --type "SPARK" \
    --job-level-cost-allocation-configuration '{
        "enabled": false
    }'
```

Update the `jobLevelCostAllocationConfiguration` parameter for an existing application:

```
# Enable job-level cost allocation:
aws emr-serverless update-application \
    --application-id <application-id> \
    --job-level-cost-allocation-configuration '{
        "enabled": true
    }'

# Disable job-level cost allocation:
aws emr-serverless update-application \
    --application-id <application-id> \
    --job-level-cost-allocation-configuration '{
        "enabled": false
    }'
```

Considerations and Limitations

- Enabling job-level cost allocation does not retroactively attribute costs for job runs that completed before the feature was enabled. Job runs started after enabling the feature will have granular cost attribution.
- Job-level cost allocation parameter can only be updated when an Application is in either CREATED or STOPPED state.
- When job-level cost allocation is enabled, costs are attributed to individual job runs rather than the application. To view aggregated costs at the application level, you must apply consistent tags (such as application-name or application-id) to all job runs within that application and filter by those tags in Cost Explorer or Cost and Usage Reports.

Run interactive workloads with EMR Serverless through EMR Studio

With EMR Serverless interactive applications, run interactive workloads for Spark with EMR Serverless using notebooks that are hosted in EMR Studio.

Overview

An *interactive application* is an EMR Serverless application that has interactive capabilities enabled. With Amazon EMR Serverless interactive applications, you can execute interactive workloads with Jupyter notebooks that are managed in Amazon EMR Studio. This helps data engineers, data scientists, and data analysts use EMR Studio to run interactive analytics with datasets in data stores such as Amazon S3 and Amazon DynamoDB.

Use cases for interactive applications in EMR Serverless include the following:

- Data engineers use the IDE experience in EMR Studio to create an ETL script. The script ingests data from on-premises, transforms the data for analysis, and stores the data in Amazon S3.
- Data scientists use notebooks to explore datasets and train machine-learning (ML) models to detect anomalies in the datasets.
- Data analysts explore datasets and create scripts that generate daily reports to update applications like business dashboards.

Prerequisites

To use interactive workloads with EMR Serverless, meet the following requirements:

- EMR Serverless interactive applications are supported with Amazon EMR 6.14.0 and higher.
- To access your interactive application, execute the workloads that you submit, and run interactive notebooks from EMR Studio, you need specific permissions and roles. For more information, refer to Required permissions for interactive workloads.

Required permissions for interactive workloads

In addition to the basic permissions that are required to access EMR Serverless, configure additional permissions for your IAM identity or role:

To access your interactive application

Set up user and Workspace permissions for EMR Studio. For more information, refer to Configure EMR Studio user permissions in the *Amazon EMR Management Guide*.

To execute the workloads that you submit with EMR Serverless

Set up a job runtime role. For more information, refer to Create a job runtime role.

To run the interactive notebooks from EMR Studio

Add the following additional permissions to the IAM policy for the Studio users:

- **`emr-serverless:AccessInteractiveEndpoints`** - Grants permission to access and connect to the interactive application that you specify as `Resource`. This permission is required to attach to an EMR Serverless application from an EMR Studio Workspace.
- **`iam:PassRole`** - Grants permission to access the IAM execution role that you plan to use when you attach to an application. The appropriate `PassRole`permission is required to attach to an EMR Serverless application from an EMR Studio Workspace.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "EMRServerlessInteractiveAccess",
      "Effect": "Allow",
      "Action": [
        "emr-serverless:AccessInteractiveEndpoints"
      ],
      "Resource": [
        "arn:aws:emr-serverless:*:123456789012:/applications/*"
      ]
    },
    {
      "Sid": "EMRServerlessRuntimeRoleAccess",
      "Effect": "Allow",
      "Action": [
        "iam:PassRole"
      ],
      "Resource": [
        "arn:aws:iam::123456789012:role/EMRServerlessInteractiveRole"
      ],
      "Condition": {
        "StringLike": {
          "iam:PassedToService": "emr-serverless.amazonaws.com"
        }
      }
    }
  ]
}
```

Configuring interactive applications

Use the following high-level steps to create an EMR Serverless application with interactive capabilities from Amazon EMR Studio in the AWS Management Console.

1. Follow the steps in Getting started with Amazon EMR Serverless to create an application.
2. Then, launch a workspace from EMR Studio and attach to an EMR Serverless application as a compute option. For more information, refer to the **Interactive workload** tab in Step 2 of the EMR Serverless Getting Started documentation.

When you attach an application to a Studio Workspace, the application start triggers automatically if it's not already running. You can also pre-start the application and keep it ready before you attach it to the Workspace.

Considerations with interactive applications

- EMR Serverless interactive applications are supported with Amazon EMR 6.14.0 and higher.
- EMR Studio is the only client that is integrated with EMR Serverless interactive applications. The following EMR Studio capabilities aren't supported with EMR Serverless interactive applications: Workspace collaboration, SQL Explorer, and programmatic execution of notebooks.
- Interactive applications are only supported for Spark engine.
- Interactive applications support Python 3, PySpark and Spark Scala kernels.
- You can run up to 25 concurrent notebooks on a single interactive application.

- There isn't an endpoint or API interface that supports self-hosted Jupyter notebooks with interactive applications.
- For an optimized startup experience, we suggest that you configure pre-initialized capacity for drivers and executors, and that you pre-start your application. When you pre-start the application, you ensure that it's ready when you want to attach it to your Workspace.

  ```
  aws emr-serverless start-application \
  --application-id your-application-id
  ```

- By default, `autoStopConfig` is enabled for applications. This shuts down the application after 30 minutes of idle time. You can change this configuration as part of your `create-application` or `update-application` request.
- When using an interactive application, we suggest that you configure a pre-intialized capacity of kernels, drivers, and executors to run your notebooks. Each Spark interactive session requires one kernel and one driver, so EMR Serverless maintains a pre-initialized kernel worker for every pre-initialized driver. By default, EMR Serverless maintains a pre-initialized capacity of one kernel worker throughout the entire application even if you don't specify any pre-initialized capacity for drivers. Each kernel worker uses 4 vCPU and 16 GB of memory. For current pricing information, refer to the Amazon EMR Pricing page.
- You must have sufficient vCPU service quota in your AWS account to run interactive workloads. If you don't run Lake Formation-enabled workloads, we suggest at least 24 vCPU. If you do, we suggest at least 28 vCPU.
- EMR Serverless automatically terminates the kernels from the notebooks if they have been idle for more than 60 minutes. EMR Serverless calculates the kernel idle time from the last activity completed during the notebook session. You can't currently modify the kernel idle timeout setting.
- To enable Lake Formation with interactive workloads, set the configuration `spark.emr-serverless.lakeformation.enabled` to `true` under the `spark-defaults` classification in the `runtime-configuration` object when you create an EMR Serverless application. To learn more, refer to Enabling Lake Formation in Amazon EMR.

Run interactive workloads with EMR Serverless through an Apache Livy endpoint

With Amazon EMR releases 6.14.0 and higher, create and enable an Apache Livy endpoint when creating an EMR Serverless application and run interactive workloads through your self-hosted notebooks or with a custom client. An Apache Livy endpoint offers the following benefits:

- You can securely connect to an Apache Livy endpoint through Jupyter notebooks and manage Apache Spark workloads with Apache Livy's REST interface.
- Use the Apache Livy REST API operations for interactive web applications that use data from Apache Spark workloads.

Prerequisites

To use an Apache Livy endpoint with EMR Serverless, meet the following requirements:

- Complete the steps in Getting started with Amazon EMR Serverless.
- To run interactive workloads through Apache Livy endpoints, you need certain permissions and roles. For more information, refer to Required permissions for interactive workloads.

Required permissions

In addition to the required permissions to access EMR Serverless, also add the following permissions to your IAM role to access an Apache Livy endpoint and run applications:

- `emr-serverless:AccessLivyEndpoints` – grants permission to access and connect to the Livy-enabled application that you specify as `Resource`. You need this permission to run the REST API operations available from the Apache Livy endpoint.
- `iam:PassRole` – grants permission to access the IAM execution role when creating the Apache Livy session. EMR Serverless will use this role to execute your workloads.
- `emr-serverless:GetDashboardForJobRun` – grants permission to generate the Spark Live UI and driver log links and provides access to the logs as part of the Apache Livy session results.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "EMRServerlessInteractiveAccess",
      "Effect": "Allow",
      "Action": [
        "emr-serverless:AccessLivyEndpoints"
      ],
      "Resource": [
        "arn:aws:emr-serverless:*:123456789012:/applications/*"
      ]
    },
    {
      "Sid": "EMRServerlessRuntimeRoleAccess",
      "Effect": "Allow",
      "Action": [
        "iam:PassRole"
      ],
      "Resource": [
        "arn:aws:iam::123456789012:role/EMRServerlessExecutionRole"
      ],
      "Condition": {
        "StringLike": {
          "iam:PassedToService": "emr-serverless.amazonaws.com"
        }
      }
    },
    {
      "Sid": "EMRServerlessDashboardAccess",
      "Effect": "Allow",
      "Action": [
        "emr-serverless:GetDashboardForJobRun"
      ],
      "Resource": [
        "arn:aws:emr-serverless:*:123456789012:/applications/*"
      ]
    }
  ]
}
```

Getting started

To create an Apache Livy-enabled application and run it, follow these steps.

1. To create an Apache Livy-enabled application, run the following command.

   ```
    aws emr-serverless create-application \
   --name my-application-name \
   --type 'application-type' \
    --release-label <Amazon EMR-release-version>
   --interactive-configuration '{"livyEndpointEnabled": true}'
   ```

2. After EMR Serverless creates your application, start the application to make the Apache Livy endpoint available.

   ```
    aws emr-serverless start-application \
    --application-id application-id
   ```

   Use the following command to check whether the status of your application. Once the status becomes STARTED, access the Apache Livy endpoint.

   ```
   aws emr-serverless get-application \
   --region <AWS_REGION> --application-id >application_id>
   ```

3. Use the following URL to access the endpoint:

   ```
   https://_<application-id>_.livy.emr-serverless-
   services._<AWS_REGION>_.amazonaws.com
   ```

Once the endpoint is ready, submit workloads based on your use case. You must sign every request to the endpoint with the SIGv4 protocol and pass in an authorization header. You can use the following methods to run workloads:

- HTTP client – submit your Apache Livy endpoint API operations with a custom HTTP client.
- Sparkmagic kernel – run the sparkmagic kernel locally and submit interactive queries with Jupyter notebooks.

HTTP clients

To create an Apache Livy session, submit `emr-serverless.session.executionRoleArn` in the `conf` parameter of your request body. The following example is a sample `POST /sessions` request.

```
{
    "kind": "pyspark",
    "heartbeatTimeoutInSecond": 60,
    "conf": {
        "emr-serverless.session.executionRoleArn": "<executionRoleArn>"
    }
}
```

The following table describes all of the available Apache Livy API operations.

API operation	Description
GET /sessions	Returns a list of all of the active interactive sessions.
POST /sessions	Creates a new interactive session via spark or pyspark.
GET /sessions/<*sessionId* >	Returns the session information.
GET /sessions/<*sessionId* >/state	Returns the state of session.
DELETE /sessions/<*sessionId* >	Stops and deletes the session.
GET /sessions/<*sessionId* >/statements	Returns all the statements in a session.
POST /sessions/<*sessionId* >/statements	Runs a statement in a session.
GET /sessions/<*sessionId* >/statements/<*statementId* >	Returns the details of the specified statement in a session.
POST /sessions/<*sessionId* >/statements/<*statementId* >/cancel	Cancels the specified statement in this session.

Sending requests to the Apache Livy endpoint

You can also send requests directly to the Apache Livy endpoint from an HTTP client. Doing so lets you remotely run code for your use cases outside of a notebook.

Before you start sending requests to the endpoint, make sure that you've installed the following libraries:

```
pip3 install botocore awscrt requests
```

The following is a sample Python script to send HTTP requests directly to an endpoint:

```
from botocore import crt
import requests
from botocore.awsrequest import AWSRequest
from botocore.credentials import Credentials
import botocore.session
import json, pprint, textwrap

endpoint = 'https://<application_id>.livy.emr-serverless-
services.<AWS_REGION>.amazonaws.com'
headers = {'Content-Type': 'application/json'}

session = botocore.session.Session()
signer = crt.auth.CrtS3SigV4Auth(session.get_credentials(), 'emr-serverless',
 '<AWS_REGION>')


### Create session request

data = {'kind': 'pyspark', 'heartbeatTimeoutInSecond': 60, 'conf': { 'emr-
serverless.session.executionRoleArn': 'arn:aws:iam::123456789012:role/role1'}}

request = AWSRequest(method='POST', url=endpoint + "/sessions", data=json.dumps(data),
 headers=headers)

request.context["payload_signing_enabled"] = False

signer.add_auth(request)

prepped = request.prepare()

r = requests.post(prepped.url, headers=prepped.headers, data=json.dumps(data))
```

```
pprint.pprint(r.json())


### List Sessions Request

request = AWSRequest(method='GET', url=endpoint + "/sessions", headers=headers)

request.context["payload_signing_enabled"] = False

signer.add_auth(request)

prepped = request.prepare()

r2 = requests.get(prepped.url, headers=prepped.headers)
pprint.pprint(r2.json())


### Get session state

session_url = endpoint + r.headers['location']

request = AWSRequest(method='GET', url=session_url, headers=headers)

request.context["payload_signing_enabled"] = False

signer.add_auth(request)

prepped = request.prepare()

r3 = requests.get(prepped.url, headers=prepped.headers)

pprint.pprint(r3.json())


### Submit Statement

data = {
      'code': "1 + 1"
}

statements_url = endpoint + r.headers['location'] + "/statements"
```

```
request = AWSRequest(method='POST', url=statements_url, data=json.dumps(data),
 headers=headers)

request.context["payload_signing_enabled"] = False

signer.add_auth(request)

prepped = request.prepare()

r4 = requests.post(prepped.url, headers=prepped.headers, data=json.dumps(data))

pprint.pprint(r4.json())

### Check statements results

specific_statement_url = endpoint + r4.headers['location']

request = AWSRequest(method='GET', url=specific_statement_url, headers=headers)

request.context["payload_signing_enabled"] = False

signer.add_auth(request)

prepped = request.prepare()

r5 = requests.get(prepped.url, headers=prepped.headers)

pprint.pprint(r5.json())


### Delete session


session_url = endpoint + r.headers['location']

request = AWSRequest(method='DELETE', url=session_url, headers=headers)

request.context["payload_signing_enabled"] = False

signer.add_auth(request)

prepped = request.prepare()

r6 = requests.delete(prepped.url, headers=prepped.headers)
```

```
pprint.pprint(r6.json())
```

Sparkmagic kernel

Before you install sparkmagic, make sure that you have configured AWS credentials in the instance in which you want to install sparkmagic

1. Install sparkmagic by following the installation steps. Note that you only perform the first four steps.
2. The sparkmagic kernel supports custom authenticators, so you can integrate an authenticator with the sparkmagic kernel so that every request is SIGv4 signed.
3. Install the EMR Serverless custom authenticator.

   ```
   pip install emr-serverless-customauth
   ```

4. Now provide the path to the custom authenticator and the Apache Livy endpoint URL in the sparkmagic configuration json file. Use the following command to open the configuration file.

   ```
   vim ~/.sparkmagic/config.json
   ```

   The following is a sample `config.json` file.

   ```
   {
   "kernel_python_credentials" : {
       "username": "",
       "password": "",
       "url": "https://<application-id>.livy.emr-serverless-
   services.<AWS_REGION>.amazonaws.com",
       "auth": "Custom_Auth"
     },

     "kernel_scala_credentials" : {
       "username": "",
       "password": "",
       "url": "https://<application-id>.livy.emr-serverless-
   services.<AWS_REGION>.amazonaws.com",
       "auth": "Custom_Auth"
     },
     "authenticators": {
   ```

```
    "None": "sparkmagic.auth.customauth.Authenticator",
    "Basic_Access": "sparkmagic.auth.basic.Basic",
    "Custom_Auth":
 "emr_serverless_customauth.customauthenticator.EMRServerlessCustomSigV4Signer"
  },
  "livy_session_startup_timeout_seconds": 600,
  "ignore_ssl_errors": false
}
```

5. Start Jupyter lab. It should use the custom authentication that you set up in the last step.
6. You can then run the following notebook commands and your code to get started.

```
%%info //Returns the information about the current sessions.
```

```
%%configure -f //Configure information specific to a session. We supply
 executionRoleArn in this example. Change it for your use case.
{
    "driverMemory": "4g",
    "conf": {
          "emr-serverless.session.executionRoleArn":
 "arn:aws:iam::123456789012:role/JobExecutionRole"
    }
}
```

```
<your code>//Run your code to start the session
```

Internally, each instruction calls each of the Apache Livy API operations through the configured Apache Livy endpoint URL. You can then write your instructions according to your use case.

Considerations

Consider the following considerations when running interactive workloads through Apache Livy endpoints.

- EMR Serverless maintains session-level isolation using the caller principal. The caller principal that creates the session is the only one that can access that session. For more granular isolation, configure a source identity when you assume credentials. In this case, EMR Serverless enforces session-level isolation based on the caller principal and the source identity. For more information about source identity, refer to Monitor and control actions taken with assumed roles.

- Apache Livy endpoints are supported with EMR Serverless releases 6.14.0 and higher.
- Apache Livy endpoints are supported only for the Apache Spark engine.
- Apache Livy endpoints support Scala Spark and PySpark.
- By default, `autoStopConfig` is enabled in your applications. This means that applications shut down after 15 minutes of being idle. You can change this configuration as part of your `create-application` or `update-application` request.
- You can run up to 25 concurrent sessions on a single Apache Livy endpoint-enabled application.
- For the best startup experience, we suggest that you configure pre-initialized capacity for drivers and executors.
- You must manually start your application before connecting to the Apache Livy endpoint.
- You must have sufficient vCPU service quota in your AWS account to run interactive workloads with the Apache Livy endpoint. We suggest at least 24 vCPU.
- The default Apache Livy session timeout is 1 hour. If you don't run statements for one hour, then Apache Livy deletes the session and releases the driver and executors. From release emr-7.8.0, this value can be set by specifying the `ttl` parameter as part of Livy `/sessions POST` request, for example, `2h`(hours), `120m`(minutes), `7200s`(seconds), `7200000ms`(milliseconds).

> **Note**
>
> This configuration cannot be changed prior to emr-7.8.0. The following is a sample of a `POST /sessions` request body.

```
{
    "kind": "pyspark",
    "heartbeatTimeoutInSecond": 60,
    "conf": {
        "emr-serverless.session.executionRoleArn": "executionRoleArn"
    },
    "ttl": "2h"
}
```

- Starting with Amazon EMR release emr-7.8.0 for Applications with fine-grained access control via LakeFormation enabled, the setting can be disabled per session. For more information on enabling fine grained access control for an EMR Serverless application, refer to Methods for fine-grained access control.

> **Note**
>
> Lake Formation cannot be enabled for a Session when it has not been enabled for an Application. The following is a sample of a `POST /sessions` request body.

```
{
    "kind": "pyspark",
    "heartbeatTimeoutInSecond": 60,
    "conf": {
        "emr-serverless.session.executionRoleArn": "executionRoleArn"
    },
    "spark.emr-serverless.lakeformation.enabled" : "false"
}
```

- Only active sessions can interact with an Apache Livy endpoint. Once the session finishes, cancels, or terminates, you can't access it through the Apache Livy endpoint.

Logging and monitoring

Monitoring is an important part of maintaining the reliability, availability, and performance of EMR Serverless applications and jobs. You should collect monitoring data from all of the parts of your EMR Serverless solutions so that multipoint failures can be debugged more easily if they occur.

Topics

Storing logs

To monitor your job progress on EMR Serverless and troubleshoot job failures, choose how EMR Serverless stores and serves application logs. When you submit a job run, specify managed storage, Amazon S3, and Amazon CloudWatch as your logging options.

With CloudWatch, specify the log types and log locations that you want to use, or accept the default types and locations. For more information on CloudWatch logs, refer to the section called “Amazon CloudWatch”. With managed storage and S3 logging, the following table lists the log locations and UI availability that you can expect if you choose managed storage, Amazon S3 buckets, or both.

Option	Event logs	Container logs	Application UI
Managed storage	Stored in managed storage	Stored in managed storage	Supported
Both managed storage and S3 bucket	Stored in both places	Stored in S3 bucket	Supported

Option	Event logs	Container logs	Application UI
Amazon S3 bucket	Stored in S3 bucket	Stored in S3 bucket	Not supported[1]

[1] We suggest that you keep the **Managed storage** option selected. Otherwise, you can't use the built-in application UIs.

Logging for EMR Serverless with managed storage

By default, EMR Serverless stores application logs securely in Amazon EMR managed storage for a maximum of 30 days.

Note

If you turn off the default option, Amazon EMR can't troubleshoot your jobs on your behalf. Example: You cannot access Spark-UI from the EMR Serverless Console.

To turn off this option from EMR Studio, deselect the **Allow AWS to retain logs for 30 days** check box in the **Additional settings** section of the **Submit job** page.

To turn off this option from the AWS CLI, use the `managedPersistenceMonitoringConfiguration` configuration when you submit a job run.

```
{
    "monitoringConfiguration": {
        "managedPersistenceMonitoringConfiguration": {
            "enabled": false
        }
    }
}
```

If your EMR Serverless application is in a private subnet with VPC endpoints for Amazon S3 and you attach an endpoint policy to control access, add the following permissions for EMR Serverless to store and serve application logs. Replace `Resource` with the `AppInfo` buckets from the available regions table in Sample policies for private subnets that access Amazon S3.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "EMRServerlessManagedLogging",
      "Effect": "Allow",
      "Action": [
        "s3:PutObject",
        "s3:PutObjectAcl"
      ],
      "Resource": [
        "arn:aws:s3:::prod.us-east-1.appinfo.src",
        "arn:aws:s3:::prod.us-east-1.appinfo.src/*"
      ],
      "Condition": {
        "StringEquals": {
          "aws:PrincipalServiceName": "emr-serverless.amazonaws.com",
          "aws:SourceVpc": "vpc-12345678"
        }
      }
    }
  ]
}
```

Additionally, use the `aws:SourceVpc` condition key to ensure that the request travels through the VPC that the VPC endpoint is attached to.

Logging for EMR Serverless with Amazon S3 buckets

Before your jobs can send log data to Amazon S3, include the following permissions in the permissions policy for the job runtime role. Replace *`amzn-s3-demo-logging-bucket`* with the name of your logging bucket.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "s3:PutObject"
      ],
      "Resource": [
        "arn:aws:s3:::amzn-s3-demo-bucket/*"
      ],
      "Sid": "AllowS3Putobject"
    }
  ]
}
```

To set up an Amazon S3 bucket to store logs from the AWS CLI, use the `s3MonitoringConfiguration` configuration when you start a job run. To do this, provide the following `--configuration-overrides` in the configuration.

```
{
    "monitoringConfiguration": {
        "s3MonitoringConfiguration": {
            "logUri": "s3://amzn-s3-demo-logging-bucket/logs/"
        }
    }
}
```

For batch jobs that don't have retries enabled, EMR Serverless sends the logs to the following path:

```
'/applications/<applicationId>/jobs/<jobId>'
```

Spark driver logs are stored in the following path by EMR Serverless

```
'/applications/<applicationId>/jobs/<jobId>/SPARK_DRIVER/'
```

Spark executor logs are stored in the following path by EMR Serverless

```
'/applications/<applicationId>/jobs/<jobId>/SPARK_EXECUTOR/<EXECUTOR-ID>'
```

The <EXECUTOR-ID> is an integer.

EMR Serverless releases 7.1.0 and higher support retry attempts for streaming jobs and batch jobs. If you run a job with retries enabled, EMR Serverless automatically adds an attempt number to the log path prefix, so you can better distinguish and track logs.

```
'/applications/<applicationId>/jobs/<jobId>/attempts/<attemptNumber>/'
```

Logging for EMR Serverless with Amazon CloudWatch

When you submit a job to an EMR Serverless application, choose Amazon CloudWatch as an option to store your application logs. This allows you to use CloudWatch log analysis features such as CloudWatch Logs Insights and Live Tail. You can also stream logs from CloudWatch to other systems such as OpenSearch for further analysis.

EMR Serverless provides real-time logging for driver logs. You can access the logs in real time with the CloudWatch live tail capability, or through CloudWatch CLI tail commands.

By default, CloudWatch logging is disabled for EMR Serverless. To enable it, use the configuration in AWS CLI.

> **Note**
>
> Amazon CloudWatch publishes logs in real time, so it incurs more resources from workers. If you choose a low worker capacity, the impact to your job run time might increase. If you enable CloudWatch logging, we suggest that you choose a greater worker capacity. It's also possible that log publication could throttle if the transactions per second (TPS) rate is too low for `PutLogEvents`. The CloudWatch throttling configuration is global to all services, including EMR Serverless. For more information, refer to How do I determine throttling in my CloudWatch logs? on *AWS re:post*.

Required permissions for logging with CloudWatch

Before your jobs can send log data to Amazon CloudWatch, include the following permissions in the permissions policy for the job runtime role.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "logs:DescribeLogGroups"
      ],
      "Resource": [
        "arn:aws:logs:*:123456789012:*"
      ],
      "Sid": "AllowLOGSDescribeloggroups"
    },
    {
      "Effect": "Allow",
      "Action": [
        "logs:PutLogEvents",
        "logs:CreateLogGroup",
        "logs:CreateLogStream",
        "logs:DescribeLogStreams"
      ],
      "Resource": [
        "arn:aws:logs:*:123456789012:log-group:my-log-group-name:*"
      ],
      "Sid": "AllowLOGSPutlogevents"
    }
  ]
}
```

AWS CLI

To set up Amazon CloudWatch to store logs for EMR Serverless from the AWS CLI, use the `cloudWatchLoggingConfiguration` configuration when you start a job run. To do this, provide the following configuration overrides. Optionally, also provide a log group name, log stream prefix name, log types, and an encryption key ARN.

If you don't specify the optional values, then CloudWatch publishes the logs to a default log group `/aws/emr-serverless`, with the default log stream `/applications/`*`applicationId`*`/jobs/`*`jobId`*`/`*`worker-type`*.

EMR Serverless releases 7.1.0 and higher support retry attempts for streaming jobs and batch jobs. If you enabled retries for a job, EMR Serverless automatically adds an attempt number to the log path prefix, so you can better distinguish and track logs.

```
'/applications/<applicationId>/jobs/<jobId>/attempts/<attemptNumber>/worker-type'
```

The following demonstrates the minimum configuration that is required to turn on Amazon CloudWatch logging with the default settings for EMR Serverless:

```
{
    "monitoringConfiguration": {
        "cloudWatchLoggingConfiguration": {
            "enabled": true
         }
     }
}
```

The following example shows all of the required and optional configurations that specify when you turn on Amazon CloudWatch logging for EMR Serverless. The supported `logTypes` values are also listed in the following this example.

```
{
    "monitoringConfiguration": {
        "cloudWatchLoggingConfiguration": {
            "enabled": true, // Required
            "logGroupName": "Example_logGroup", // Optional
            "logStreamNamePrefix": "Example_logStream", // Optional
            "encryptionKeyArn": "key-arn", // Optional
            "logTypes": {
                "SPARK_DRIVER": ["stdout", "stderr"] //List of values
             }
         }
     }
}
```

By default, EMR Serverless publishes only the driver stdout and stderr logs to CloudWatch. If you want other logs, then specify a container role and corresponding log types with the `logTypes` field.

The following list shows the supported worker types that specify for the `logTypes` configuration:

Spark

- `SPARK_DRIVER : ["STDERR", "STDOUT"]`
- `SPARK_EXECUTOR : ["STDERR", "STDOUT"]`

Hive

- `HIVE_DRIVER : ["STDERR", "STDOUT", "HIVE_LOG", "TEZ_AM"]`
- `TEZ_TASK : ["STDERR", "STDOUT", "SYSTEM_LOGS"]`

Rotating logs

Amazon EMR Serverless can rotate Spark application logs and event logs. Log rotation helps with the issue of long running jobs generating large log files that can take up all of your disk space. Rotating logs helps you save disk storage and reduces the amount of job failures because you have no more space left on your disk.

Log rotation is enabled by default and is available only for Spark jobs.

Spark event logs

Note

Spark event log rotation is available across all Amazon EMR release labels.

Instead of generating a single event log file, EMR Serverless rotates the event log at a regular time interval and removes the older event log files. Rotating logs doesn't affect the logs uploaded to the S3 bucket.

Spark application logs

Note

Spark application log rotation is available across all Amazon EMR release labels.

EMR Serverless also rotates the spark application logs for drivers and executors, such as `stdout` and `stderr` files. You can access the latest log files by choosing the log links in Studio by using the Spark History Server and Live UI links. Log files are the truncated versions of the latest logs. To refer to the older rotated logs, specify an Amazon S3 location when storing logs. Refer to Logging for EMR Serverless with Amazon S3 buckets for more information.

You can find the latest log files at the following location. EMR Serverless refreshes the files every 15 seconds. These files can range from 0 MB to 128 MB.

```
<example-S3-logUri>/applications/<application-id>/jobs/<job-id>/SPARK_DRIVER/stderr.gz
```

The following location contains the older rotated files. Each file is 128 MB.

```
<example-S3-logUri>/applications/<application-id>/jobs/<job-id>/SPARK_DRIVER/archived/
stderr_<index>.gz
```

The same behavior applies to Spark executors as well. This change is only applicable to S3 logging. Log rotation doesn't introduce any changes to log streams uploaded to Amazon CloudWatch.

EMR Serverless releases 7.1.0 and higher support retry attempts for streaming and batch jobs. If you enabled retry attempts with your job, EMR Serverless adds a prefix to the log path for such jobs so you can better track and distinguish the logs from one another. This path contains all rotated logs.

```
'/applications/<applicationId>/jobs/<jobId>/attempts/<attemptNumber>/'.
```

Encrypting logs

Encrypting EMR Serverless logs with managed storage

To encrypt logs in managed storage with your own KMS key, use the `managedPersistenceMonitoringConfiguration` configuration when you submit a job run.

```
{
    "monitoringConfiguration": {
        "managedPersistenceMonitoringConfiguration" : {
            "encryptionKeyArn": "key-arn"
        }
    }
}
```

Encrypting EMR Serverless logs with Amazon S3 buckets

To encrypt logs in your Amazon S3 bucket with your own KMS key, use the `s3MonitoringConfiguration` configuration when you submit a job run.

```
{
    "monitoringConfiguration": {
        "s3MonitoringConfiguration": {
            "logUri": "s3://amzn-s3-demo-logging-bucket/logs/",
            "encryptionKeyArn": "key-arn"
        }
    }
}
```

Encrypting EMR Serverless logs with Amazon CloudWatch

To encrypt logs in Amazon CloudWatch with your own KMS key, use the `cloudWatchLoggingConfiguration` configuration when you submit a job run.

```
{
    "monitoringConfiguration": {
        "cloudWatchLoggingConfiguration": {
            "enabled": true,
            "encryptionKeyArn": "key-arn"
         }
     }
}
```

Required permissions for log encryption

In this section

- Required user permissions
- Encryption key permissions for Amazon S3 and managed storage
- Encryption key permissions for Amazon CloudWatch

Required user permissions

The user who submits the job or views the logs or the application UIs must have permissions to use the key. You can specify the permissions in either the KMS key policy or the IAM policy for the user, group, or role. If the user who submits the job lacks the KMS key permissions, EMR Serverless rejects the job run submission.

Example key policy

The following key policy provides the permissions to `kms:GenerateDataKey` and `kms:Decrypt`:

```
{
   "Effect": "Allow",
   "Principal":{
      "AWS": "arn:aws:iam::111122223333:user/user-name"
    },
    "Action": [
      "kms:GenerateDataKey",
      "kms:Decrypt"
     ],
    "Resource": "*"
}
```

Example IAM policy

The following IAM policy provides the permissions to `kms:GenerateDataKey` and `kms:Decrypt`:

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "kms:GenerateDataKey",
        "kms:Decrypt"
      ],
      "Resource": [
        "arn:aws:kms:*:123456789012:key/12345678-1234-1234-1234-123456789012"
      ],
      "Sid": "AllowKMSGeneratedatakey"
    }
  ]
}
```

To launch the Spark or Tez UI, give your users, groups, or roles permissions to access the `emr-serverless:GetDashboardForJobRun` API as follows:

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "emr-serverless:GetDashboardForJobRun"
      ],
      "Resource": [
        "*"
      ],
      "Sid": "AllowEMRSERVERLESSGetdashboardforjobrun"
    }
  ]
}
```

Encryption key permissions for Amazon S3 and managed storage

When you encrypt logs with your own encryption key either in managed storage or in your S3 buckets, configure KMS key permissions as follows.

The `emr-serverless.amazonaws.com` principal must have the following permissions in the policy for the KMS key:

```
{
    "Effect": "Allow",
    "Principal":{
       "Service": "emr-serverless.amazonaws.com"
     },
     "Action": [
       "kms:Decrypt",
       "kms:GenerateDataKey"
      ],
     "Resource": "*"
     "Condition": {
       "StringLike": {
         "aws:SourceArn": "arn:aws:emr-serverless:region:aws-account-id:/
applications/application-id"
       }
     }
 }
```

As a security best practice, we suggest that you add an `aws:SourceArn` condition key to the KMS key policy. The IAM global condition key `aws:SourceArn` helps ensure that EMR Serverless uses the KMS key only for an application ARN.

The job runtime role must have the following permissions in its IAM policy:

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "kms:GenerateDataKey",
        "kms:Decrypt"
      ],
      "Resource": [
        "arn:aws:kms:*:123456789012:key/12345678-1234-1234-1234-123456789012"
      ],
      "Sid": "AllowKMSGeneratedatakey"
    }
  ]
}
```

Encryption key permissions for Amazon CloudWatch

To associate the KMS key ARN to your log group, use the following IAM policy for the job runtime role.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "logs:AssociateKmsKey"
      ],
      "Resource": [
        "arn:aws:logs:*:123456789012:log-group:my-log-group-name:*"
      ],
      "Sid": "AllowLOGSAssociatekmskey"
    }
  ]
}
```

Configure the KMS key policy to grant KMS permissions to Amazon CloudWatch:

JSON

```
{
  "Version":"2012-10-17",
  "Id": "key-default-1",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "kms:Decrypt",
        "kms:GenerateDataKey"
      ],
      "Resource": [
        "*"
      ],
      "Condition": {
        "ArnLike": {
          "kms:EncryptionContext:aws:logs:arn": "arn:aws:logs:*:123456789012:*"
        }
      },
      "Sid": "AllowKMSDecrypt"
    }
  ]
}
```

Configure Apache Log4j2 properties for Amazon EMR Serverless

This page describes how to configure custom Apache Log4j 2.x properties for EMR Serverless jobs at `StartJobRun`. If you want to configure Log4j classifications at the application level, refer to Default application configuration for EMR Serverless.

Configure Spark Log4j2 properties for Amazon EMR Serverless

With Amazon EMR releases 6.8.0 and higher, you can customize Apache Log4j 2.x properties to specify fine-grained log configurations. This simplifies troubleshooting of your Spark jobs on EMR Serverless. To configure these properties, use the `spark-driver-log4j2` and `spark-executor-log4j2` classifications.

Topics

Log4j2 classifications for Spark

To customize the Spark log configurations, use the following classifications with `applicationConfiguration`. To configure the Log4j 2.x properties, use the following `properties`.

`spark-driver-log4j2`

This classification sets the values in the `log4j2.properties` file for the driver.

`spark-executor-log4j2`

This classification sets the values in the `log4j2.properties` file for the executor.

Log4j2 configuration example for Spark

The following example shows how to submit a Spark job with `applicationConfiguration` to customize Log4j2 configurations for the Spark driver and executor.

To configure Log4j classifications at the application level instead of when you submit the job, refer to Default application configuration for EMR Serverless.

```
aws emr-serverless start-job-run \
    --application-id application-id \
    --execution-role-arn job-role-arn \
    --job-driver '{
        "sparkSubmit": {
            "entryPoint": "/usr/lib/spark/examples/jars/spark-examples.jar",
            "entryPointArguments": ["1"],
            "sparkSubmitParameters": "--class org.apache.spark.examples.SparkPi --conf
 spark.executor.cores=4 --conf spark.executor.memory=20g --conf spark.driver.cores=4 --
conf spark.driver.memory=8g --conf spark.executor.instances=1"
        }
    }'
    --configuration-overrides '{
        "applicationConfiguration": [
             {
                "classification": "spark-driver-log4j2",
                "properties": {
                    "rootLogger.level":"error", // will only display Spark error logs
                    "logger.IdentifierForClass.name": "classpath for setting logger",
                    "logger.IdentifierForClass.level": "info"

                }
            },
            {
                "classification": "spark-executor-log4j2",
                "properties": {
                    "rootLogger.level":"error", // will only display Spark error logs
                    "logger.IdentifierForClass.name": "classpath for setting logger",
                    "logger.IdentifierForClass.level": "info"
                }
            }
       ]
    }'
```

Log4j2 in sample Spark jobs

The following code samples demonstrate how to create a Spark application while you initialize a custom Log4j2 configuration for the application.

Python

Example- Using Log4j2 for a Spark job with Python

```
import os
import sys

from pyspark import SparkConf, SparkContext
from pyspark.sql import SparkSession

app_name = "PySparkApp"
if __name__ == "__main__":
    spark = SparkSession\
        .builder\
        .appName(app_name)\
        .getOrCreate()

    spark.sparkContext._conf.getAll()
    sc = spark.sparkContext
    log4jLogger = sc._jvm.org.apache.log4j
    LOGGER = log4jLogger.LogManager.getLogger(app_name)

    LOGGER.info("pyspark script logger info")
    LOGGER.warn("pyspark script logger warn")
    LOGGER.error("pyspark script logger error")

    // your code here

    spark.stop()
```

To customize Log4j2 for the driver when you execute a Spark job, use the following configuration:

```
{
   "classification": "spark-driver-log4j2",
      "properties": {
          "rootLogger.level":"error", // only display Spark error logs
          "logger.PySparkApp.level": "info",
          "logger.PySparkApp.name": "PySparkApp"
      }
}
```

Scala

Example- Using Log4j2 for a Spark job with Scala

```
import org.apache.log4j.Logger
import org.apache.spark.sql.SparkSession

object ExampleClass {
  def main(args: Array[String]): Unit = {
    val spark = SparkSession
    .builder
    .appName(this.getClass.getName)
    .getOrCreate()

    val logger = Logger.getLogger(this.getClass);
    logger.info("script logging info logs")
    logger.warn("script logging warn logs")
    logger.error("script logging error logs")

// your code here
    spark.stop()
  }
}
```

To customize Log4j2 for the driver when you execute a Spark job, use the following configuration:

```
{
   "classification": "spark-driver-log4j2",
      "properties": {
          "rootLogger.level":"error", // only display Spark error logs
          "logger.ExampleClass.level": "info",
          "logger.ExampleClass.name": "ExampleClass"
      }
}
```

Log4j2 considerations for Spark

The following Log4j2.x properties are not configurable for Spark processes:

- `rootLogger.appenderRef.stdout.ref`

- `appender.console.type`
- `appender.console.name`
- `appender.console.target`
- `appender.console.layout.type`
- `appender.console.layout.pattern`

For detailed information about the Log4j2.x properties that configure, refer to the `log4j2.properties.template` file on GitHub.

Monitoring EMR Serverless

This section covers the ways that monitor your Amazon EMR Serverless applications and jobs.

Topics

Monitoring EMR Serverless applications and jobs

With Amazon CloudWatch metrics for EMR Serverless, you can receive 1-minute CloudWatch metrics and access CloudWatch dashboards to access near-real-time operations and performance of your EMR Serverless applications.

EMR Serverless sends metrics to CloudWatch every minute. EMR Serverless emits these metrics at the application level as well as the job, worker-type, and capacity-allocation-type levels.

To get started, use the EMR Serverless CloudWatch dashboard template provided in the EMR Serverless GitHub repository and deploy it.

Note

EMR Serverless interactive workloads have only application-level monitoring enabled, and have a new worker type dimension, `Spark_Kernel`. To monitor and debug your interactive workloads, access the logs and Apache Spark UI from within your EMR Studio Workspace.

Monitoring metrics

Important

We are restructuring our metrics display to add `ApplicationName` and `JobName` as dimensions. For release 7.10 and later, the older metrics will no longer be updated. For EMR releases below 7.10, the older metrics are still available.

Current dimensions

The table below describes the EMR Serverless dimensions available within the `AWS/EMR Serverless` namespace.

Dimensions for EMR Serverless metrics

Dimension	Description	
`ApplicationId`	Filters for all metrics of an EMR Serverless application using the application ID.	
`ApplicationName`	Filters for all metrics of an EMR Serverless application using the name. If the name isn't provided, or contains non-ASCII characters, it is published as **[Unspecified]**.	
`JobId`	Filters for all metrics of an EMR Serverless the job run ID.	
`JobName`	Filters for all metrics of an EMR Serverless job run using the name. If the name isn't provided, or contains non-ASCII characters, it is published as **[Unspecified]**.	

Dimension	Description	
WorkerType	Filters for all metrics of a given worker type. For example, you can filter for SPARK_DRIVER and SPARK_EXECUTORS for Spark jobs.	
CapacityAllocation Type	Filters for all metrics of a given capacity allocation type. For example, you can filter for PreInitCapacity for pre-initialized capacity and OnDemandCapacity for everything else.	

Application-level monitoring

You can monitor capacity usage at the EMR Serverless application level with Amazon CloudWatch metrics. You can also set up a single display to monitor application capacity usage in a CloudWatch dashboard.

EMR Serverless application metrics

Metric	Description	Unit	Dimension
MaxCPUAllowed	The maximum CPU allowed for the application.	vCPU	ApplicationId , ApplicationName
MaxMemory Allowed	The maximum memory in GB allowed for the application.	Gigabytes (GB)	ApplicationId , ApplicationName

Metric	Description	Unit	Dimension
MaxStorageAllowed	The maximum storage in GB allowed for the application.	Gigabytes (GB)	ApplicationId , ApplicationName
CPUAllocated	The total numbers of vCPUs allocated.	vCPU	ApplicationId , ApplicationName , WorkerType ,CapacityAllocationType
IdleWorkerCount	The number of total workers idle.	Count	ApplicationId , ApplicationName , WorkerType ,CapacityAllocationType
MemoryAllocated	The total memory in GB allocated.	Gigabytes (GB)	ApplicationId , ApplicationName , WorkerType ,CapacityAllocationType
PendingCreationWorkerCount	The number of total workers pending creation.	Count	ApplicationId , ApplicationName , WorkerType ,CapacityAllocationType
RunningWorkerCount	The number of total workers in use by the application.	Count	ApplicationId , ApplicationName , WorkerType ,CapacityAllocationType

Metric	Description	Unit	Dimension
StorageAllocated	The total disk storage in GB allocated.	Gigabytes (GB)	ApplicationId , ApplicationName , WorkerType ,CapacityAllocationType
TotalWorkerCount	The number of total workers available.	Count	ApplicationId , ApplicationName , WorkerType ,CapacityAllocationType

Job-level monitoring

Amazon EMR Serverless sends the following job-level metrics to Amazon CloudWatch every one minute. You can access the metric values for aggregate job runs by job run state. The unit for each of the metrics is *count*.

EMR Serverless job-level metrics

Metric	Description	Dimension
SubmittedJobs	The number of jobs in a Submitted state.	ApplicationId , ApplicationName
PendingJobs	The number of jobs in a Pending state.	ApplicationId , ApplicationName
ScheduledJobs	The number of jobs in a Scheduled state.	ApplicationId , ApplicationName
RunningJobs	The number of jobs in a Running state.	ApplicationId , ApplicationName
SuccessJobs	The number of jobs in a Success state.	ApplicationId , ApplicationName

Metric	Description	Dimension
FailedJobs	The number of jobs in a Failed state.	ApplicationId , ApplicationName
CancellingJobs	The number of jobs in a Cancelling state.	ApplicationId , ApplicationName
CancelledJobs	The number of jobs in a Cancelled state.	ApplicationId , ApplicationName

You can monitor engine-specific metrics for running and completed EMR Serverless jobs with engine-specific application UIs. When you access the UI for a running job, the live application UI displays with real-time updates. When you access the UI for a completed job, the persistent app UI displays.

Running jobs

For your running EMR Serverless jobs, access a real-time interface that provides engine-specific metrics. You can use either the Apache Spark UI or the Hive Tez UI to monitor and debug your jobs. To access these UIs, use the EMR Studio console or request a secure URL endpoint with the AWS Command Line Interface.

Completed jobs

For your completed EMR Serverless jobs, use the Spark History Server or the Persistent Hive Tez UI to access jobs details, stages, tasks, and metrics for Spark or Hive jobs runs. To access these UIs, use the EMR Studio console, or request a secure URL endpoint with the AWS Command Line Interface.

Job worker-level monitoring

Amazon EMR Serverless sends the following job worker level metrics that are available in the `AWS/EMRServerless` namespace and `Job Worker Metrics` metric group to Amazon CloudWatch. EMR Serverless collects data points from individual workers during job runs at the job level, worker-type, and the capacity-allocation-type level. You can use `ApplicationId` as a dimension to monitor multiple jobs that belong to the same application.

Note

To view the total CPU and Memory used by an EMR Serverless job when viewing the metrics in the Amazon CloudWatch console, use the Statistic as Sum and Period as 1 minute.

EMR Serverless job worker-level metrics

Metric	Description	Unit	Dimension
`WorkerCpuAllocated`	The total numbers of vCPU cores allocated for workers in a job run.	vCPU	`JobId`, `JobName`, `ApplicationId` , `ApplicationName` , `WorkerType` , and `CapacityAllocationType`
`WorkerCpuUsed`	The total numbers of vCPU cores utilized by workers in a job run.	vCPU	`JobId`, `JobName`, `ApplicationId` , `ApplicationName` , `WorkerType` , and `CapacityAllocationType`
`WorkerMemoryAllocated`	The total memory in GB allocated for workers in a job run.	Gigabytes (GB)	`JobId`, `JobName`, `ApplicationId` , `Applicati`

Metric	Description	Unit	Dimension	
			onName , WorkerType , and CapacityA llocation Type	
WorkerMem oryUsed	The total memory in GB utilized by workers in a job run.	Gigabytes (GB)	JobId, JobName, Applicati onId , Applicati onName , WorkerType , and CapacityA llocation Type	
WorkerEph emeralSto rageAlloc ated	The number of bytes of ephemeral storage allocated for workers in a job run.	Gigabytes (GB)	JobId, JobName, Applicati onId , Applicati onName , WorkerType , and CapacityA llocation Type	

Metric	Description	Unit	Dimension
`WorkerEphemeralStorageUsed`	The number of bytes of ephemeral storage used by workers in a job run.	Gigabytes (GB)	`JobId`, `JobName`, `ApplicationId` , `ApplicationName` , `WorkerType` , and `CapacityAllocationType`
`WorkerStorageReadBytes`	The number of bytes read from storage by workers in a job run.	Bytes	`JobId`, `JobName`, `ApplicationId` , `ApplicationName` , `WorkerType` , and `CapacityAllocationType`
`WorkerStorageWriteBytes`	The number of bytes written to storage from workers in a job run.	Bytes	`JobId`, `JobName`, `ApplicationId` , `ApplicationName` , `WorkerType` , and `CapacityAllocationType`

The steps below describe how to access the various types of metrics.

Console

To access your application UI with the console

1. Navigate to your EMR Serverless application on the EMR Studio with the instructions in Getting started from the console.
2. To access engine-specific application UIs and logs for a running job:
   1. Choose a job with a `RUNNING` status.
   2. Select the job on the **Application details** page, or navigate to the **Job details** page for your job.
   3. Under the **Display UI** dropdown menu, choose either **Spark UI** or **Hive Tez UI** to navigate to the application UI for your job type.
   4. To access Spark engine logs, navigate to the **Executors** tab in the Spark UI, and choose the **Logs** link for the driver. To access Hive engine logs, choose the **Logs** link for the appropriate DAG in the Hive Tez UI.
3. To access engine-specific application UIs and logs for a completed job:
   1. Choose a job with a `SUCCESS` status.
   2. Select the job on your application's **Application details** page or navigate to the job's **Job details** page.
   3. Under the **Display UI** dropdown menu, choose either **Spark History Server** or **Persistent Hive Tez UI** to navigate to the application UI for your job type.
   4. To access Spark engine logs, navigate to the **Executors** tab in the Spark UI, and choose the **Logs** link for the driver. To access Hive engine logs, choose the **Logs** link for the appropriate DAG in the Hive Tez UI.

AWS CLI

To access your application UI with the AWS CLI

- To generate a URL that use to access your application UI for running and completed jobs, call the `GetDashboardForJobRun` API.

```
aws emr-serverless get-dashboard-for-job-run /
--application-id <application-id> /
--job-run-id <job-id>
```

The URL that you generate is valid for one hour.

Monitor Spark metrics with Amazon Managed Service for Prometheus

With Amazon EMR releases 7.1.0 and higher, you can integrate EMR Serverless with Amazon Managed Service for Prometheus to collect Apache Spark metrics for EMR Serverless jobs and applications. This integration is available when you submit a job or create an application using either the AWS console, the EMR Serverless API, or the AWS CLI.

Prerequisites

Before you can deliver your Spark metrics to Amazon Managed Service for Prometheus, complete the following prerequisites.

- Create an Amazon Managed Service for Prometheus workspace. This workspace serves as an ingestion endpoint. Make a note of the URL displayed for **Endpoint - remote write URL**. You'll need to specify the URL when you create your EMR Serverless application.
- To grant access of your jobs to Amazon Managed Service for Prometheus for monitoring purposes, add the following policy to your job execution role.

```
{
    "Sid": "AccessToPrometheus",
    "Effect": "Allow",
    "Action": ["aps:RemoteWrite"],
    "Resource": "arn:aws:aps:<AWS_REGION>:<AWS_ACCOUNT_ID>:workspace/<WORKSPACE_ID>"
}
```

Setup

To use the AWS console to create an application that's integrated with Amazon Managed Service for Prometheus

1. See Getting started with Amazon EMR Serverless to create an application.
2. While you're creating an application, choose **Use custom settings**, and then configure your application by specifying the information into the fields you want to configure.
3. Under **Application logs and metrics**, choose **Deliver engine metrics to Amazon Managed Service for Prometheus**, and then specify your remote write URL.

4. Specify any other configuration settings you want, and then choose **Create and start application**.

Use the AWS CLI or EMR Serverless API

You can also use the AWS CLI or EMR Serverless API to integrate your EMR Serverless application with Amazon Managed Service for Prometheus when you're running the `create-application` or the `start-job-run` commands.

create-application

```
aws emr-serverless create-application \
--release-label emr-7.1.0 \
--type "SPARK" \
--monitoring-configuration '{
    "prometheusMonitoringConfiguration": {
        "remoteWriteUrl": "https://aps-workspaces.<AWS_REGION>.amazonaws.com/
workspaces/<WORKSPACE_ID>/api/v1/remote_write"
    }
}'
```

start-job-run

```
aws emr-serverless start-job-run \
--application-id <APPPLICATION_ID> \
--execution-role-arn <JOB_EXECUTION_ROLE> \
--job-driver '{
    "sparkSubmit": {
        "entryPoint": "local:///usr/lib/spark/examples/src/main/python/pi.py",
        "entryPointArguments": ["10000"],
        "sparkSubmitParameters": "--conf spark.dynamicAllocation.maxExecutors=10"
    }
}' \
--configuration-overrides '{
     "monitoringConfiguration": {
        "prometheusMonitoringConfiguration": {
            "remoteWriteUrl": "https://aps-workspaces.<AWS_REGION>.amazonaws.com/
workspaces/<WORKSPACE_ID>/api/v1/remote_write"
        }
    }
}'
```

Including `prometheusMonitoringConfiguration` in your command indicates that EMR Serverless must run the Spark job with an agent that collects the Spark metrics and writes them to your `remoteWriteUrl` endpoint for Amazon Managed Service for Prometheus. You can then use the Spark metrics in Amazon Managed Service for Prometheus for visualization, alerts, and analysis.

Advanced configuration properties

EMR Serverless uses a component within Spark named `PrometheusServlet` to collect Spark metrics and translates performance data into data that's compatible with Amazon Managed Service for Prometheus. By default, EMR Serverless sets default values in Spark and parses driver and executor metrics when you submit a job using `PrometheusMonitoringConfiguration`.

The following table describes all of the properties configure when submitting a Spark job that sends metrics to Amazon Managed Service for Prometheus.

Spark property	Default value	Description
`spark.metrics.conf.*.sink.prometheusServlet.class`	org.apache.spark.metrics.sink.PrometheusServlet	The class that Spark uses to send metrics to Amazon Managed Service for Prometheus. To override the default behavior, specify your own custom class.
`spark.metrics.conf.*.source.jvm.class`	org.apache.spark.metrics.source.JvmSource	The class Spark uses to collect and send crucial metrics from the underlying Java virtual machine. To stop collecting JVM metrics, disable this property by setting it to an empty string, such as `""`. To override the default behavior, specify your own custom class.

Spark property	Default value	Description
`spark.metrics.conf.driver.sink.prometheusServlet.path`	/metrics/prometheus	The distinct URL that Amazon Managed Service for Prometheus uses to collect metrics from the driver. To override the default behavior, specify your own path. To stop collecting driver metrics, disable this property by setting it to an empty string, such as `""`.
`spark.metrics.conf.executor.sink.prometheusServlet.path`	/metrics/executor/prometheus	The distinct URL that Amazon Managed Service for Prometheus uses to collect metrics from the executor. To override the default behavior, specify your own path. To stop collecting executor metrics, disable this property by setting it to an empty string, such as `""`.

For more information about the Spark metrics, refer to Apache Spark metrics.

Considerations and limitations

When using Amazon Managed Service for Prometheus to collect metrics from EMR Serverless, consider the following considerations and limitations.

- Support for using Amazon Managed Service for Prometheus with EMR Serverless is available only in the AWS Regions where Amazon Managed Service for Prometheus is generally available.
- Running the agent to collect Spark metrics on Amazon Managed Service for Prometheus requires more resources from workers. If you choose a smaller worker size, such as one vCPU worker, your job run time might increase.

- Support for using Amazon Managed Service for Prometheus with EMR Serverless is available only for Amazon EMR releases 7.1.0 and higher.
- Amazon Managed Service for Prometheus must be deployed in the same account where you run EMR Serverless to collect metrics.

EMR Serverless usage metrics

You can use Amazon CloudWatch usage metrics to provide visibility into the resources that your account uses. Use these metrics to visualize your service usage on CloudWatch graphs and dashboards.

EMR Serverless usage metrics correspond to Service Quotas. You can configure alarms that alert you when your usage approaches a service quota. For more information, refer to Service Quotas and Amazon CloudWatch alarms in the *Service Quotas User Guide*.

For more information about EMR Serverless service quotas, refer to Endpoints and quotas for EMR Serverless.

Service quota usage metrics for EMR Serverless

EMR Serverless publishes the following service quota usage metrics in the `AWS/Usage` namespace.

Metric	Description
`ResourceCount`	The total number of the specified resource that is running on your account. The resource is defined by the dimensions that are associate d with the metric.

Dimensions for EMR Serverless service quota usage metrics

You can use the following dimensions to refine the usage metrics that EMR Serverless publishes.

Dimension	Value	Description
`Service`	EMR Serverless	The name of the AWS service that contains the resource.

Dimension	Value	Description
`Type`	Resource	The type of entity that EMR Serverless is reporting.
`Resource`	vCPU	The type of resource that EMR Serverless is tracking.
`Class`	None	The class of resource that EMR Serverless is tracking.

Automating EMR Serverless with Amazon EventBridge

You can use Amazon EventBridge to automate your AWS services and respond automatically to system events, such as application availability issues or resource changes. EventBridge delivers a near real-time stream of system events that describe changes in your AWS resources. 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, you can automatically:

- Invoke an AWS Lambda function
- Relay an event to Amazon Kinesis Data Streams
- Activate an AWS Step Functions state machine
- Notify an Amazon SNS topic or an Amazon SQS queue

For example, when you use EventBridge with EMR Serverless, you can activate an AWS Lambda function when an ETL job succeed or notify an Amazon SNS topic when an ETL job fails.

EMR Serverless emits four kinds of events:

- Application state change events – Events that emit every state change of an application. For more information about application states, refer to Application states.
- Job run state change events – Events that emit every state change of a job run. For more information about, refer to Job run states.
- Job run retry events – Events that emit every retry of a job run from Amazon EMR Serverless releases 7.1.0 and higher.

- Job resource utilization update events – Events that emit resource utilization updates for a job run at close to 30-minute intervals.

Sample EMR Serverless EventBridge events

Events reported by EMR Serverless have a value of `aws.emr-serverless` assigned to `source`, as in the following examples.

Application state change event

The following example event shows an application in the `CREATING` state.

```
{
    "version": "0",
    "id": "9fd3cf79-1ff1-b633-4dd9-34508dc1e660",
    "detail-type": "EMR Serverless Application State Change",
    "source": "aws.emr-serverless",
    "account": "123456789012",
    "time": "2022-05-31T21:16:31Z",
    "region": "us-east-1",
    "resources": [],
    "detail": {
        "applicationId": "00f1cbsc6anuij25",
        "applicationName": "3965ad00-8fba-4932-a6c8-ded32786fd42",
        "arn": "arn:aws:emr-serverless:us-east-1:111122223333:/
applications/00f1cbsc6anuij25",
        "releaseLabel": "emr-6.6.0",
        "state": "CREATING",
        "type": "HIVE",
        "createdAt": "2022-05-31T21:16:31.547953Z",
        "updatedAt": "2022-05-31T21:16:31.547970Z",
        "autoStopConfig": {
            "enabled": true,
            "idleTimeout": 15
        },
        "autoStartConfig": {
            "enabled": true
        }
    }
}
```

Job run state change event

The following example event shows a job run that moves from the SCHEDULED state to the RUNNING state.

```
{
    "version": "0",
    "id": "00df3ec6-5da1-36e6-ab71-20f0de68f8a0",
    "detail-type": "EMR Serverless Job Run State Change",
    "source": "aws.emr-serverless",
    "account": "123456789012",
    "time": "2022-05-31T21:07:42Z",
    "region": "us-east-1",
    "resources": [],
    "detail": {
        "jobRunId": "00f1cbn5g4bb0c01",
        "applicationId": "00f1982r1uukb925",
        "arn": "arn:aws:emr-serverless:us-east-1:123456789012:/
applications/00f1982r1uukb925/jobruns/00f1cbn5g4bb0c01",
        "releaseLabel": "emr-6.6.0",
        "state": "RUNNING",
        "previousState": "SCHEDULED",
        "createdBy": "arn:aws:sts::123456789012:assumed-role/
TestRole-402dcef3ad14993c15d28263f64381e4cda34775/6622b6233b6d42f59c25dd2637346242",
        "updatedAt": "2022-05-31T21:07:42.299487Z",
        "createdAt": "2022-05-31T21:07:25.325900Z"
    }
}
```

Job run retry event

The following is an example of a job run retry event.

```
{
    "version": "0",
    "id": "00df3ec6-5da1-36e6-ab71-20f0de68f8a0",
    "detail-type": "EMR Serverless Job Run Retry",
    "source": "aws.emr-serverless",
    "account": "123456789012",
    "time": "2022-05-31T21:07:42Z",
    "region": "us-east-1",
    "resources": [],
    "detail": {
        "jobRunId": "00f1cbn5g4bb0c01",
        "applicationId": "00f1982r1uukb925",
        "arn": "arn:aws:emr-serverless:us-east-1:123456789012:/
applications/00f1982r1uukb925/jobruns/00f1cbn5g4bb0c01",
        "releaseLabel": "emr-6.6.0",
        "createdBy": "arn:aws:sts::123456789012:assumed-role/
TestRole-402dcef3ad14993c15d28263f64381e4cda34775/6622b6233b6d42f59c25dd2637346242",
        "updatedAt": "2022-05-31T21:07:42.299487Z",
        "createdAt": "2022-05-31T21:07:25.325900Z",
        //Attempt Details
        "previousAttempt": 1,
        "previousAttemptState": "FAILED",
        "previousAttemptCreatedAt": "2022-05-31T21:07:25.325900Z",
        "previousAttemptEndedAt": "2022-05-31T21:07:30.325900Z",
        "newAttempt": 2,
        "newAttemptCreatedAt": "2022-05-31T21:07:30.325900Z"
    }
}
```

Job Resource Utilization Update

The following example event shows the final resource utilization update for a job that moved to a terminal state after running.

```
{
    "version": "0",
    "id": "00df3ec6-5da1-36e6-ab71-20f0de68f8a0",
    "detail-type": "EMR Serverless Job Resource Utilization Update",
    "source": "aws.emr-serverless",
    "account": "123456789012",
    "time": "2022-05-31T21:07:42Z",
    "region": "us-east-1",
    "resources": [
        "arn:aws:emr-serverless:us-east-1:123456789012:/applications/00f1982r1uukb925/
jobruns/00f1cbn5g4bb0c01"
    ],
    "detail": {
        "applicationId": "00f1982r1uukb925",
        "jobRunId": "00f1cbn5g4bb0c01",
        "attempt": 1,
        "mode": "BATCH",
        "createdAt": "2022-05-31T21:07:25.325900Z",
        "startedAt": "2022-05-31T21:07:26.123Z",
        "calculatedFrom": "2022-05-31T21:07:42.299487Z",
        "calculatedTo": "2022-05-31T21:07:30.325900Z",
        "resourceUtilizationFinal": true,
        "resourceUtilizationForInterval": {
            "vCPUHour": 0.023,
            "memoryGBHour": 0.114,
            "storageGBHour": 0.228
        },
        "billedResourceUtilizationForInterval": {
            "vCPUHour": 0.067,
            "memoryGBHour": 0.333,
            "storageGBHour": 0
        },
        "totalResourceUtilization": {
            "vCPUHour": 0.023,
            "memoryGBHour": 0.114,
            "storageGBHour": 0.228
        },
        "totalBilledResourceUtilization": {
            "vCPUHour": 0.067,
            "memoryGBHour": 0.333,
            "storageGBHour": 0
        }
    }
}
```

The **startedAt** field will only be present in the event if the job had moved to a running state.

Tagging resources

Assign your own metadata to each resource using tags to help you manage your EMR Serverless resources. This section provides an overview of the tag functions and shows how to create tags.

Topics

- What is a tag?
- Tagging your resources
- Tagging limitations
- Working with tags using the AWS CLI and the Amazon EMR Serverless API

What is a tag?

A tag is a label that you assign to an AWS resource. Each tag consists of a key and a value, both of which you define. Tags enable you to categorize your AWS resources by attributes such as purpose, owner, and environment. When you have many resources of the same type, quickly identify a specific resource based on the tags assigned to it. For example, define a set of tags for your Amazon EMR Serverless applications to help track each application's owner and stack level. We suggest that you devise a consistent set of tag keys for each resource type.

Tags are not automatically assigned to your resources. After you add a tag to a resource, modify a tag’s value or remove the tag from the resource at any time. Tags do not have any semantic meaning to Amazon EMR Serverless and are interpreted strictly as strings of characters. If you add a tag that has the same key as an existing tag on that resource, the new value overwrites the earlier value.

If you use IAM, you can control which users in your AWS account have permission to manage tags. For tag-based access control policy examples, refer to Policies for tag-based access control.

Tagging your resources

You can tag new or existing applications and job runs. If you're using the Amazon EMR Serverless API, the AWS CLI, or an AWS SDK, you can apply tags to new resources using the `tags` parameter on the relevant API action. You can apply tags to existing resources using the `TagResource` API action.

You can use some resource-creating actions to specify tags for a resource when the resource is created. In this case, if tags cannot be applied while the resource is being created, the resource fails to be created. This mechanism ensures that resources you intended to tag on creation are either created with specified tags or not created at all. If you tag resources at the time of creation, you do not need to run custom tagging scripts after creating a resource.

The following table describes the Amazon EMR Serverless resources that can be tagged.

Taggable resources

Resource	Supports tags	Supports tag propagation	Supports tagging on creation (Amazon EMR Serverless API, AWS CLI, and AWS SDK)	API for creation (tags can be added during creation)
Application	Yes	No. Tags associated with an application do not propagate to job runs submitted to that application.	Yes	`CreateApplication`
Job run	Yes	No	Yes	`StartJobRun`

Tagging limitations

The following basic limitations apply to tags:

- Each resource can have a maximum of 50 user-created tags.
- For each resource, each tag key must be unique, and each tag key can have only one value.
- The maximum key length is 128 Unicode characters in UTF-8.
- The maximum value length is 256 Unicode characters in UTF-8.

- Allowed characters are letters, numbers, spaces representable in UTF-8, and the following characters: _ . : / = + - @.
- A tag key cannot be an empty string. A tag value can be an empty string, but not null.
- Tag keys and values are case sensitive.
- Do not use `AWS:` or any upper or lowercase combination of such as a prefix for either keys or values. These are reserved only for AWS use.

Working with tags using the AWS CLI and the Amazon EMR Serverless API

Use the following AWS CLI commands or Amazon EMR Serverless API operations to add, update, list, and delete the tags for your resources.

CLI commands and API operations for tags

Resource	Supports tags	Supports tag propagation
Add or overwrite one or more tags	`tag-resource`	`TagResource`
List tags for a resource	`list-tags-for-resource`	`ListTagsForResource`
Delete one or more tags	`untag-resource`	`UntagResource`

The following examples demonstrate how to tag or untag resources using the AWS CLI.

Tag an existing application

The following command tags an existing application.

```
aws emr-serverless tag-resource --resource-arn resource_ARN --tags team=devs
```

Untag an existing application

The following command deletes a tag from an existing application.

```
aws emr-serverless untag-resource --resource-arn resource_ARN --tag-keys tag_key
```

List tags for a resource

The following command lists the tags associated with an existing resource.

```
aws emr-serverless list-tags-for-resource --resource-arn resource_ARN
```

Tutorials for EMR Serverless

This section describes common use cases when you work with EMR Serverless applications. This includes a variety of tools including Hudi and Iceberg for working on large data sets and using Python and Python libraries to submit Spark jobs.

Topics

Using Java 17 with Amazon EMR Serverless

With Amazon EMR releases 6.11.0 and higher, configure EMR Serverless Spark jobs to use Java 17 runtime for the Java Virtual Machine (JVM). Use one of the following methods to configure Spark with Java 17.

`JAVA_HOME`

To override the JVM setting for EMR Serverless 6.11.0 and higher, supply the `JAVA_HOME` setting to its `spark.emr-serverless.driverEnv` and `spark.executorEnv` environment classifications.

x86_64

Set the required properties to specify Java 17 as the `JAVA_HOME` configuration for the Spark driver and executors:

```
--conf spark.emr-serverless.driverEnv.JAVA_HOME=/usr/lib/jvm/java-17-amazon-
corretto.x86_64/
--conf spark.executorEnv.JAVA_HOME=/usr/lib/jvm/java-17-amazon-corretto.x86_64/
```

arm_64

Set the required properties to specify Java 17 as the `JAVA_HOME` configuration for the Spark driver and executors:

```
--conf spark.emr-serverless.driverEnv.JAVA_HOME=/usr/lib/jvm/java-17-amazon-
corretto.aarch64/
--conf spark.executorEnv.JAVA_HOME=/usr/lib/jvm/java-17-amazon-corretto.aarch64/
```

`spark-defaults`

Alternatively, you can specify Java 17 in the `spark-defaults` classification to override the JVM setting for EMR Serverless 6.11.0 and higher.

x86_64

Specify Java 17 in the `spark-defaults` classification:

```
{
"applicationConfiguration": [
         {
            "classification": "spark-defaults",
            "properties": {
               "spark.emr-serverless.driverEnv.JAVA_HOME" : "/usr/lib/jvm/java-17-
amazon-corretto.x86_64/",
               "spark.executorEnv.JAVA_HOME": "/usr/lib/jvm/java-17-amazon-
corretto.x86_64/"
            }
         }
      ]
}
```

arm_64

Specify Java 17 in the `spark-defaults` classification:

```
{
```

```
"applicationConfiguration": [
         {
            "classification": "spark-defaults",
            "properties": {
               "spark.emr-serverless.driverEnv.JAVA_HOME" : "/usr/lib/jvm/java-17-
amazon-corretto.aarch64/",
               "spark.executorEnv.JAVA_HOME": "/usr/lib/jvm/java-17-amazon-
corretto.aarch64/"
            }
         }
      ]
}
```

Using Apache Hudi with EMR Serverless

This section describes using Apache Hudi with EMR Serverless applications. Hudi is a data-management framework that makes data processing more simple.

To use Apache Hudi with EMR Serverless applications

1. Set the required Spark properties in the corresponding Spark job run.

   ```
   spark.jars=/usr/lib/hudi/hudi-spark-bundle.jar,/usr/lib/hudi/hudi-utilities-
   bundle.jar,/usr/lib/hudi/hudi-aws-bundle.jar
   spark.serializer=org.apache.spark.serializer.KryoSerializer
   ```

2. To sync a Hudi table to the configured catalog, designate either the AWS Glue Data Catalog as your metastore, or configure an external metastore. EMR Serverless supports `hms` as the sync mode for Hive tables for Hudi workloads. EMR Serverless activates this property as a default. To learn more about how to set up your metastore, refer to Metastore configuration for EMR Serverless.

   > **Important**
   >
   > EMR Serverless doesn't support `HIVEQL` or `JDBC` as sync mode options for Hive tables to handle Hudi workloads. To learn more, refer to Sync modes.

When you use the AWS Glue Data Catalog as your metastore, specify the following configuration properties for your Hudi job.

```
--conf spark.jars=/usr/lib/hudi/hudi-spark-bundle.jar,
--conf spark.serializer=org.apache.spark.serializer.KryoSerializer,
--conf
 spark.hadoop.hive.metastore.client.factory.class=com.amazonaws.glue.catalog.metastore.AWSG
```

To learn more about Apache Hudi releases of Amazon EMR, refer to Hudi release history.

Using Apache Iceberg with EMR Serverless

This section describes how to use Apache Iceberg with EMR Serverless applications. Apache Iceberg is a table format that helps working with large data sets in data lakes.

To use Apache Iceberg with EMR Serverless applications

1. Set the required Spark properties in the corresponding Spark job run.

```
spark.jars=/usr/share/aws/iceberg/lib/iceberg-spark3-runtime.jar
```

2. Designate either the AWS Glue Data Catalog as your metastore or configure an external metastore. To learn more about setting up your metastore, refer to Metastore configuration for EMR Serverless.

   Configure the metastore properties that you want to use for Iceberg. For example, if you want to use the AWS Glue Data Catalog, set the following properties in the application configuration.

```
spark.sql.catalog.dev.warehouse=s3://amzn-s3-demo-bucket/EXAMPLE-PREFIX/
spark.sql.extensions=org.apache.iceberg.spark.extensions.IcebergSparkSessionExtensions
spark.sql.catalog.dev=org.apache.iceberg.spark.SparkCatalog
spark.sql.catalog.dev.catalog-impl=org.apache.iceberg.aws.glue.GlueCatalog
spark.hadoop.hive.metastore.client.factory.class=com.amazonaws.glue.catalog.metastore.AWSGl
```

   When you use the AWS Glue Data Catalog as your metastore, specify the following configuration properties for your Iceberg job.

```
--conf spark.jars=/usr/share/aws/iceberg/lib/iceberg-spark3-runtime.jar,
--conf
 spark.sql.extensions=org.apache.iceberg.spark.extensions.IcebergSparkSessionExtensions,
--conf spark.sql.catalog.dev=org.apache.iceberg.spark.SparkCatalog,
--conf spark.sql.catalog.dev.catalog-impl=org.apache.iceberg.aws.glue.GlueCatalog,
--conf spark.sql.catalog.dev.warehouse=s3://amzn-s3-demo-bucket/EXAMPLE-PREFIX/
--conf
 spark.hadoop.hive.metastore.client.factory.class=com.amazonaws.glue.catalog.metastore.AWSG
```

To learn more about Apache Iceberg releases of Amazon EMR, refer to Iceberg release history.

Using Python libraries with EMR Serverless

When you run PySpark jobs on Amazon EMR Serverless applications, package various Python libraries as dependencies. To do this, use native Python features, build a virtual environment, or directly configure your PySpark jobs to use Python libraries. This page covers each approach.

Using native Python features

When you set the following configuration, use PySpark to upload Python files (`.py`), zipped Python packages (`.zip`), and Egg files (`.egg`) to Spark executors.

```
--conf spark.submit.pyFiles=s3://amzn-s3-demo-bucket/EXAMPLE-PREFIX/<.py|.egg|.zip
 file>
```

For more details about how to use Python virtual environments for PySpark jobs, refer to Using PySpark Native Features.

When using EMR Notebook, you can make the Python dependency available in your Notebook by executing the following code:

```
    %%configure -f
 {
    "conf": {
    "spark.submit.pyFiles":"s3:///amzn-s3-demo-bucket/EXAMPLE-PREFIX/<.py|.egg|.zip
 file>
                   }
 }
```

Building a Python virtual environment

To package multiple Python libraries for a PySpark job, create isolated Python virtual environments.

1. To build the Python virtual environment, use the following commands. The example shown installs the packages `scipy` and `matplotlib` into a virtual environment package and copies the archive to an Amazon S3 location.

   > ⚠ **Important**
   >
   > You must run the following commands in a similar Amazon Linux 2 environment with the same version of Python as you use in EMR Serverless, that is, Python 3.7.10 for Amazon EMR release 6.6.0. You can find an example Dockerfile in the EMR Serverless Samples GitHub repository.

   ```
   # initialize a python virtual environment
   python3 -m venv pyspark_venvsource
   source pyspark_venvsource/bin/activate

   # optionally, ensure pip is up-to-date
   pip3 install --upgrade pip

   # install the python packages
   pip3 install scipy
   pip3 install matplotlib

   # package the virtual environment into an archive
   pip3 install venv-pack
   venv-pack -f -o pyspark_venv.tar.gz

   # copy the archive to an S3 location
   aws s3 cp pyspark_venv.tar.gz s3://amzn-s3-demo-bucket/EXAMPLE-PREFIX/

   # optionally, remove the virtual environment directory
   rm -fr pyspark_venvsource
   ```

2. Submit the Spark job with your properties set to use the Python virtual environment.

```
--conf spark.archives=s3://amzn-s3-demo-bucket/EXAMPLE-PREFIX/
pyspark_venv.tar.gz#environment
--conf spark.emr-serverless.driverEnv.PYSPARK_DRIVER_PYTHON=./environment/bin/
python
--conf spark.emr-serverless.driverEnv.PYSPARK_PYTHON=./environment/bin/python
--conf spark.executorEnv.PYSPARK_PYTHON=./environment/bin/python
```

Note that if you don't override the original Python binary, the second configuration in the preceding sequence of settings will be `--conf spark.executorEnv.PYSPARK_PYTHON=python`.

For more on how to use Python virtual environments for PySpark jobs, refer to Using Virtualenv. For more examples of how to submit Spark jobs, refer to Using Spark configurations when you run EMR Serverless jobs.

Configuring PySpark jobs to use Python libraries

With Amazon EMR releases 6.12.0 and higher, you can directly configure EMR Serverless PySpark jobs to use popular data science Python libraries like pandas, NumPy, and PyArrow without any additional setup.

The following examples demonstrate how to package each Python library for a PySpark job.

NumPy

NumPy is a Python library for scientific computing that offers multidimensional arrays and operations for math, sorting, random simulation, and basic statistics. To use NumPy, run the following command:

```
import numpy
```

pandas

pandas is a Python library that is built on NumPy. The pandas library provides datas scientists with DataFrame data structures and data analysis tools. To use pandas, run the following command:

```
import pandas
```

PyArrow

PyArrow is a Python library that manages in-memory columnar data for improved job performance. PyArrow is based on the Apache Arrow cross-language development specification, which is a standard way to represent and exchange data in a columnar format. To use PyArrow, run the following command:

```
import pyarrow
```

Using different Python versions with EMR Serverless

In addition to the use case in Using Python libraries with EMR Serverless, you can also use Python virtual environments to work with different Python versions than the version packaged in the Amazon EMR release for your Amazon EMR Serverless application. To do this, build a Python virtual environment with the Python version you want to use.

To submit a job from a Python virtual environment

1. Build your virtual environment with the commands in the following example. This example installs Python 3.9.9 into a virtual environment package and copies the archive to an Amazon S3 location.

   ⚠ **Important**

   If you use Amazon EMR releases 7.0.0 and higher, run your commands in an Amazon Linux 2023 environment similar to the one you use for your EMR Serverless applications.
   If you use release 6.15.0 or lower, run the following commands in a similar Amazon Linux 2 environment.

   ```
   # install Python 3.9.9 and activate the venv
   yum install -y gcc openssl-devel bzip2-devel libffi-devel tar gzip wget make
   wget https://www.python.org/ftp/python/3.9.9/Python-3.9.9.tgz && \
   tar xzf Python-3.9.9.tgz && cd Python-3.9.9 && \
   ./configure --enable-optimizations && \
   make altinstall
   ```

```
# create python venv with Python 3.9.9
python3.9 -m venv pyspark_venv_python_3.9.9 --copies
source pyspark_venv_python_3.9.9/bin/activate

# copy system python3 libraries to venv
cp -r /usr/local/lib/python3.9/* ./pyspark_venv_python_3.9.9/lib/python3.9/

# package venv to archive.
# **Note** that you have to supply --python-prefix option
# to make sure python starts with the path where your
# copied libraries are present.
# Copying the python binary to the "environment" directory.
pip3 install venv-pack
venv-pack -f -o pyspark_venv_python_3.9.9.tar.gz --python-prefix /home/hadoop/
environment

# stage the archive in S3
aws s3 cp pyspark_venv_python_3.9.9.tar.gz s3://<path>

# optionally, remove the virtual environment directory
rm -fr pyspark_venv_python_3.9.9
```

2. Set your properties to use the Python virtual environment and submit the Spark job.

```
# note that the archive suffix "environment" is the same as the directory where you
 copied the Python binary.
--conf spark.archives=s3://amzn-s3-demo-bucket/EXAMPLE-PREFIX/
pyspark_venv_python_3.9.9.tar.gz#environment
--conf spark.emr-serverless.driverEnv.PYSPARK_DRIVER_PYTHON=./environment/bin/
python
--conf spark.emr-serverless.driverEnv.PYSPARK_PYTHON=./environment/bin/python
--conf spark.executorEnv.PYSPARK_PYTHON=./environment/bin/python
```

For more on how to use Python virtual environments for PySpark jobs, refer to Using Virtualenv. For more examples of how to submit Spark jobs, refer to Using Spark configurations when you run EMR Serverless jobs.

Using Delta Lake OSS with EMR Serverless

Amazon EMR versions 6.9.0 and higher

Note

Amazon EMR 7.0.0 and higher uses Delta Lake 3.0.0, which renames the `delta-core.jar` file to `delta-spark.jar`. If you use Amazon EMR 7.0.0 or higher, make sure to specify `delta-spark.jar` in your configurations.

Amazon EMR 6.9.0 and higher includes Delta Lake, so you no longer have to package Delta Lake yourself or provide the `--packages` flag with your EMR Serverless jobs.

1. When you submit EMR Serverless jobs, make sure that you have the following configuration properties and include the following parameters in the `sparkSubmitParameters` field.

```
--conf spark.jars=/usr/share/aws/delta/lib/delta-core.jar,/usr/share/aws/delta/lib/
delta-storage.jar
    --conf spark.sql.extensions=io.delta.sql.DeltaSparkSessionExtension
    --conf
 spark.sql.catalog.spark_catalog=org.apache.spark.sql.delta.catalog.DeltaCatalog
```

2. Create a local `delta_sample.py` to test creating and reading a Delta table.

```
# delta_sample.py
    from pyspark.sql import SparkSession

    import uuid

    url = "s3://amzn-s3-demo-bucket/delta-lake/output/%s/" % str(uuid.uuid4())
    spark = SparkSession.builder.appName("DeltaSample").getOrCreate()

    ## creates a Delta table and outputs to target S3 bucket
    spark.range(5).write.format("delta").save(url)

    ## reads a Delta table and outputs to target S3 bucket
    spark.read.format("delta").load(url).show
```

3. Using the AWS CLI, upload the `delta_sample.py` file to your Amazon S3 bucket. Then use the `start-job-run` command to submit a job to an existing EMR Serverless application.

```
aws s3 cp delta_sample.py s3://amzn-s3-demo-bucket/code/

    aws emr-serverless start-job-run \
        --application-id application-id \
        --execution-role-arn job-role-arn \
        --name emr-delta \
        --job-driver '{
            "sparkSubmit": {
                "entryPoint": "s3://amzn-s3-demo-bucket/code/delta_sample.py",
                "sparkSubmitParameters": "--conf spark.jars=/usr/share/
aws/delta/lib/delta-core.jar,/usr/share/aws/delta/lib/delta-storage.jar --
conf spark.sql.extensions=io.delta.sql.DeltaSparkSessionExtension --conf
 spark.sql.catalog.spark_catalog=org.apache.spark.sql.delta.catalog.DeltaCatalog"
            }
        }'
```

To use Python libraries with Delta Lake, add the `delta-core` library by packaging it as a dependency or by using it as a custom image.

Alternatively, you can use the `SparkContext.addPyFile` to add the Python libraries from the `delta-core` JAR file:

```
import glob
from pyspark.sql import SparkSession

spark = SparkSession.builder.getOrCreate()
spark.sparkContext.addPyFile(glob.glob("/usr/share/aws/delta/lib/delta-core_*.jar")[0])
```

Amazon EMR versions 6.8.0 and lower

If you're using Amazon EMR 6.8.0 or lower, follow these steps to use Delta Lake OSS with your EMR Serverless applications.

1. To build an open source version of Delta Lake that’s compatible with the version of Spark on your Amazon EMR Serverless application, navigate to the Delta GitHub and follow the instructions.
2. Upload the Delta Lake libraries to an Amazon S3 bucket in your AWS account.
3. When you submit EMR Serverless jobs in the application configuration, include the Delta Lake JAR files that are now in your bucket.

```
--conf spark.jars=s3://amzn-s3-demo-bucket/jars/delta-core_2.12-1.1.0.jar
```

4. To ensure that you can read to and write from a Delta table, run a sample PySpark test.

```
from pyspark import SparkConf, SparkContext
    from pyspark.sql import HiveContext, SparkSession

    import uuid

    conf = SparkConf()
    sc = SparkContext(conf=conf)
    sqlContext = HiveContext(sc)

    url = "s3://amzn-s3-demo-bucket/delta-lake/output/1.0.1/%s/" %
 str(uuid.uuid4())

    ## creates a Delta table and outputs to target S3 bucket
    session.range(5).write.format("delta").save(url)

    ## reads a Delta table and outputs to target S3 bucket
    session.read.format("delta").load(url).show
```

Submitting EMR Serverless jobs from Airflow

The Amazon Provider in Apache Airflow provides EMR Serverless operators. For more information about operators, refer to Amazon EMR Serverless Operators in the Apache Airflow documentation.

You can use `EmrServerlessCreateApplicationOperator` to create a Spark or Hive application. You can also use `EmrServerlessStartJobOperator` to start one or more jobs with the your new application.

To use the operator with Amazon Managed Workflows for Apache Airflow (MWAA) with Airflow 2.2.2, add the following line to your `requirements.txt` file and update your MWAA environment to use the new file.

```
apache-airflow-providers-amazon==6.0.0
boto3>=1.23.9
```

Note that EMR Serverless support was added to release 5.0.0 of the Amazon provider. Release 6.0.0 is the last version compatible with Airflow 2.2.2. You can use later versions with Airflow 2.4.3 on MWAA.

The following abbreviated example shows how to create an application, run multiple Spark jobs, and then stop the application. A full example is available in the EMR Serverless Samples GitHub repository. For additional details of `sparkSubmit` configuration, refer to Using Spark configurations when you run EMR Serverless jobs.

```
from datetime import datetime

from airflow import DAG
from airflow.providers.amazon.aws.operators.emr import (
    EmrServerlessCreateApplicationOperator,
    EmrServerlessStartJobOperator,
    EmrServerlessDeleteApplicationOperator,
)

# Replace these with your correct values
JOB_ROLE_ARN = "arn:aws:iam::account-id:role/emr_serverless_default_role"
S3_LOGS_BUCKET = "amzn-s3-demo-bucket"

DEFAULT_MONITORING_CONFIG = {
    "monitoringConfiguration": {
        "s3MonitoringConfiguration": {"logUri": f"s3://amzn-s3-demo-bucket/logs/"}
    },
}

with DAG(
    dag_id="example_endtoend_emr_serverless_job",
    schedule_interval=None,
    start_date=datetime(2021, 1, 1),
    tags=["example"],
    catchup=False,
) as dag:
    create_app = EmrServerlessCreateApplicationOperator(
        task_id="create_spark_app",
        job_type="SPARK",
        release_label="emr-6.7.0",
        config={"name": "airflow-test"},
    )

    application_id = create_app.output
    job1 = EmrServerlessStartJobOperator(
        task_id="start_job_1",
        application_id=application_id,
        execution_role_arn=JOB_ROLE_ARN,
        job_driver={
            "sparkSubmit": {
                "entryPoint": "local:///usr/lib/spark/examples/src/main/python/
pi_fail.py",
            }
        },
        configuration_overrides=DEFAULT_MONITORING_CONFIG,
    )

    job2 = EmrServerlessStartJobOperator(
        task_id="start_job_2",
        application_id=application_id,
        execution_role_arn=JOB_ROLE_ARN,
        job_driver={
            "sparkSubmit": {
                "entryPoint": "local:///usr/lib/spark/examples/src/main/python/pi.py",
                "entryPointArguments": ["1000"]
            }
        },
        configuration_overrides=DEFAULT_MONITORING_CONFIG,
    )

    delete_app = EmrServerlessDeleteApplicationOperator(
        task_id="delete_app",
        application_id=application_id,
        trigger_rule="all_done",
    )

    (create_app >> [job1, job2] >> delete_app)
```

Using Hive user-defined functions with EMR Serverless

Hive user-defined functions (UDFs) let you create custom functions to process records or groups of records. In this tutorial, you'll use a sample UDF with a pre-existing Amazon EMR Serverless application to run a job that outputs a query result. To learn how to set up an application, refer to Getting started with Amazon EMR Serverless.

To use a UDF with EMR Serverless

1. Navigate to the GitHub for a sample UDF. Clone the repo and switch to the git branch that you want to use. Update the `maven-compiler-plugin` in the `pom.xml` file of the repository to have a source. Also update the target java version configuration to `1.8`. Run `mvn package -DskipTests` to create the JAR file that contains your sample UDFs.
2. After you create the JAR file, upload it to your S3 bucket with the following command.

    ```
    aws s3 cp brickhouse-0.8.2-JS.jar s3://amzn-s3-demo-bucket/jars/
    ```

3. Create an example file to use one of the sample UDF functions. Save this query as `udf_example.q` and upload it to your S3 bucket.

    ```
    add jar s3://amzn-s3-demo-bucket/jars/brickhouse-0.8.2-JS.jar;
    CREATE TEMPORARY FUNCTION from_json AS 'brickhouse.udf.json.FromJsonUDF';
    select from_json('{"key1":[0,1,2], "key2":[3,4,5,6], "key3":[7,8,9]}', map("",
     array(cast(0 as int))));
    select from_json('{"key1":[0,1,2], "key2":[3,4,5,6], "key3":[7,8,9]}', map("",
     array(cast(0 as int))))["key1"][2];
    ```

4. Submit the following Hive job.

    ```
    aws emr-serverless start-job-run \
      --application-id application-id \
      --execution-role-arn job-role-arn \
      --job-driver '{
        "hive": {
            "query": "s3://amzn-s3-demo-bucket/queries/udf_example.q",
            "parameters": "--hiveconf hive.exec.scratchdir=s3://amzn-s3-demo-bucket/
    emr-serverless-hive/scratch --hiveconf hive.metastore.warehouse.dir=s3://'$BUCKET'/
    emr-serverless-hive/warehouse"
        }
    }' --configuration-overrides '{
        "applicationConfiguration": [{
            "classification": "hive-site",
            "properties": {
                "hive.driver.cores": "2",
                "hive.driver.memory": "6G"
            }
        }],
        "monitoringConfiguration": {
            "s3MonitoringConfiguration": {
    ```

```
            "logUri": "s3://amzn-s3-demo-bucket/logs/"
        }
    }
}'
```

5. Use the `get-job-run` command to check your job's state. Wait for the state to change to SUCCESS.

```
aws emr-serverless get-job-run --application-id application-id --job-run-id job-id
```

6. Download the output files with the following command.

```
aws s3 cp --recursive s3://amzn-s3-demo-bucket/logs/applications/application-id/
jobs/job-id/HIVE_DRIVER/ .
```

The `stdout.gz` file resembles the following.

```
{"key1":[0,1,2],"key2":[3,4,5,6],"key3":[7,8,9]}
2
```

Using custom images with EMR Serverless

Topics

Use a custom Python version

You can build a custom image to use a different version of Python. To use Python version 3.10 for Spark jobs, for example, run the following command:

```
FROM public.ecr.aws/emr-serverless/spark/emr-6.9.0:latest
```

```
USER root

# install python 3
RUN yum install -y gcc openssl-devel bzip2-devel libffi-devel tar gzip wget make
RUN wget https://www.python.org/ftp/python/3.10.0/Python-3.10.0.tgz && \
tar xzf Python-3.10.0.tgz && cd Python-3.10.0 && \
./configure --enable-optimizations && \
make altinstall

# EMRS runs the image as hadoop
USER hadoop:hadoop
```

Before you submit the Spark job, set your properties to use the Python virtual environment, as follows.

```
--conf spark.emr-serverless.driverEnv.PYSPARK_DRIVER_PYTHON=/usr/local/bin/python3.10
--conf spark.emr-serverless.driverEnv.PYSPARK_PYTHON=/usr/local/bin/python3.10
--conf spark.executorEnv.PYSPARK_PYTHON=/usr/local/bin/python3.10
```

Use a custom Java version

The following example demonstrates how to build a custom image to use Java 11 for your Spark jobs.

```
FROM public.ecr.aws/emr-serverless/spark/emr-6.9.0:latest

USER root

# install JDK 11
RUN amazon-linux-extras install java-openjdk11

# EMRS runs the image as hadoop
USER hadoop:hadoop
```

Before you submit the Spark job, set Spark properties to use Java 11, as follows.

```
--conf spark.executorEnv.JAVA_HOME=/usr/lib/jvm/java-11-
openjdk-11.0.16.0.8-1.amzn2.0.1.x86_64
--conf spark.emr-serverless.driverEnv.JAVA_HOME=/usr/lib/jvm/java-11-
openjdk-11.0.16.0.8-
```

Build a data science image

The following example shows how to include common, data science Python packages, such as Pandas and NumPy.

```
FROM public.ecr.aws/emr-serverless/spark/emr-6.9.0:latest

USER root

# python packages
RUN pip3 install boto3 pandas numpy
RUN pip3 install -U scikit-learn==0.23.2 scipy
RUN pip3 install sk-dist
RUN pip3 install xgboost

# EMR Serverless runs the image as hadoop
USER hadoop:hadoop
```

Processing geospatial data with Apache Sedona

The following example shows how to build an image to include Apache Sedona for geospatial processing.

```
FROM public.ecr.aws/emr-serverless/spark/emr-6.9.0:latest

USER root

RUN yum install -y wget
RUN wget https://repo1.maven.org/maven2/org/apache/sedona/sedona-core-3.0_2.12/1.3.0-
incubating/sedona-core-3.0_2.12-1.3.0-incubating.jar -P /usr/lib/spark/jars/
RUN pip3 install apache-sedona

# EMRS runs the image as hadoop
USER hadoop:hadoop
```

Licensing information for using custom images

You can build custom images with EMR Serverless to perform specific tasks or to use specific versions of a software package. Modification and distribution of custom images can be subject to rules and licensing terms. The licensing text appears in the subsection that follows.

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For more information about using custom images, refer to Using custom images with EMR Serverless.

Using Amazon Redshift integration for Apache Spark on Amazon EMR Serverless

With Amazon EMR release 6.9.0 and later, every release image includes a connector between Apache Spark and Amazon Redshift. With this connector, use Spark on Amazon EMR Serverless to process data stored in Amazon Redshift. The integration is based on the `spark-redshift` open-source connector. For Amazon EMR Serverless, the Amazon Redshift integration for Apache Spark is included as a native integration.

Topics

Launching a Spark application with the Amazon Redshift integration for Apache Spark

To use the integration with EMR Serverless 6.9.0, pass the required Spark-Redshift dependencies with your Spark job. Use `--jars` to include Redshift connector related libraries. To access other file locations supported by the `--jars` option, refer to the [Advanced Dependency Management](#) section of the Apache Spark documentation.

- `spark-redshift.jar`
- `spark-avro.jar`
- `RedshiftJDBC.jar`
- `minimal-json.jar`

Amazon EMR releases 6.10.0 and higher don't require the `minimal-json.jar` dependency, and automatically install the other dependencies to each cluster by default. The following examples demonstrate how to launch a Spark application with the Amazon Redshift integration for Apache Spark.

Amazon EMR 6.10.0 +

Launch a Spark job on Amazon EMR Serverless with the Amazon Redshift integration for Apache Spark on EMR Serverless release 6.10.0 and higher.

```
spark-submit my_script.py
```

Amazon EMR 6.9.0

To launch a Spark job on Amazon EMR Serverless with the Amazon Redshift integration for Apache Spark on EMR Serverless release 6.9.0, use the `--jars` option as shown in the following example. Note that the paths listed with the `--jars` option are the default paths for the JAR files.

```
--jars
    /usr/share/aws/redshift/jdbc/RedshiftJDBC.jar,
    /usr/share/aws/redshift/spark-redshift/lib/spark-redshift.jar,
    /usr/share/aws/redshift/spark-redshift/lib/spark-avro.jar,
    /usr/share/aws/redshift/spark-redshift/lib/minimal-json.jar
```

```
spark-submit \
  --jars /usr/share/aws/redshift/jdbc/RedshiftJDBC.jar,/usr/share/aws/redshift/
spark-redshift/lib/spark-redshift.jar,/usr/share/aws/redshift/spark-redshift/lib/
spark-avro.jar,/usr/share/aws/redshift/spark-redshift/lib/minimal-json.jar \
  my_script.py
```

Authenticating with the Amazon Redshift integration for Apache Spark

Use AWS Secrets Manager to retrieve credentials and connect to Amazon Redshift

You can securely authenticate to Amazon Redshift by storing the credentials in Secrets Manager and have the Spark job call the `GetSecretValue` API to fetch it:

```
from pyspark.sql import SQLContextimport boto3

sc = # existing SparkContext
sql_context = SQLContext(sc)

secretsmanager_client = boto3.client('secretsmanager',
 region_name=os.getenv('AWS_REGION'))
secret_manager_response = secretsmanager_client.get_secret_value(
    SecretId='string',
    VersionId='string',
    VersionStage='string'
)
username = # get username from secret_manager_response
password = # get password from secret_manager_response
url = "jdbc:redshift://redshifthost:5439/database?user=" + username + "&password="
 + password

# Access to Redshift cluster using Spark
```

Authenticate to Amazon Redshift with a JDBC driver

Set username and password inside the JDBC URL

You can authenticate a Spark job to an Amazon Redshift cluster by specifying the Amazon Redshift database name and password in the JDBC URL.

Note

If you pass the database credentials in the URL, anyone who has access to the URL can also access the credentials. This method isn't generally recommended because it's not a secure option.

If security isn't a concern for your application, use the following format to set the username and password in the JDBC URL:

```
jdbc:redshift://redshifthost:5439/database?user=username&password=password
```

Use IAM based authentication with Amazon EMR Serverless job execution role

Starting with Amazon EMR Serverless release 6.9.0, the Amazon Redshift JDBC driver 2.1 or higher is packaged into the environment. With JDBC driver 2.1 and higher, you can specify the JDBC URL and not include the raw username and password.

Instead, specify `jdbc:redshift:iam://` scheme. This commands the JDBC driver to use your EMR Serverless job execution role to fetch the credentials automatically. Refer to Configure a JDBC or ODBC connection to use IAM credentials in the *Amazon Redshift Management Guide* for more information. An example of this URL is:

```
jdbc:redshift:iam://examplecluster.abc123xyz789.us-west-2.redshift.amazonaws.com:5439/
dev
```

The following permissions are required for your job execution role when the provided conditions are met:

Permission	Conditions when required for job execution role
`redshift:GetClusterCredentials`	Required for JDBC driver to fetch the credentials from Amazon Redshift
`redshift:DescribeCluster`	Required if you specify the Amazon Redshift cluster and AWS Region in the JDBC URL instead of endpoint

Permission	Conditions when required for job execution role
`redshift-serverless:GetCredentials`	Required for JDBC driver to fetch the credentials from Amazon Redshift Serverless
`redshift-serverless:GetWorkgroup`	Required if you are using Amazon Redshift Serverless and you are specifying the URL in terms of workgroup name and Region

Connecting to Amazon Redshift within a different VPC

When you set up a provisioned Amazon Redshift cluster or Amazon Redshift Serverless workgroup under a VPC, configure VPC connectivity for your Amazon EMR Serverless application to access to the resources. For more information on how to configure VPC connectivity on an EMR Serverless application, refer to Configuring VPC access for EMR Serverless applications to connect to data.

- If your provisioned Amazon Redshift cluster or Amazon Redshift Serverless workgroup is publicly accessible, specify one or more private subnets that have a NAT gateway attached when you create EMR Serverless applications.
- If your provisioned Amazon Redshift cluster or Amazon Redshift Serverless workgroup isn't publicly accessible, you must create an Amazon Redshift managed VPC endpoint for your Amazon Redshift cluster as described in Configuring VPC access for EMR Serverless applications to connect to data. Alternatively, you can create your Amazon Redshift Serverless workgroup as described in Connecting to Amazon Redshift Serverless in the *Amazon Redshift Management Guide*. You must associate your cluster or your subgroup to the private subnets that you specify when you create your EMR Serverless application.

Note

If you use IAM based authentication, and your private subnets for the EMR Serverless application don't have a NAT gateway attached, then you must also create a VPC endpoint on those subnets for Amazon Redshift or Amazon Redshift Serverless. This way, the JDBC driver can fetch the credentials.

Reading and writing from and to Amazon Redshift

The following code examples use PySpark to read and write sample data from and to an Amazon Redshift database with a data source API and with SparkSQL.

Data source API

Use PySpark to read and write sample data from and to an Amazon Redshift database with data source API.

```
import boto3
from pyspark.sql import SQLContext

sc = # existing SparkContext
sql_context = SQLContext(sc)

url = "jdbc:redshift:iam://redshifthost:5439/database"
aws_iam_role_arn = "arn:aws:iam::account-id:role/role-name"

df = sql_context.read \
    .format("io.github.spark_redshift_community.spark.redshift") \
    .option("url", url) \
    .option("dbtable", "table-name") \
    .option("tempdir", "s3://path/for/temp/data") \
    .option("aws_iam_role", "aws-iam-role-arn") \
    .load()

df.write \
    .format("io.github.spark_redshift_community.spark.redshift") \
    .option("url", url) \
    .option("dbtable", "table-name-copy") \
    .option("tempdir", "s3://path/for/temp/data") \
    .option("aws_iam_role", "aws-iam-role-arn") \
    .mode("error") \
    .save()
```

SparkSQL

Use PySpark to read and write sample data from and to an Amazon Redshift database with SparkSQL.

```
import boto3
import json
import sys
import os
from pyspark.sql import SparkSession

spark = SparkSession \
    .builder \
    .enableHiveSupport() \
    .getOrCreate()

url = "jdbc:redshift:iam://redshifthost:5439/database"
aws_iam_role_arn = "arn:aws:iam::account-id:role/role-name"

bucket = "s3://path/for/temp/data"
tableName = "table-name" # Redshift table name

s = f"""CREATE TABLE IF NOT EXISTS {table-name} (country string, data string)
    USING io.github.spark_redshift_community.spark.redshift
    OPTIONS (dbtable '{table-name}', tempdir '{bucket}', url '{url}', aws_iam_role
 '{aws-iam-role-arn}' ); """

spark.sql(s)

columns = ["country" ,"data"]
data = [("test-country","test-data")]
df = spark.sparkContext.parallelize(data).toDF(columns)

# Insert data into table
df.write.insertInto(table-name, overwrite=False)
df = spark.sql(f"SELECT * FROM {table-name}")
df.show()
```

Considerations and limitations when using the Spark connector

- We suggest that you turn on SSL for the JDBC connection from Spark on Amazon EMR to Amazon Redshift.
- We suggest that you manage the credentials for the Amazon Redshift cluster in AWS Secrets Manager as a best practice. Refer to Using AWS Secrets Manager to retrieve credentials for connecting to Amazon Redshift for an example.
- We suggest that you pass an IAM role with the parameter `aws_iam_role` for the Amazon Redshift authentication parameter.

- The parameter `tempformat` currently doesn't support the Parquet format.
- The `tempdir` URI points to an Amazon S3 location. This temp directory isn't cleaned up automatically and therefore could add additional cost.
- Consider the following recommendations for Amazon Redshift:
  - We suggest that you block public access to the Amazon Redshift cluster.
  - We suggest that you turn on Amazon Redshift audit logging.
  - We suggest that you turn on Amazon Redshift at-rest encryption.
- Consider the following recommendations for Amazon S3:
  - We suggest that you block public access to Amazon S3 buckets.
  - We suggest that you use Amazon S3 server-side encryption to encrypt the Amazon S3 buckets used.
  - We suggest that you use Amazon S3 lifecycle policies to define the retention rules for the Amazon S3 bucket.
  - Amazon EMR always verifies code imported from open-source into the image. For security, we don't support the following authentication methods from Spark to Amazon S3:
    - Setting AWS access keys in the `hadoop-env` configuration classification
    - Encoding AWS access keys in the `tempdir` URI

For more information on using the connector and its supported parameters, see the following resources:

- Amazon Redshift integration for Apache Spark in the *Amazon Redshift Management Guide*
- The `spark-redshift` community repository on Github

Connecting to DynamoDB with Amazon EMR Serverless

In this tutorial, you upload a subset of data from the United States Board on Geographic Names to an Amazon S3 bucket and then use Hive or Spark on Amazon EMR Serverless to copy the data to an Amazon DynamoDB table for querying.

Step 1: Upload data to an Amazon S3 bucket

To create an Amazon S3 bucket, follow the instructions in Creating a bucket in the *Amazon Simple Storage Service Console User Guide*. Replace references to *amzn-s3-demo-bucket* with the name of your newly created bucket. Now your EMR Serverless application is ready to run jobs.

1. Download the sample data archive `features.zip` with the following command.

   ```
   wget https://docs.aws.amazon.com/amazondynamodb/latest/developerguide/samples/
   features.zip
   ```

2. Extract the `features.txt` file from the archive and access the first the few lines in the file:

   ```
   unzip features.zip
   head features.txt
   ```

   The result should appear similar to the following.

   ```
   1535908|Big Run|Stream|WV|38.6370428|-80.8595469|794
   875609|Constable Hook|Cape|NJ|40.657881|-74.0990309|7
   1217998|Gooseberry Island|Island|RI|41.4534361|-71.3253284|10
   26603|Boone Moore Spring|Spring|AZ|34.0895692|-111.410065|3681
   1506738|Missouri Flat|Flat|WA|46.7634987|-117.0346113|2605
   1181348|Minnow Run|Stream|PA|40.0820178|-79.3800349|1558
   1288759|Hunting Creek|Stream|TN|36.343969|-83.8029682|1024
   533060|Big Charles Bayou|Bay|LA|29.6046517|-91.9828654|0
   829689|Greenwood Creek|Stream|NE|41.596086|-103.0499296|3671
   541692|Button Willow Island|Island|LA|31.9579389|-93.0648847|98
   ```

   The fields in each line here indicate a unique identifier, name, type of natural feature, state, latitude in degrees, longitude in degrees, and height in feet.

3. Upload your data to Amazon S3

   ```
   aws s3 cp features.txt s3://amzn-s3-demo-bucket/features/
   ```

Step 2: Create a Hive table

Use Apache Spark or Hive to create a new Hive table that contains the uploaded data in Amazon S3.

Spark

To create a Hive table with Spark, run the following command.

```
import org.apache.spark.sql.SparkSession

val sparkSession = SparkSession.builder().enableHiveSupport().getOrCreate()

sparkSession.sql("CREATE TABLE hive_features \
    (feature_id BIGINT, \
    feature_name STRING, \
    feature_class STRING, \
    state_alpha STRING, \
    prim_lat_dec DOUBLE, \
    prim_long_dec DOUBLE, \
    elev_in_ft BIGINT) \
    ROW FORMAT DELIMITED \
    FIELDS TERMINATED BY '|' \
    LINES TERMINATED BY '\n' \
    LOCATION 's3://amzn-s3-demo-bucket/features';")
```

You now have a populated Hive table with data from the `features.txt` file. To verify that your data is in the table, run a Spark SQL query as shown in the following example.

```
sparkSession.sql(
    "SELECT state_alpha, COUNT(*) FROM hive_features GROUP BY state_alpha;")
```

Hive

To create a Hive table with Hive, run the following command.

```
CREATE TABLE hive_features
    (feature_id             BIGINT,
    feature_name            STRING ,
    feature_class           STRING ,
    state_alpha             STRING,
    prim_lat_dec            DOUBLE ,
    prim_long_dec           DOUBLE ,
    elev_in_ft              BIGINT)
    ROW FORMAT DELIMITED
    FIELDS TERMINATED BY '|'
    LINES TERMINATED BY '\n'
    LOCATION 's3://amzn-s3-demo-bucket/features';
```

You now have a Hive table that contains data from the `features.txt` file. To verify that your data is in the table, run a HiveQL query, as shown in the following example.

```
SELECT state_alpha, COUNT(*) FROM hive_features GROUP BY state_alpha;
```

Step 3: Copy data to DynamoDB

Use Spark or Hive to copy data to a new DynamoDB table.

Spark

To copy data from the Hive table that you created in the previous step to DynamoDB, follow **Steps 1-3** in Copy data to DynamoDB. This creates a new DynamoDB table called `Features`. You can then read data directly from the text file and copy it to your DynamoDB table, as the following example shows.

```
import com.amazonaws.services.dynamodbv2.model.AttributeValue
import org.apache.hadoop.dynamodb.DynamoDBItemWritable
import org.apache.hadoop.dynamodb.read.DynamoDBInputFormat
import org.apache.hadoop.io.Text
import org.apache.hadoop.mapred.JobConf
import org.apache.spark.SparkContext

import scala.collection.JavaConverters._

object EmrServerlessDynamoDbTest {

    def main(args: Array[String]): Unit = {

        jobConf.set("dynamodb.input.tableName", "Features")
        jobConf.set("dynamodb.output.tableName", "Features")
        jobConf.set("dynamodb.region", "region")

        jobConf.set("mapred.output.format.class",
 "org.apache.hadoop.dynamodb.write.DynamoDBOutputFormat")
        jobConf.set("mapred.input.format.class",
 "org.apache.hadoop.dynamodb.read.DynamoDBInputFormat")

        val rdd = sc.textFile("s3://amzn-s3-demo-bucket/ddb-connector/")
```

```
            .map(row => {
                val line = row.split("\\|")
                val item = new DynamoDBItemWritable()

                val elevInFt = if (line.length > 6) {
                    new AttributeValue().withN(line(6))
                } else {
                    new AttributeValue().withNULL(true)
                }

                item.setItem(Map(
                    "feature_id" -> new AttributeValue().withN(line(0)),
                    "feature_name" -> new AttributeValue(line(1)),
                    "feature_class" -> new AttributeValue(line(2)),
                    "state_alpha" -> new AttributeValue(line(3)),
                    "prim_lat_dec" -> new AttributeValue().withN(line(4)),
                    "prim_long_dec" -> new AttributeValue().withN(line(5)),
                    "elev_in_ft" -> elevInFt)
                    .asJava)
                (new Text(""), item)
        })
        rdd.saveAsHadoopDataset(jobConf)
    }
}
```

Hive

To copy data from the Hive table that you created in the previous step to DynamoDB, follow the instructions in Copy data to DynamoDB.

Step 4: Query data from DynamoDB

Use Spark or Hive to query your DynamoDB table.

Spark

To query data from the DynamoDB table that you created in the previous step, use either Spark SQL or the Spark MapReduce API.

Example– Query your DynamoDB table with Spark SQL

The following Spark SQL query returns a list of all the feature types in alphabetical order.

```
val dataFrame = sparkSession.sql("SELECT DISTINCT feature_class \
    FROM ddb_features \
    ORDER BY feature_class;")
```

The following Spark SQL query returns a list of all lakes that begin with the letter *M*.

```
val dataFrame = sparkSession.sql("SELECT feature_name, state_alpha \
    FROM ddb_features \
    WHERE feature_class = 'Lake' \
    AND feature_name LIKE 'M%' \
    ORDER BY feature_name;")
```

The following Spark SQL query returns a list of all states with at least three features that are higher than one mile.

```
val dataFrame = sparkSession.dql("SELECT state_alpha, feature_class, COUNT(*) \
    FROM ddb_features \
    WHERE elev_in_ft > 5280 \
    GROUP by state_alpha, feature_class \
    HAVING COUNT(*) >= 3 \
    ORDER BY state_alpha, feature_class;")
```

Example– Query your DynamoDB table with the Spark MapReduce API

The following MapReduce query returns a list of all the feature types in alphabetical order.

```
val df = sc.hadoopRDD(jobConf, classOf[DynamoDBInputFormat], classOf[Text],
 classOf[DynamoDBItemWritable])
    .map(pair => (pair._1, pair._2.getItem))
    .map(pair => pair._2.get("feature_class").getS)
    .distinct()
    .sortBy(value => value)
    .toDF("feature_class")
```

The following MapReduce query returns a list of all lakes that begin with the letter *M*.

```
val df = sc.hadoopRDD(jobConf, classOf[DynamoDBInputFormat], classOf[Text],
 classOf[DynamoDBItemWritable])
    .map(pair => (pair._1, pair._2.getItem))
    .filter(pair => "Lake".equals(pair._2.get("feature_class").getS))
    .filter(pair => pair._2.get("feature_name").getS.startsWith("M"))
    .map(pair => (pair._2.get("feature_name").getS,
 pair._2.get("state_alpha").getS))
    .sortBy(_._1)
    .toDF("feature_name", "state_alpha")
```

The following MapReduce query returns a list of all states with at least three features that are higher than one mile.

```
val df = sc.hadoopRDD(jobConf, classOf[DynamoDBInputFormat], classOf[Text],
 classOf[DynamoDBItemWritable])
    .map(pair => pair._2.getItem)
    .filter(pair => pair.get("elev_in_ft").getN != null)
    .filter(pair => Integer.parseInt(pair.get("elev_in_ft").getN) > 5280)
    .groupBy(pair => (pair.get("state_alpha").getS, pair.get("feature_class").getS))
    .filter(pair => pair._2.size >= 3)
    .map(pair => (pair._1._1, pair._1._2, pair._2.size))
    .sortBy(pair => (pair._1, pair._2))
    .toDF("state_alpha", "feature_class", "count")
```

Hive

To query data from the DynamoDB table that you created in the previous step, follow the instructions in Query the data in the DynamoDB table.

Setting up cross-account access

To set up cross-account access for EMR Serverless, complete the following steps. In the example, `AccountA` is the account where you created your Amazon EMR Serverless application, and `AccountB` is the account where your Amazon DynamoDB is located.

1. Create a DynamoDB table in `AccountB`. For more information, refer to Step 1: Create a table.
2. Create a `Cross-Account-Role-B` IAM role in `AccountB` that can access the DynamoDB table.
    a. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.
    b. Choose **Roles**, and create a new role called `Cross-Account-Role-B`. For more information on how to create IAM roles, refer to Creating IAM roles in the *a user Guide*.

c. Create an IAM policy that grants permissions to access the cross-account DynamoDB table. Then attach the IAM policy to `Cross-Account-Role-B`.

   The following is a policy that grants access to a DynamoDB table `CrossAccountTable`.

d. Edit the trust relationship for the `Cross-Account-Role-B` role.

   To configure the trust relationship for the role, choose the **Trust Relationships** tab in the IAM console for the role that you created in *Step 2: Cross-Account-Role-B*.

   Select **Edit Trust Relationship** and then add the following policy document. This document allows `Job-Execution-Role-A` in `AccountA` to assume this `Cross-Account-Role-B` role.

   JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "sts:AssumeRole"
      ],
      "Resource": "arn:aws:iam::123456789012:role/Job-Execution-Role-A",
      "Sid": "AllowSTSAssumerole"
    }
  ]
}
```

e. Grant `Job-Execution-Role-A` in `AccountA` with `- STS Assume role` permissions to assume `Cross-Account-Role-B`.

   In the IAM console for AWS account `AccountA`, select `Job-Execution-Role-A`. Add the following policy statement to the `Job-Execution-Role-A` to allow the `AssumeRole` action on the `Cross-Account-Role-B` role.

   JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "sts:AssumeRole"
      ],
      "Resource": [
        "arn:aws:iam::123456789012:role/Cross-Account-Role-B"
      ],
      "Sid": "AllowSTSAssumerole"
    }
  ]
}
```

f. Set the `dynamodb.customAWSCredentialsProvider` property with value as `com.amazonaws.emr.AssumeRoleAWSCredentialsProvider` in core-site classification. Set the environment variable `ASSUME_ROLE_CREDENTIALS_ROLE_ARN` with the ARN value of `Cross-Account-Role-B`.

3. Run Spark or Hive job using `Job-Execution-Role-A`.

Considerations

Note these behaviors and limitations when you use the DynamoDB connector with Apache Spark or Apache Hive.

Considerations when using the DynamoDB connector with Apache Spark

- Spark SQL doesn't support the creation of a Hive table with the storage-handler option. For more information, refer to Specifying storage format for Hive tables in the Apache Spark documentation.
- Spark SQL doesn't support the `STORED BY` operation with storage handler. If you want to interact with a DynamoDB table through an external Hive table, use Hive to create the table first.
- To translate a query to a DynamoDB query, the DynamoDB connector uses *predicate pushdown*. Predicate pushdown filters data by a column that is mapped to the partition key of a DynamoDB table. Predicate pushdown only operates when you use the connector with Spark SQL, and not with the MapReduce API.

Considerations when using the DynamoDB connector with Apache Hive

Tuning the maximum number of mappers

- If you use the `SELECT` query to read data from an external Hive table that maps to DynamoDB, the number of map tasks on EMR Serverless is calculated as the total read throughput configured for the DynamoDB table, divided by the throughput per map task. The default throughput per map task is 100.
- The Hive job can use the number of map tasks beyond the maximum number of containers configured per EMR Serverless application, depending upon the read throughput configured for DynamoDB. Also, a long-running Hive query can consume all of the provisioned read capacity of the DynamoDB table. This negatively impacts other users.
- You can use the `dynamodb.max.map.tasks` property to set an upper limit for map tasks. You can also use this property to tune the amount of data read by each map task based on the task container size.
- You can set the `dynamodb.max.map.tasks`property at Hive query level, or in the `hive-site` classification of the **start-job-run** command. This value must be equal to or greater than 1. When Hive processes your query, the resulting Hive job uses no more than the values of `dynamodb.max.map.tasks` when it reads from the DynamoDB table.

Tuning the write throughput per task

- Write throughput per task on EMR Serverless is calculated as the total write throughput that is configured for a DynamoDB table, divided by the value of the `mapreduce.job.maps` property. For Hive, the default value of this property is 2. Thusthe first two tasks in the final stage of Hive job can consume all of the write throughput . This leads to throttling of writes of other tasks in the same job or other jobs.
- To avoid write throttling, set the value of `mapreduce.job.maps` property based on the number of tasks in the final stage or the write throughput that you want to allocate per task. Set this property in the `mapred-site` classification of the **start-job-run** command on EMR Serverless.

Security

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 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 Amazon EMR Serverless, refer to 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 Amazon EMR Serverless. The topics explain how to configure Amazon EMR Serverless and use other AWS services to meet your security and compliance objectives.

Topics

- Resilience in Amazon EMR Serverless
- Infrastructure security in Amazon EMR Serverless
- Configuration and vulnerability analysis in Amazon EMR Serverless

Security best practices for Amazon EMR Serverless

Amazon EMR Serverless provides a number of security features to consider as you develop and implement your own security policies. The following best practices are general guidelines and don't represent a complete security solution. Because these best practices might not be appropriate or sufficient for your environment, treat them as helpful considerations rather than prescriptions.

Apply principle of least privilege

EMR Serverless provides a granular access policy for applications using IAM roles, such as execution roles. We suggest that execution roles be granted only the minimum set of privileges required by the job, such as covering your application and access to log destination. We also recommend auditing the jobs for permissions on a regular basis and upon any change to application code.

Isolate untrusted application code

EMR Serverless creates full network isolation between jobs belonging to different EMR Serverless applications. In cases where job-level isolation is desired, consider isolating jobs into different EMR Serverless applications.

Role-based access control (RBAC) permissions

Administrators should strictly control Role-based access control (RBAC) permissions for EMR Serverless applcations.

Data protection

The AWS shared responsibility model applies to data protection in Amazon EMR Serverless. As described in this model, AWS is responsible for protecting the global infrastructure that runs all of the AWS Cloud. You are responsible for maintaining control over your content that is hosted on this infrastructure. This content includes the security configuration and management tasks for the AWS services that you use. For more information about data privacy, refer to the Data Privacy FAQ. For information about data protection in Europe, refer to the AWS Shared Responsibility Model and GDPR blog post on the AWS Security Blog.

For data protection purposes, we suggest that you protect AWS account credentials and set up individual accounts with AWS Identity and Access Management (IAM). That way each user is given only the permissions necessary to fulfill their job duties. We also recommend that you secure your data in the following ways:

- Use multi-factor authentication (MFA) with each account.
- Use SSL/TLS to communicate with AWS resources. We suggest TLS 1.2 or later.
- Set up API and user activity logging with AWS CloudTrail.
- Use AWS encryption solutions, along with all default security controls within AWS services.
- Use advanced managed security services such as Amazon Macie, which assists in discovering and securing personal data that is stored in Amazon S3.
- Use Amazon EMR Serverless encryption options to encrypt data at rest and in transit.
- 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, refer to Federal Information Processing Standard (FIPS) 140-2.

We strongly suggest that you never put sensitive identifying information, such as your customers' account numbers, into free-form fields such as a **Name** field. This includes when you work with Amazon EMR Serverless or other AWS services using the console, API, AWS CLI, or AWS SDKs. Any data that you enter into Amazon EMR Serverless or other services might get picked up for inclusion in diagnostic logs. When you provide a URL to an external server, don't include credentials information in the URL to validate your request to that server.

Encryption at rest

Data encryption helps prevent unauthorized users from reading data on a cluster and associated data storage systems. This includes data saved to persistent media, known as data at rest, and data that may be intercepted as it travels the network, known as data in transit.

Data encryption requires keys and certificates. You can choose from several options, including keys managed by AWS Key Management Service, keys managed by Amazon S3, and keys and certificates from custom providers that you supply. When using AWS KMS as your key provider, charges apply for the storage and use of encryption keys. For more information, refer to AWS KMS pricing.

Before you specify encryption options, decide on the key and certificate management systems you want to use. Then create the keys and certificates for the custom providers that you specify as part of encryption settings.

Encryption at rest for EMRFS data in Amazon S3

Each EMR Serverless application uses a specific release version, which includes EMRFS (EMR File System). Amazon S3 encryption works with EMR File System (EMRFS) objects read from and written to Amazon S3. You can specify Amazon S3 server-side encryption (SSE) or client-side encryption (CSE) as the **Default encryption mode** when you enable encryption at rest. Optionally, specify different encryption methods for individual buckets using **Per bucket encryption overrides**. Regardless of whether Amazon S3 encryption is enabled, Transport Layer Security (TLS) encrypts the EMRFS objects in transit between EMR cluster nodes and Amazon S3. If you use Amazon S3 CSE with customer-managed keys, your execution role used to run jobs in an EMR Serverless application must have access to the key. For in-depth information about Amazon S3 encryption, refer to Protecting data using encryption in the Amazon Simple Storage Service Developer Guide.

> **Note**
>
> When you use AWS KMS, charges apply for the storage and use of encryption keys. For more information, refer to AWS KMS pricing.

Amazon S3 server-side encryption

All Amazon S3 buckets have encryption configured by default, and all new objects that are uploaded to an S3 bucket are automatically encrypted at rest, Amazon S3 encrypts data at the object level as it writes the data to disk and decrypts the data when it is accessed. For more information about SSE, refer to Protecting data using server-side encryption in the Amazon Simple Storage Service Developer Guide.

You can choose between two different key management systems when you specify SSE in Amazon EMR Serverless:

- **SSE-S3** - Amazon S3 manages keys for you. No additional setup is required on EMR Serverless.
- **SSE-KMS** - You use an AWS KMS key to set up with policies suitable for EMR Serverless. No additional setup is required on EMR Serverless.

To use AWS KMS encryption for data that you write to Amazon S3, you have two options when you use the `StartJobRun` API. You can either enable encrytion for everything that you write to Amazon S3, or enable encryption for data that you write to a specific bucket. For more information about the `StartJobRun` API, refer to the EMR Serverless API Reference.

To turn on AWS KMS encryption for all data that you write to Amazon S3, use the following commands when you call the `StartJobRun` API.

```
--conf spark.hadoop.fs.s3.enableServerSideEncryption=true
--conf spark.hadoop.fs.s3.serverSideEncryption.kms.keyId=<kms_id>
```

To turn on AWS KMS encryption for data that you write to a specific bucket, use the following commands when you call the `StartJobRun` API.

```
--conf spark.hadoop.fs.s3.bucket.<amzn-s3-demo-bucket1>.enableServerSideEncryption=true
--conf spark.hadoop.fs.s3.bucket.<amzn-s3-demo-
bucket1>.serverSideEncryption.kms.keyId=<kms-id>
```

SSE with customer-provided keys (SSE-C) is not available for use with EMR Serverless.

Amazon S3 client-side encryption

With Amazon S3 client-side encryption, the Amazon S3 encryption and decryption takes place in the EMRFS client available on every Amazon EMR release. Objects are encrypted before being uploaded to Amazon S3 and decrypted after they are downloaded. The provider you specify supplies the encryption key that the client uses. The client can use keys provided by AWS KMS (CSE-KMS) or a custom Java class that provides the client-side root key (CSE-C). The encryption specifics are slightly different between CSE-KMS and CSE-C, depending on the specified provider and the metadata of the object being decrypted or encrypted. If you use Amazon S3 CSE with customer-managed keys, your execution role used to run jobs in an EMR Serverless application must have access to the key. Additional KMS charges may apply. For more information about these differences, refer to Protecting data using client-side encryption in the Amazon Simple Storage Service Developer Guide.

Local disk encryption

Data stored in ephemeral storage is encrypted with service owned keys using industry standard AES-256 cryptographic algorithm.

Key management

You can configure KMS to automatically rotate your KMS keys. This rotates your keys once a year while saving old keys indefinitely so that your data can still be decrypted. For additional information, refer to Rotating customer-managed keys.

Encryption in transit

The following application-specific encryption features are available with Amazon EMR Serverless:

- Spark
  - By default, communication between Spark drivers and executors is authenticated and internal. RPC communication between drivers and executors is encrypted.
- Hive
  - Communication between the AWS Glue metastore and EMR Serverless applications happens via TLS.

You should allow only encrypted connections over HTTPS (TLS) using the aws:SecureTransport condition on Amazon S3 bucket IAM policies.

Identity and Access Management (IAM) in Amazon EMR Serverless

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 Amazon EMR Serverless resources. IAM is an AWS service that you can use with no additional charge.

Topics

- Troubleshooting Amazon EMR Serverless identity and access

Audience

How you use AWS Identity and Access Management (IAM) differs based on your role:

- **Service user** - request permissions from your administrator if you cannot access features (see Troubleshooting Amazon EMR Serverless identity and access)
- **Service administrator** - determine user access and submit permission requests (see Identity and Access Management (IAM) in Amazon EMR Serverless)
- **IAM administrator** - write policies to manage access (see Sample identity-based policies for EMR Serverless)

Authenticating with identities

Authentication is how you sign in to AWS using your identity credentials. You must be authenticated as the AWS account root user, an IAM user, or by assuming an IAM role.

You can sign in as a federated identity using credentials from an identity source like AWS IAM Identity Center (IAM Identity Center), single sign-on authentication, or Google/Facebook credentials. For more information about signing in, see How to sign in to your AWS account in the *AWS Sign-In User Guide*.

For programmatic access, AWS provides an SDK and CLI to cryptographically sign requests. For more information, see AWS Signature Version 4 for API requests in the *IAM User Guide*.

AWS account root user

When you create an AWS account, you begin with one sign-in identity called the AWS account *root user* that has complete access to all AWS services and resources. We strongly recommend that you don't use the root user for everyday tasks. For tasks that require root user credentials, see Tasks that require root user credentials in the *IAM User Guide*.

Federated identity

As a best practice, require human users to use federation with an identity provider to access AWS services using temporary credentials.

A *federated identity* is a user from your enterprise directory, web identity provider, or Directory Service that accesses AWS services using credentials from an identity source. Federated identities assume roles that provide temporary credentials.

For centralized access management, we recommend AWS IAM Identity Center. For more information, see What is IAM Identity Center? in the *AWS IAM Identity Center User Guide*.

IAM users and groups

An *IAM user* is an identity with specific permissions for a single person or application. We recommend using temporary credentials instead of IAM users with long-term credentials. For more information, see Require human users to use federation with an identity provider to access AWS using temporary credentials in the *IAM User Guide*.

An *IAM group* specifies a collection of IAM users and makes permissions easier to manage for large sets of users. For more information, see Use cases for IAM users in the *IAM User Guide*.

IAM roles

An *IAM role* is an identity with specific permissions that provides temporary credentials. You can assume a role by switching from a user to an IAM role (console) or by calling an AWS CLI or AWS API operation. For more information, see Methods to assume a role in the *IAM User Guide*.

IAM roles are useful for federated user access, temporary IAM user permissions, cross-account access, cross-service access, and applications running on Amazon EC2. For more information, see Cross account resource access in IAM 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 defines permissions when associated with an identity or resource. AWS evaluates these policies when a principal makes a request. Most policies are stored in AWS as JSON documents. For more information about JSON policy documents, see Overview of JSON policies in the *IAM User Guide*.

Using policies, administrators specify who has access to what by defining which **principal** can perform **actions** on what **resources**, and under what **conditions**.

By default, users and roles have no permissions. An IAM administrator creates IAM policies and adds them to roles, which users can then assume. IAM policies define permissions regardless of the method used to perform the operation.

Identity-based policies

Identity-based policies are JSON permissions policy documents that you attach to an identity (user, group, or role). These policies control what actions identities can perform, on which resources, and under what conditions. To learn how to create an identity-based policy, see Define custom IAM permissions with customer managed policies in the *IAM User Guide*.

Identity-based policies can be *inline policies* (embedded directly into a single identity) or *managed policies* (standalone policies attached to multiple identities). To learn how to choose between managed and inline policies, see Choose 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 include 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. You must specify a principal in a resource-based policy.

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.

Other policy types

AWS supports additional policy types that can set the maximum permissions granted by more common policy types:

- **Permissions boundaries** – Set the maximum permissions that an identity-based policy can grant to an IAM entity. For more information, see Permissions boundaries for IAM entities in the *IAM User Guide*.
- **Service control policies (SCPs)** – Specify the maximum permissions for an organization or organizational unit in AWS Organizations. For more information, see Service control policies in the *AWS Organizations User Guide*.
- **Resource control policies (RCPs)** – Set the maximum available permissions for resources in your accounts. For more information, see Resource control policies (RCPs) in the *AWS Organizations User Guide*.
- **Session policies** – Advanced policies passed as a parameter when creating a temporary session for a role or federated user. 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 EMR Serverless works with IAM

Before you use IAM to manage access to Amazon EMR Serverless, learn what IAM features are available to use with Amazon EMR Serverless.

IAM features use with EMR Serverless

IAM feature	Amazon EMR Serverless support
Identity-based policies	Yes
Resource-based policies	No
Policy actions	Yes
Policy resources	Yes
Policy condition keys	No
ACLs	No
ABAC (tags in policies)	Yes
Temporary credentials	Yes
Principal permissions	Yes
Service roles	No
Service-linked roles	Yes

To get a high-level view of how EMR Serverless and other AWS services work with most IAM features, refer to AWS services that work with IAM in the *IAM User Guide*.

Identity-based policies for EMR Serverless

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 Define custom IAM permissions with customer managed 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. 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*.

Sample identity-based policies for EMR Serverless

To access examples of Amazon EMR Serverless identity-based policies, refer to Identity-based policy examples for EMR Serverless.

Resource-based policies within EMR Serverless

Supports resource-based policies: No

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. For more information, see Cross account resource access in IAM in the *IAM User Guide*.

Policy actions for EMR Serverless

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. Include actions in a policy to grant permissions to perform the associated operation.

To refer to a list of EMR Serverless actions, refer to Actions, resources, and condition keys for Amazon EMR Serverless in the *Service Authorization Reference*.

Policy actions in EMR Serverless use the following prefix before the action.

```
emr-serverless
```

To specify multiple actions in a single statement, separate them with commas.

```
"Action": [
      "emr-serverless:action1",
      "emr-serverless:action2"
         ]
```

To access examples of Amazon EMR Serverless identity-based policies, refer to Identity-based policy examples for EMR Serverless.

Policy resources for EMR Serverless

Supports policy resources: 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 `Resource` JSON policy element specifies the object or objects to which the action applies. As a best practice, specify a resource using its Amazon Resource Name (ARN). For actions that don't support resource-level permissions, use a wildcard (*) to indicate that the statement applies to all resources.

```
"Resource": "*"
```

To refer to a list of Amazon EMR Serverless resource types and their ARNs, see Resources defined by Amazon EMR Serverless in the *Service Authorization Reference*. To learn which actions specify the ARN of each resource, refer to Actions, resources, and condition keys for Amazon EMR Serverless.

To access examples of Amazon EMR Serverless identity-based policies, refer to Identity-based policy examples for EMR Serverless.

Policy condition keys for EMR Serverless

Policy condition keys support

Supports service-specific policy condition keys	No

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 specifies when statements execute based on defined criteria. 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. To see all AWS global condition keys, see AWS global condition context keys in the *IAM User Guide*.

To refer to a list of Amazon EMR Serverless condition keys and to learn which actions and resources you can use a condition key, refer to Actions, resources, and condition keys for Amazon EMR Serverless in the *Service Authorization Reference*.

All Amazon EC2 actions support the `aws:RequestedRegion` and `ec2:Region` condition keys. For more information, refer to Example: Restricting access to a specific region.

Access control lists (ACLs) in EMR Serverless

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.

Attribute-based access control (ABAC) with EMR Serverless

Attribute-based access control (ABAC) support

Supports ABAC (tags in policies)	Yes

Attribute-based access control (ABAC) is an authorization strategy that defines permissions based on attributes called tags. You can attach tags to IAM entities and AWS resources, then design ABAC policies to allow operations when the principal's tag matches the tag on the resource.

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 Define permissions with ABAC authorization 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*.

Using Temporary credentials with EMR Serverless

Supports temporary credentials: Yes

Temporary credentials provide short-term access to AWS resources and are automatically created when you use federation or switch roles. AWS recommends that you dynamically generate temporary credentials instead of using long-term access keys. For more information, see Temporary security credentials in IAM and AWS services that work with IAM in the *IAM User Guide*.

Cross-service principal permissions for EMR Serverless

Supports forward access sessions (FAS): Yes

Forward access sessions (FAS) use the permissions of the principal calling an AWS service, combined with the requesting AWS service to make requests to downstream services. For policy details when making FAS requests, see Forward access sessions.

Service roles for EMR Serverless

Supports service roles	No

Service-linked roles for EMR Serverless

Supports service-linked roles	Yes

For details about creating or managing service-linked roles, refer to 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 access the service-linked role documentation for that service.

Using service-linked roles for EMR Serverless

Amazon EMR Serverless uses AWS Identity and Access Management (IAM) service-linked roles. A service-linked role is a unique type of IAM role that is linked directly to EMR Serverless. Service-linked roles are predefined by EMR Serverless and include all the permissions that the service requires to call other AWS services on your behalf.

A service-linked role makes setting up EMR Serverless easier because you don’t have to manually add the necessary permissions. EMR Serverless defines the permissions of its service-linked roles, and unless defined otherwise, only EMR Serverless can assume its roles. The defined permissions include the trust policy and the permissions policy, and that permissions policy cannot be attached to any other IAM entity.

You can delete a service-linked role only after first deleting their related resources. This protects your EMR Serverless resources because you can't inadvertently remove permission to access the resources.

For information about other services that support service-linked roles, refer to AWS Services That Work with IAM and check for the services that have **Yes** in the **Service-linked roles** column. Choose a **Yes** with a link to access the service-linked role documentation for that service.

Service-linked role permissions for EMR Serverless

EMR Serverless uses the service-linked role named **AWSServiceRoleForAmazonEMRServerless** to enable it to call AWS APIs on your behalf.

The AWSServiceRoleForAmazonEMRServerless service-linked role trusts the following services to assume the role:

- `ops.emr-serverless.amazonaws.com`

The role permissions policy named AmazonEMRServerlessServiceRolePolicy allows EMR Serverless to complete the following actions on the specified resources.

> **Note**
>
> Managed policy contents change, so the policy shown here might be out of date. View the most up-to-date policy AmazonEMRServerlessServiceRolePolicy in the AWS Management Console.

- Action: ec2:CreateNetworkInterface
- Action: ec2:DeleteNetworkInterface
- Action: ec2:DescribeNetworkInterfaces
- Action: ec2:DescribeSecurityGroups
- Action: ec2:DescribeSubnets
- Action: ec2:DescribeVpcs
- Action: ec2:DescribeDhcpOptions
- Action: ec2:DescribeRouteTables
- Action: cloudwatch:PutMetricData

The following is the full AmazonEMRServerlessServiceRolePolicy policy.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "EC2PolicyStatement",
      "Effect": "Allow",
      "Action": [
        "ec2:CreateNetworkInterface",
        "ec2:DeleteNetworkInterface",
        "ec2:DescribeNetworkInterfaces",
        "ec2:DescribeSecurityGroups",
        "ec2:DescribeSubnets",
        "ec2:DescribeVpcs",
        "ec2:DescribeDhcpOptions",
        "ec2:DescribeRouteTables"
      ],
      "Resource": [
        "*"
      ]
    },
    {
      "Sid": "CloudWatchPolicyStatement",
      "Effect": "Allow",
      "Action": [
        "cloudwatch:PutMetricData"
      ],
      "Resource": [
        "*"
      ],
      "Condition": {
        "StringEquals": {
          "cloudwatch:namespace": [
            "AWS/EMRServerless",
            "AWS/Usage"
          ]
        }
      }
    }
  ]
}
```

The following trust policy is attached to this role to allow the EMR Serverless principal to assume this role.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "sts:AssumeRole"
      ],
      "Resource": "arn:aws:iam::123456789012:role/aws-service-role/emr-
serverless.amazonaws.com/AWSServiceRoleForEMRServerless",
      "Sid": "AllowSTSAssumerole"
    }
  ]
}
```

You must configure permissions to allow an IAM entity (such as a user, group, or role) to create, edit, or delete a service-linked role. For more information, refer to Service-linked role permissions in the *IAM User Guide*.

Creating a service-linked role for EMR Serverless

You don't need to manually create a service-linked role. When you create a new EMR Serverless application in the AWS Management Console (using EMR Studio), the AWS CLI, or the AWS API, EMR Serverless creates the service-linked role for you. You must configure permissions to allow an IAM entity (such as a user, group, or role) to create, edit, or delete a service-linked role.

To create the AWSServiceRoleForAmazonEMRServerless service-linked role using IAM

Add the following statement to the permissions policy for the IAM entity that needs to create the service-linked role.

```
{
    "Effect": "Allow",
    "Action": [
        "iam:CreateServiceLinkedRole"
    ],
    "Resource": "arn:aws:iam::*:role/aws-service-role/ops.emr-serverless.amazonaws.com/
AWSServiceRoleForAmazonEMRServerless*",
    "Condition": {"StringLike": {"iam:AWSServiceName": "ops.emr-
serverless.amazonaws.com"}}
}
```

If you delete this service-linked role, and then need to create it again, use the same process to recreate the role in your account. When you create a new EMR Serverless application, EMR Serverless creates the service-linked role for you again.

You can also use the IAM console to create a service-linked role with the **EMR Serverless** use case. In the AWS CLI or the AWS API, create a service-linked role with the `ops.emr-serverless.amazonaws.com` service name. For more information, refer to Creating a service-linked role in the *IAM User Guide*. If you delete this service-linked role, use this same process to create the role again.

Editing a service-linked role for EMR Serverless

EMR Serverless does not allow you to edit the AWSServiceRoleForAmazonEMRServerless service-linked role because various entities might reference the role. You can't edit the AWS-owned IAM policy that the EMR Serverless service-linked role uses, as it contains all the necessary permissions EMR Serverless needs. However, you can edit the description of the role using IAM.

To edit the description of the AWSServiceRoleForAmazonEMRServerless service-linked role using IAM

Add the following statement to the permissions policy for the IAM entity that needs to edit the description of a service-linked role.

```
{
    "Effect": "Allow",
    "Action": [
        "iam: UpdateRoleDescription"
    ],
    "Resource": "arn:aws:iam::*:role/aws-service-role/ops.emr-serverless.amazonaws.com/
AWSServiceRoleForAmazonEMRServerless*",
    "Condition": {"StringLike": {"iam:AWSServiceName": "ops.emr-
serverless.amazonaws.com"}}
}
```

For more information, refer to Editing a service-linked role in the *IAM User Guide*.

Deleting a service-linked role for EMR Serverless

If you no longer need to use a feature or service that requires a service-linked role, we suggest that you delete that role. This is so you don’t have an unused entity that is not actively monitored or maintained. However, delete all EMR Serverless applications in all Regions before delete the service-linked role.

Note

If the EMR Serverless service is using the role when you try to delete the resources associated with the role, then the deletion might fail. If that happens, wait for a few minutes and try the operation again.

To delete the AWSServiceRoleForAmazonEMRServerless service-linked role using IAM

Add the following statement to the permissions policy for the IAM entity that needs to delete a service-linked role.

```
{
    "Effect": "Allow",
    "Action": [
        "iam:DeleteServiceLinkedRole",
        "iam:GetServiceLinkedRoleDeletionStatus"
    ],
    "Resource": "arn:aws:iam::*:role/aws-service-role/ops.emr-serverless.amazonaws.com/
AWSServiceRoleForAmazonEMRServerless*",
    "Condition": {"StringLike": {"iam:AWSServiceName": "ops.emr-
serverless.amazonaws.com"}}
}
```

To manually delete the service-linked role using IAM

Use the IAM console, the AWS CLI, or the AWS API to delete the AWSServiceRoleForAmazonEMRServerless service-linked role. For more information, refer to Deleting a service-linked role in the *IAM User Guide*.

Supported Regions for EMR Serverless service-linked roles

EMR Serverless supports using service-linked roles in all of the Regions where the service is available. For more information, refer to AWS Regions and endpoints.

Job runtime roles for Amazon EMR Serverless

You can specify IAM role permissions that a EMR Serverless job run can assume when calling other services on your behalf. This includes access to Amazon S3 for any data sources, targets, as well as other AWS resources like Amazon Redshift clusters and DynamoDB tables. To learn more about how to create a role, refer to Create a job runtime role.

Sample runtime policies

You can attach a runtime policy, such as the following, to a job runtime role. The following job runtime policy allows:

- Read access to Amazon S3 buckets with EMR samples.
- Full access to S3 buckets.

- Create and read access to AWS Glue Data Catalog.

To add access to other AWS resources like DynamoDB, you’ll need to include permissions for them in the policy when creating the runtime role.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "ReadAccessForEMRSamples",
      "Effect": "Allow",
      "Action": [
        "s3:GetObject",
        "s3:ListBucket"
      ],
      "Resource": [
        "arn:aws:s3:::*.elasticmapreduce",
        "arn:aws:s3:::*.elasticmapreduce/*"
      ]
    },
    {
      "Sid": "FullAccessToS3Bucket",
      "Effect": "Allow",
      "Action": [
        "s3:PutObject",
        "s3:GetObject",
        "s3:ListBucket",
        "s3:DeleteObject"
      ],
      "Resource": [
        "arn:aws:s3:::amzn-s3-demo-bucket",
        "arn:aws:s3:::amzn-s3-demo-bucket/*"
      ]
    },
    {
      "Sid": "GlueCreateAndReadDataCatalog",
      "Effect": "Allow",
      "Action": [
        "glue:GetDatabase",
        "glue:CreateDatabase",
        "glue:GetDataBases",
        "glue:CreateTable",
        "glue:GetTable",
        "glue:UpdateTable",
        "glue:DeleteTable",
        "glue:GetTables",
        "glue:GetPartition",
        "glue:GetPartitions",
        "glue:CreatePartition",
        "glue:BatchCreatePartition",
        "glue:GetUserDefinedFunctions"
      ],
      "Resource": [
        "*"
      ]
    }
  ]
}
```

Pass role privileges

You can attach IAM permissions policies to the a user's role to allow the user to pass only approved roles. This allows administrators to control which users can pass specific job runtime roles to EMR Serverless jobs. To learn more about setting permissions, refer to Granting a user permissions to pass a role to an AWS service.

The following is an example policy that allows passing a job runtime role to the EMR Serverless service principal.

```
{
     "Effect": "Allow",
     "Action": "iam:PassRole",
     "Resource": "arn:aws:iam::1234567890:role/JobRuntimeRoleForEMRServerless",
        "Condition": {
                "StringLike": {
                    "iam:PassedToService": "emr-serverless.amazonaws.com"
                }
            }
}
```

Managed permission policies associated with runtime roles

When you submit job runs to EMR serverless through the EMR Studio console, there is a step where you choose a **Runtime role** to associate with your application. There are underlying managed policies associated with each selection in the console that are important to be aware of. The three selections are the following:

1. **All buckets** – When you choose this, it specifies the AmazonS3FullAccess AWS managed policy, which provides full access to all buckets.
2. **Specific buckets** – This specifies the Amazon resource name (ARN) identifier of each bucket that you choose. There isn't an underlying managed policy included.
3. **None** – No managed-policy permissions are included.

We suggest adding specific buckets. If you choose all buckets, keep in mind that it sets full access for all buckets.

User access policy examples for EMR Serverless

You can set up fine-grained policies for your users depending on the actions you want each user to perform when interacting with EMR Serverless applications. The following policies are examples that might help in setting up the appropriate permissions for your users. This section focuses only on EMR Serverless policies. For samples of EMR Studio user policies, refer to Configure EMR Studio user permissions. For information about how to attach policies to IAM users (principals), refer to Managing IAM policies in the IAM User Guide.

Power user policy

To grant all the required actions for EMR Serverless, create and attach a `AmazonEMRServerlessFullAccess` policy to the required IAM user, role, or group.

The following is a sample policy that allows power users to create and modify EMR Serverless applications, as well as perform other actions like submitting and debugging jobs. It reveals all the actions that EMR Serverless requires for other services.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "EMRServerlessActions",
      "Effect": "Allow",
      "Action": [
        "emr-serverless:CreateApplication",
        "emr-serverless:UpdateApplication",
        "emr-serverless:DeleteApplication",
        "emr-serverless:ListApplications",
        "emr-serverless:GetApplication",
        "emr-serverless:StartApplication",
        "emr-serverless:StopApplication",
        "emr-serverless:StartJobRun",
        "emr-serverless:CancelJobRun",
        "emr-serverless:ListJobRuns",
        "emr-serverless:GetJobRun"
      ],
      "Resource": [
        "*"
      ]
    }
  ]
}
```

When you enable network connectivity to your VPC, EMR Serverless applications create Amazon EC2 elastic network interfaces (ENIs) to communicate with VPC resources. The following policy ensures that any new EC2 ENIs are only created in the context of EMR Serverless applications.

> **Note**
>
> We strongly recommend setting this policy to ensure that users cannot create EC2 ENIs except in the context of launching EMR Serverless applications.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "AllowEC2ENICreationWithEMRTags",
      "Effect": "Allow",
      "Action": [
        "ec2:CreateNetworkInterface"
      ],
      "Resource": [
        "arn:aws:ec2:*:*:network-interface/*"
      ],
      "Condition": {
        "StringEquals": {
          "aws:CalledViaLast": "ops.emr-serverless.amazonaws.com"
        }
      }
    }
  ]
}
```

If you want to restrict EMR Serverless access to certain subnets, you can tag each subnet with a tag condition. This IAM policy ensures that EMR Serverless applications can only create EC2 ENIs within allowed subnets.

```
{
    "Sid": "AllowEC2ENICreationInSubnetAndSecurityGroupWithEMRTags",
    "Effect": "Allow",
    "Action": [
        "ec2:CreateNetworkInterface"
    ],
    "Resource": [
        "arn:aws:ec2:*:*:subnet/*",
        "arn:aws:ec2:*:*:security-group/*"
    ],
    "Condition": {
        "StringEquals": {
            "aws:ResourceTag/KEY": "VALUE"
        }
    }
}
```

Important

If you're an Administrator or power user creating your first application, you must configure your permission policies to allow you to create a EMR Serverless service-linked role. To learn more, refer to Using service-linked roles for EMR Serverless.

The following IAM policy permits you to create a EMR Serverless service-linked role for your account.

```
{
   "Sid":"AllowEMRServerlessServiceLinkedRoleCreation",
   "Effect":"Allow",
   "Action":"iam:CreateServiceLinkedRole",
   "Resource":"arn:aws:iam::account-id:role/aws-service-role/ops.emr-
serverless.amazonaws.com/AWSServiceRoleForAmazonEMRServerless"
}
```

Data engineer policy

This following is a sample policy that allows users read-only permissions on EMR Serverless applications, as well as the ability to submit and debug jobs. Keep in mind that because this policy does not explicitly deny actions, a different policy statement may still be used to grant access to specified actions.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "EMRServerlessActions",
      "Effect": "Allow",
      "Action": [
        "emr-serverless:ListApplications",
        "emr-serverless:GetApplication",
        "emr-serverless:StartApplication",
        "emr-serverless:StartJobRun",
        "emr-serverless:CancelJobRun",
        "emr-serverless:ListJobRuns",
        "emr-serverless:GetJobRun"
      ],
      "Resource": [
        "*"
      ]
    }
  ]
}
```

Using tags for access control

You can use tag conditions for fine-grained access control. For example, you can restrict users from one team such that they're only able to submit jobs to EMR Serverless applications tagged with their team name.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "EMRServerlessActions",
      "Effect": "Allow",
      "Action": [
        "emr-serverless:ListApplications",
        "emr-serverless:GetApplication",
        "emr-serverless:StartApplication",
        "emr-serverless:StartJobRun",
        "emr-serverless:CancelJobRun",
        "emr-serverless:ListJobRuns",
        "emr-serverless:GetJobRun"
      ],
      "Resource": [
        "*"
      ]
    }
  ]
}
```

Policies for tag-based access control

You can use conditions in your identity-based policy to control access to applications and job runs based on tags.

The following examples demonstrate different scenarios and ways to use condition operators with EMR Serverless condition keys. These IAM policy statements are intended for demonstration purposes only and should not be used in production environments. There are multiple ways to combine policy statements to grant and deny permissions according to your requirements. For more information about planning and testing IAM policies, refer to the IAM user Guide.

> **Important**
>
> Explicitly denying permission for tagging actions is an important consideration. This prevents users from tagging a resource and thereby granting themselves permissions that you did not intend to grant. If tagging actions for a resource are not denied, a user can modify tags and circumvent the intention of the tag-based policies. For an example of a policy that denies tagging actions, refer to Deny access to add and remove tags.

The examples below demonstrate identity-based permissions policies that are used to control the actions that are allowed with EMR Serverless applications.

Allow actions only on resources with specific tag values

In the following policy example, the `StringEquals` condition operator tries to match `dev` with the value for the tag department. If the tag department hasn't been added to the application, or doesn't contain the value `dev`, the policy doesn't apply, and the actions aren't allowed by this policy. If no other policy statements allow the actions, the user can only work with applications that have this tag with this value.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "emr-serverless:GetApplication"
      ],
      "Resource": [
        "*"
      ],
      "Condition": {
        "StringEquals": {
          "aws:ResourceTag/department": "dev"
        }
      },
      "Sid": "AllowEMRSERVERLESSGetapplication"
    }
  ]
}
```

You can also specify multiple tag values using a condition operator. For example, to allow actions on applications where the `department` tag contains the value `dev` or `test`, replace the condition block in the earlier example with the following.

```
"Condition": {
        "StringEquals": {
          "emr-serverless:ResourceTag/department": ["dev", "test"]
        }
      }
```

Require tagging when a resource is created

In the example below, the tag needs to be applied when creating the application.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "emr-serverless:CreateApplication"
      ],
      "Resource": [
        "*"
      ],
      "Condition": {
        "StringEquals": {
          "aws:RequestedRegion": "us-east-1"
        }
      },
      "Sid": "AllowEMRSERVERLESSCreateapplication"
    }
  ]
}
```

The following policy statement allows a user to create an application only if the application has a `department` tag, which can contain any value.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "emr-serverless:CreateApplication"
      ],
      "Resource": [
        "*"
      ],
      "Condition": {
        "StringEquals": {
          "aws:RequestedRegion": ["us-east-1", "us-west-2"]
        }
      },
      "Sid": "AllowEMRSERVERLESSCreateapplication"
    }
  ]
}
```

Deny access to add and remove tags

This policy prevents a user from adding or removing tags on EMR Serverless applications with a `department` tag whose value is not `dev`.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Deny",
      "Action": [
        "emr-serverless:TagResource",
        "emr-serverless:UntagResource"
      ],
      "Resource": [
        "*"
      ],
      "Condition": {
        "StringNotEquals": {
          "aws:PrincipalTag/department": "dev"
        }
      },
      "Sid": "AllowEMRSERVERLESSTagresource"
    }
  ]
}
```

Identity-based policy examples for EMR Serverless

By default, users and roles don't have permission to create or modify Amazon EMR Serverless resources. To grant users permission to perform actions on the resources that they need, an IAM administrator can create IAM policies.

To learn how to create an IAM identity-based policy by using these example JSON policy documents, see Create IAM policies (console) in the *IAM User Guide*.

For details about actions and resource types defined by Amazon EMR Serverless, including the format of the ARNs for each of the resource types, see Actions, resources, and condition keys for Amazon EMR Serverless in the *Service Authorization Reference*.

Topics

Policy best practices

> **Note**
>
> EMR Serverless doesn't support managed policies, so the first practice listed in the following doesn't apply.

Identity-based policies determine whether someone can create, access, or delete Amazon EMR Serverless 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 or AWS managed policies for job functions 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 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 CloudFormation. For more information, see IAM JSON policy elements: Condition 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 Validate policies with IAM Access Analyzer 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 Secure API access with MFA in the *IAM User Guide*.

For more information about best practices in IAM, see Security best practices in IAM in the *IAM User Guide*.

Allow users to access 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.

```
{
    "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": "*"
        }
    ]
}
```

Amazon EMR Serverless updates to AWS managed policies

Access details about updates to AWS managed policies for Amazon EMR Serverless since this service began tracking these changes. For automatic alerts about changes to this page, subscribe to the RSS feed on the Amazon EMR Serverless Document history page.

Change	Description	Date
AmazonEMRServerlessServiceRolePolicy – Update to an existing policy	Amazon EMR Serverless added the new Sid `CloudWatchPolicyStatement` and `EC2PolicyStatement` to the AmazonEMRServerlessServiceRolePolicy policy.	January 25, 2024
AmazonEMRServerlessServiceRolePolicy – Update to an existing policy	Amazon EMR Serverless added new permissions to allow Amazon EMR Serverless to publish aggregated account metrics for vCPU usage in the `"AWS/Usage"` namespace.	April 20, 2023

Change	Description	Date
Amazon EMR Serverless started tracking changes	Amazon EMR Serverless started tracking changes for its AWS managed policies.	April 20, 2023

Troubleshooting Amazon EMR Serverless identity and access

Use the following information to help you diagnose and fix common issues that you might encounter when working with Amazon EMR Serverless and IAM.

Topics

- I am not authorized to perform an action in Amazon EMR Serverless
- I am not authorized to perform iam:PassRole
- I want to allow people outside of my AWS account to access my Amazon EMR Serverless resources
- I am not able to open Live UI/Spark history server from EMR Studio to debug my job or an API error occurs when I try to get logs using get-dashboard-for-job-run

I am not authorized to perform an action in Amazon EMR Serverless

If the AWS Management Console tells you that you're not authorized to perform an action, then contact your administrator for assistance. Your administrator is the person that provided you with your user name and password.

The following example error occurs when the `mateojackson` user tries to use the console to access details about a fictional *`my-example-widget`* resource but does not have the fictional `emr-serverless:`*`GetWidget`* permissions.

```
User: arn:aws:iam::123456789012:user/mateojackson is not authorized to perform: emr-
serverless:GetWidget on resource: my-example-widget
```

In this case, Mateo asks his administrator to update his policies to allow him to access the *`my-example-widget`* resource using the `emr-serverless:`*`GetWidget`* action.

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 Amazon EMR Serverless.

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 Amazon EMR Serverless. 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 Amazon EMR Serverless 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 Amazon EMR Serverless supports these features, see Identity and Access Management (IAM) in Amazon EMR Serverless.
- 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 in the *IAM User Guide*.
- 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 Cross account resource access in IAM in the *IAM User Guide*.

I am not able to open Live UI/Spark history server from EMR Studio to debug my job or an API error occurs when I try to get logs using `get-dashboard-for-job-run`

If you use EMR Serverless managed storage for logging and your EMR Serverless application is in a private subnet with VPC endpoints for Amazon S3 and you attach an endpoint policy to control access, add the permissions mentioned in Logging for EMR Serverless with managed storage in your VPC policy to S3 gateway endpoint for EMR Serverless to store and serve application logs.

Trusted Identity Propagation

With Amazon EMR releases 7.8.0 and higher, you can propagate user-identities from AWS IAM Identity Center to interactive workloads with EMR Serverless through Apache Livy Endpoint. Apache Livy interactive workloads will further propagate supplied identity to downstream services like Amazon S3, Lake Formation and Amazon Redshift, enabling secure data access via user identity in these downstream. The following sections provide a conceptual overview, prerequisites, and steps required to launch and propagate identity to interactive workloads with EMR Serverless through Apache Livy Endpoint.

Overview

IAM Identity Center is the recommended approach for workforce authentication and authorization on AWS for organizations of any size and type. With Identity Center, create and manage user identities in AWS, or connect your existing identity source, including Microsoft Active Directory, Okta, Ping Identity, JumpCloud, Google Workspace, and Microsoft Entra ID (formerly Azure AD).

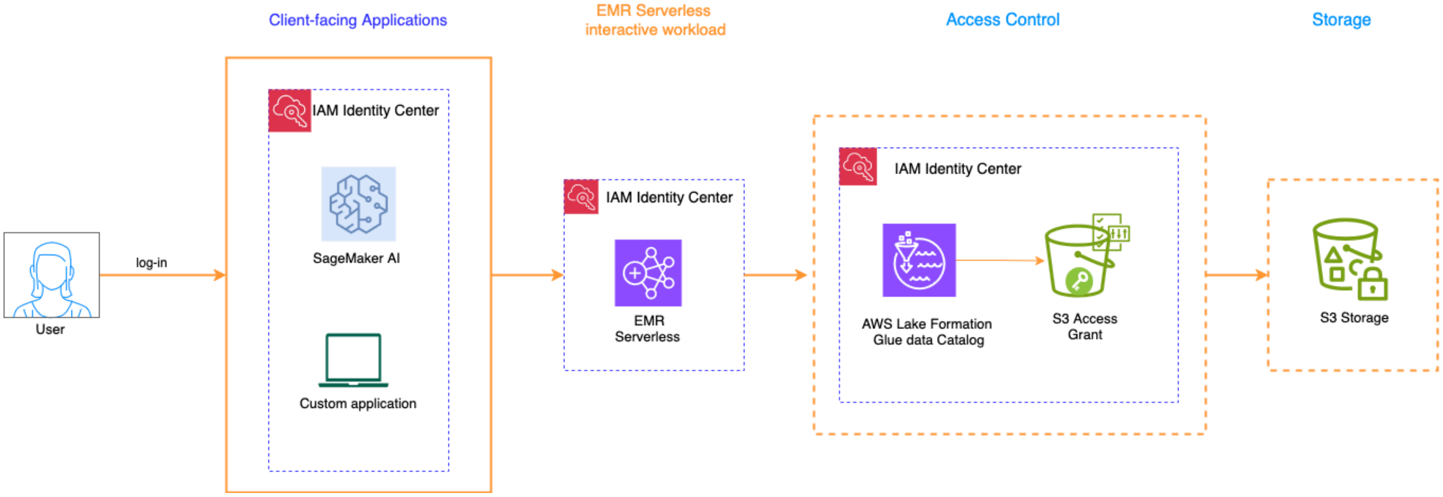
Trusted identity propagation is an AWS IAM Identity Center feature that administrators of connected AWS services can use to grant and audit access to service data. Access to this data is based on user attributes such as group associations. Setting up trusted identity propagation requires collaboration between the administrators of connected AWS services and the IAM Identity Center administrators. For more information, refer to Prerequisites and considerations in the *IAM Identity Center User Guide*.

Features and benefits

The EMR Serverless Apache Livy Endpoint integration with IAM Identity Center Trusted identity propagation provides the following benefits:

- The ability to enforce table-level authorization with Identity Center identities on AWS Lake Formation managed AWS Glue data catalog tables.
- The ability to enforce authorization with Identity Center identities on Amazon Redshift clusters.
- Enables end to end tracking of user actions for auditing.
- The ability to enforce Amazon S3 prefix-level authorization with Identity Center identities on S3 Access Grants-managed S3 prefixes.

How it works



Use case example

Data Preparation and Feature Engineering

Data scientists from multiple research teams collaborate on complex projects using a unified data platform. They log into SageMaker AI using their corporate credentials, immediately gaining access to a vast, shared data lake spanning several AWS accounts. As they begin feature engineering for new machine learning models, the Spark sessions launched through EMR Serverless enforce Lake Formation's column and row-level security policies based on their propagated identities. Scientists can efficiently prepare data and engineer features using familiar tools, while compliance teams are assured that every data interaction is automatically tracked and audited. This secure, collaborative environment accelerates research pipelines while maintaining strict data protection standards required in regulated industries.

Getting started with Trusted-Identity Propagation

This section helps you configure EMR-Serverless application with Apache Livy Endpoint to integrate with AWS IAM Identity Center and enable Trusted identity propagation.

Prerequisites

- An Identity Center instance in the AWS Region where you want to create Trusted identity propagation enabled EMR Serverless Apache Livy Endpoint. An Identity Center instance can only exist in a single Region for an AWS account. refer Enable IAM Identity Center and Provision the users and groups from your source of identities into IAM Identity Center.
- Enable Trusted identity propagation for downstream services like Lake Formation or S3 Access Grants or Amazon Redshift cluster with which interactive workload interacts to access data.

Permissions to create trusted-identity propagation enabled EMR Serverless Application

In addition to the basic permissions that are required to access EMR Serverless, you must configure additional permissions for your IAM identity or role that is used to create trusted-identity propagation enabled EMR Serverless Application. For trusted-identity propagation, EMR Serverless creates/bootstraps a single service managed Identity Center Application in your account that service leverages for identity validation and identity propagation to downstream.

```
"sso:DescribeInstance",
"sso:CreateApplication",
"sso:DeleteApplication",
"sso:PutApplicationAuthenticationMethod",
"sso:PutApplicationAssignmentConfiguration",
"sso:PutApplicationGrant",
"sso:PutApplicationAccessScope"
```

- `sso:DescribeInstance` – Grants permission to describe and validate the IAM Identity Center instanceArn that you specify in identity-center-configuration parameter.
- `sso:CreateApplication` – Grants permission to create a EMR Serverless managed IAM Identity Center Application which is used for trusted-identity-propatgion actions.

- `sso:DeleteApplication` – grants permission to cleanup a EMR Serverless managed IAM Identity Center Application
- `sso:PutApplicationAuthenticationMethod` – Grants permission to put authenticationMethod on EMR Serverless managed IAM Identity Center Application that allows emr-serverless service principal to interact with IAM Identity Center Application.
- `sso:PutApplicationAssignmentConfiguration` – Grants permission to set "User-assignment-not-required" setting on IAM Identity Center Application.
- `sso:PutApplicationGrant` – Grants permission to apply token-exchange, introspectToken, refreshToken and revokeToken grants on an IAM Identity Center Application.
- `sso:PutApplicationAccessScope` – Grants permission to apply trusted-identity propagation enabled downstream scope to IAM Identity Center Application. We apply "redshift:connect", "lakeformation:query" and "s3:read_write" scopes to enable trusted-identity-propagation to these services.

Create a trusted-identity propagation enabled EMR Serverless Application

You must specify —`identity-center-configuration` field with `identityCenterInstanceArn` to enable trusted-identity propagation in the application. Use the following example command to create an EMR Serverless Application that has trusted-identity propagation enabled.

> **Note**
>
> You also must specify `--interactive-configuration '{"livyEndpointEnabled":true}'` as trusted-identity propagation is enabled for Apache Livy Endpoint only.

```
aws emr-serverless create-application \
  --release-label emr-7.8.0 \
  --type "SPARK" \
  --identity-center-configuration '{"identityCenterInstanceArn" :
 "arn:aws:sso:::instance/ssoins-123456789"}' \
  --interactive-configuration '{"livyEndpointEnabled":true}'
```

- `identity-center-configuration` – (optional) Enables Identity Center trusted identity propagation if specified.

- `identityCenterInstanceArn` – (required) The Identity Center instance ARN.

In case you don't have the required Identity Center permissions (mentioned previously), first create the EMR Serverless Application without trusted-identity propagation (for instance, dont specify `–identity-center-configuration` parameter) and later ask your Identity Center Admin to enable the trusted-identity propagation by invoking update-application API, see example below:

```
aws emr-serverless update-application \
  --application-id applicationId \
  --identity-center-configuration '{"identityCenterInstanceArn" :
 "arn:aws:sso:::instance/ssoins-123456789"}'
```

EMR Serverless creates a service managed Identity Center Application in your account that service leverages for identity validations and identity propagation to downstream services. EMR Serverless created managed Identity Center Application is shared across all trusted-identity-propagation enabled EMR Serverless applications in your account.

> **Note**
>
> Do not manually modify settings on the managed Identity Center Application. Any changes could affect all trusted-identity-propagation enabled EMR Serverless applications in your account.

Job Execution Role permissions to propagate identity

As EMR-Serverless leverage Identity-enhanced job-execution-role credentials to propagate identity to downstream AWS services, Job Execution Role's trust-policy must have additional permission `sts:SetContext` to enhance job execution-role credential with identity to allow trusted-identity-propagation to downstream service, such as S3 access-grant, Lake Formation, or Amazon Redshift. To learn more about how to create a role, refer to Create a job runtime role.

JSON

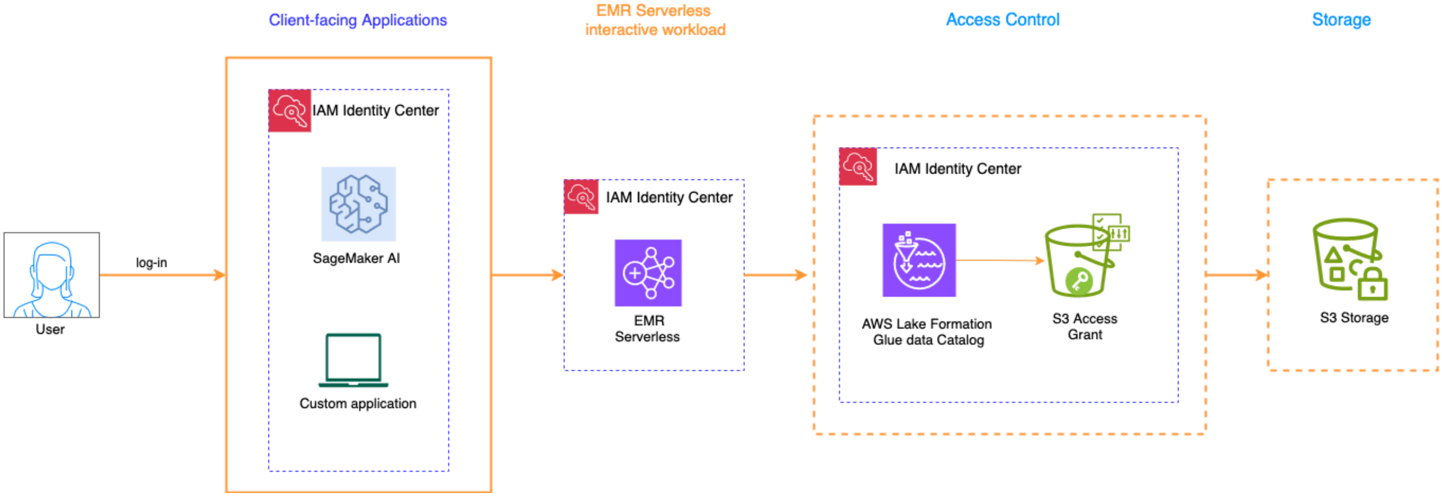
```
{
  "Version":"2012-10-17",
  "Statement": [
     {
     "Effect": "Allow",
     "Principal": {
     "Service": "emr-serverless.amazonaws.com"
     },
     "Action": [ "sts:AssumeRole", "sts:SetContext"]
     }
  ]
}
```

Additionally, JobExecutionRole needs permissions for downstream AWS services which job-run would invoke to fetch data using user identity. Please refer below links to configure S3 Access Grant, Lake Formation.

- Using Lake Formation with EMR Serverless
- Using Amazon S3 Access Grants with EMR Serverless

Trusted Identity Propagation for interactive workloads

The steps to propagate identity to interactive workloads through an Apache Livy endpoint depend on whether your users interact with AWS managed development environment like Amazon SageMaker AI or your own self-hosted Notebook environment as client-facing application.



AWS managed development environment

The following AWS managed client-facing application supports trusted identity propagation with EMR-Serverless Apache Livy endpoint:

- Amazon SageMaker AI

Customer managed self-hosted Notebook environment

To enable trusted identity propagation for users of custom-developed applications, see to Access AWS services programmatically using trusted identity propagation in the *AWS Security Blog*.

User background sessions

User background sessions enable long-running analytics and machine learning flows to continue even after the user has logged off from their notebook interface. This capability is implemented through EMR Serverless integration with IAM Identity Center's trusted identity propagation feature. This section explains the configuration options and behaviors for user background sessions.

> **Note**
>
> User background sessions apply to Spark workloads initiated through notebook interfaces like Amazon SageMaker Unified Studio. Enabling or disabling this feature affects only new Livy sessions; existing active Livy sessions are not impacted.

Configure user background sessions

User background sessions must be enabled at two levels for proper functionality:

1. **IAM Identity Center instance level** – typically configured by IdC administrators
2. **EMR Serverless application level** – configured by EMR Serverless application administrators

Enable user background sessions for EMR Serverless applications

To enable user background sessions for an EMR Serverless application, you must set the `userBackgroundSessionsEnabled` parameter to `true` in the `identityCenterConfiguration` when creating or updating an application.

Prerequisites

- Your IAM role that is used to create/update the EMR Serverless application must have the `sso:PutApplicationSessionConfiguration` permission. This permission allows EMR Serverless to enable User background sessions at EMR Serverless managed IdC application level.

- Your EMR Serverless application must use release label 7.8 or later and must be Trusted-Identity Propagation enabled.

To enable user background sessions using the AWS CLI

```
aws emr-serverless create-application \
    --name "my-analytics-app" \
    --type "SPARK" \
    --release-label "emr-7.8.0" \
    --identity-center-configuration '{"identityCenterInstanceArn":
 "arn:aws:sso:::instance/ssoins-1234567890abcdef", "userBackgroundSessionsEnabled":
 true}'
```

To update an existing application:

```
aws emr-serverless update-application \
    --application-id applicationId \
    --identity-center-configuration '{"identityCenterInstanceArn":
 "arn:aws:sso:::instance/ssoins-1234567890abcdef", "userBackgroundSessionsEnabled":
 true}'
```

Configuration Matrix

The effective user background session configuration depends on both the EMR Serverless application setting and the IAM Identity Center instance-level settings:

User Background Session Configuration Matrix

IAM Identity Center userBackgroundSessionEnabled	EMR Serverless userBackgroundSessionsEnabled	Behavior
Yes	TRUE	User background sessions enabled
Yes	FALSE	Session expires with user logout
No	TRUE	Application creation/update fails with Exception

IAM Identity Center userBackgroundSession Enabled	EMR Serverless userBackgroundSessionsEnabled	Behavior
No	FALSE	Session expires with user logout

Default user background session duration

By default, all user background sessions have a duration limit of 7 days in IAM Identity Center. Administrators can modify this duration in the IAM Identity Center console. This setting applies at the IAM Identity Center instance level, affecting all supported IAM Identity Center applications within that instance.

- Duration can be set to any value from 15 minutes up to 90 days.
- This setting is configured in the IAM Identity Center console under **Settings** → **Authentication** → **Configure** (Non-Interactive Jobs section)

Note

EMR Serverless Livy sessions have a separate maximum duration limit of 24 hours. Sessions will terminate when either the Livy session limit or the user background session duration is reached, whichever comes first.

Impact of disabling user background sessions

When user background sessions are disabled in IAM Identity Center:

Existing Livy sessions

Continue to run without interruption if they were started with user background sessions enabled. These sessions will continue using their existing background session tokens until they terminate naturally or are explicitly stopped.

New Livy sessions

Will use the standard trusted identity propagation flow and will terminate when the user logs out or their interactive session expires (such as when closing a Amazon SageMaker Unified Studio JupyterLab notebook).

Changing user background sessions duration

When the duration setting for user background sessions is modified in IAM Identity Center:

Existing Livy sessions

Continue to run with the same background session duration with which they were started.

New Livy sessions

Will use the new session duration for background sessions.

Considerations

Session Termination Conditions

When using user background sessions, a Livy session will continue running until one of the following occurs:

- The user background session expires (based on IdC configuration, up to 90 days)
- The user background session is manually revoked by an administrator
- The Livy session reaches its idle timeout (default: 1 hour after the last executed statement)
- The Livy session reaches its maximum duration (24 hours)
- The user explicitly stops or restarts the notebook kernel

Data Persistence

When using user background sessions:

- Users cannot reconnect to their notebook interface to view results once they have logged out
- Configure your Spark statements to write results to persistent storage (such as Amazon S3) before execution completes

Cost Implications

- Jobs will continue to run to completion even after users end their Amazon SageMaker Unified Studio JupyterLab session and will incur charges for the entire duration of the completed run.
- Monitor your active background sessions to avoid unnecessary costs from forgotten or abandoned sessions.

Feature Availability

User background sessions for EMR Serverless are available for:

- Spark engine only (Hive engine is not supported)
- Livy interactive sessions only (batch jobs and streaming jobs are not supported)
- EMR Serverless release labels 7.8 and later

Considerations for EMR Serverless Trusted-Identity-Propagation integration

Consider the following when you use IAM Identity Center Trusted-Identity-Propagation with EMR Serverelss Application:

- Trusted Identity Propagation through Identity Center is supported on Amazon EMR 7.8.0 and higher, and only with Apache Spark.
- Trusted Identity Propagation can only be used for interactive workloads with EMR Serverless through an Apache Livy endpoint. Interactive workloads through EMR Studio doesn't support Trusted Identity Propagation
- Batch jobs and streaming workloads do not support Trusted identity propagation
- Fine-grained access controls using AWS Lake Formation that use Trusted Identity Propagation are available for interactive workloads with EMR Serverless through an Apache Livy endpoint.
- Trusted Identity Propagation with Amazon EMR is supported in the following AWS Regions:
  - af-south-1 – Africa (Cape Town)
  - ap-east-1 – Asia Pacific (Hong Kong)
  - ap-northeast-1 – Asia Pacific (Tokyo)
  - ap-northeast-2 – Asia Pacific (Seoul)

- ap-northeast-3 – Asia Pacific (Osaka)
- ap-south-1 – Asia Pacific (Mumbai)
- ap-southeast-1 – Asia Pacific (Singapore)
- ap-southeast-2 – Asia Pacific (Sydney)
- ap-southeast-3 – Asia Pacific (Jakarta)
- ca-central-1 – Canada (Central)
- ca-west-1 – Canada (Calgary)
- eu-central-1 – Europe (Frankfurt)
- eu-north-1 – Europe (Stockholm)
- eu-south-1 – Europe (Milan)
- eu-south-2 – Europe (Spain)
- eu-west-1 – Europe (Ireland)
- eu-west-2 – Europe (London)
- eu-west-3 – Europe (Paris)
- me-central-1 – Middle East (UAE)
- me-south-1 – Middle East (Bahrain)
- sa-east-1 – South America (São Paulo)
- us-east-1 – US East (N. Virginia)
- us-east-2 – US East (Ohio)
- us-west-1 – US West (N. California)
- us-west-2 – US West (Oregon)

Using Lake Formation with EMR Serverless

You can configure EMR Serverless applications to use Lake Formation with either full table access or fine-grained access control. For details on supported features in each access mode, review the following table.

Feature availability

Feature	Available from
Read operations (SELECT, DESCRIBE) for Hive, Iceberg tables	EMR 7.2+
Multi-dialect views	EMR 7.6+
Read operations (SELECT, DESCRIBE) for Delta Lake and Hudi tables	EMR 7.6+
Full table access for Hive, Iceberg	EMR 7.9+
Full table access for Delta Lake	EMR 7.11+
Write operations (DDL, DML) for Hive, Iceberg and Delta Lake tables	EMR 7.12+
Full table access for Hudi	EMR 7.12+

Lake Formation full table access for EMR Serverless

With Amazon EMR releases 7.8.0 and higher, you can leverage AWS Lake Formation with Glue Data Catalog where the job runtime role has full table permissions without the limitations of fine-grained access control. This capability allows you to read and write to tables that are protected by Lake Formation from your EMR Serverless Spark batch and interactive jobs. See the following sections to learn more about Lake Formation and how to use it with EMR Serverless.

Using Lake Formation with full table access

You can access AWS Lake Formation protected Glue Data catalog tables from EMR Serverless Spark jobs or interactive sessions where the job's runtime role has full table access. You do not need to enable AWS Lake Formation on the EMR Serverless application. When a Spark job is configured for Full Table Access (FTA), AWS Lake Formation credentials are used to read/write S3 data for AWS Lake Formation registered tables, while the job's runtime role credentials will be used to read/write tables not registered with AWS Lake Formation.

Important

Do not enable AWS Lake Formation for fine-grained access control. A job cannot simultaneously run Full Table Access (FTA) and Fine-Grained Access Control (FGAC) on the same EMR cluster or application.

Step 1: Enable Full Table Access in Lake Formation

To use Full Table Access (FTA) mode, you must allow third-party query engines to access data without the IAM session tag validation in AWS Lake Formation. To enable, follow the steps in Application integration for full table access.

Note

When accessing cross-account tables, full-table access must be enabled in both producer and consumer accounts. In the same manner, when accessing cross-region tables, this setting must be enabled in both producer and consumer regions.

Step 2: Setup IAM permissions for job runtime role

For read or write access to underlying data, in addition to Lake Formation permissions, a job runtime role needs the `lakeformation:GetDataAccess` IAM permission. With this permission, Lake Formation grants the request for temporary credentials to access the data.

The following is an example policy of how to provide IAM permissions to access a script in Amazon S3, uploading logs to S3, AWS Glue API permissions, and permission to access Lake Formation.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "ScriptAccess",
      "Effect": "Allow",
      "Action": [
        "s3:GetObject"
      ],
      "Resource": [
        "arn:aws:s3:::*.amzn-s3-demo-bucket/scripts"
      ]
    },
    {
      "Sid": "LoggingAccess",
      "Effect": "Allow",
      "Action": [
        "s3:PutObject"
      ],
      "Resource": [
        "arn:aws:s3:::amzn-s3-demo-bucket/logs/*"
      ]
    },
    {
      "Sid": "GlueCatalogAccess",
      "Effect": "Allow",
      "Action": [
        "glue:Get*",
        "glue:Create*",
        "glue:Update*"
      ],
      "Resource": [
        "*"
      ]
    },
    {
      "Sid": "LakeFormationAccess",
      "Effect": "Allow",
      "Action": [
        "lakeformation:GetDataAccess"
      ],
      "Resource": [
        "*"
      ]
    }
  ]
}
```

Step 2.1 Configure Lake Formation permissions

- Spark jobs that read data from S3 require Lake Formation SELECT permission.

- Spark jobs that write/delete data in S3 require Lake Formation ALL (SUPER) permission.
- Spark jobs that interact with Glue Data catalog require DESCRIBE, ALTER, DROP permission as appropriate.

For more information, refer to Granting permissions on Data Catalog resources.

Step 3: Initialize a Spark session for Full Table Access using Lake Formation

Prerequisites

AWS Glue Data Catalog must be configured as a metastore to access Lake Formation tables.

Set the following settings to configure Glue catalog as a metastore:

```
--conf spark.sql.catalogImplementation=hive
--conf
 spark.hive.metastore.client.factory.class=com.amazonaws.glue.catalog.metastore.AWSGlueDataCata
```

For more information on enabling Data Catalog for EMR Serverless, refer to Metastore configuration for EMR Serverless.

To access tables registered with AWS Lake Formation, the following configurations need to be set during Spark initialization to configure Spark to use AWS Lake Formation credentials.

Hive

```
--conf
 spark.hadoop.fs.s3.credentialsResolverClass=com.amazonaws.glue.accesscontrol.AWSLakeFormati
--conf spark.hadoop.fs.s3.useDirectoryHeaderAsFolderObject=true
--conf spark.hadoop.fs.s3.folderObject.autoAction.disabled=true
--conf spark.sql.catalog.skipLocationValidationOnCreateTable.enabled=true
--conf spark.sql.catalog.createDirectoryAfterTable.enabled=true
--conf spark.sql.catalog.dropDirectoryBeforeTable.enabled=true
```

Iceberg

```
--conf spark.sql.catalog.spark_catalog=org.apache.iceberg.spark.SparkSessionCatalog
--conf spark.sql.catalog.spark_catalog.warehouse=S3_DATA_LOCATION
--conf spark.sql.catalog.spark_catalog.client.region=REGION
--conf spark.sql.catalog.spark_catalog.type=glue
--conf spark.sql.catalog.spark_catalog.glue.account-id=ACCOUNT_ID
```

```
--conf spark.sql.catalog.spark_catalog.glue.lakeformation-enabled=true
--conf spark.sql.catalog.dropDirectoryBeforeTable.enabled=true
```

Delta Lake

```
--conf
 spark.hadoop.fs.s3.credentialsResolverClass=com.amazonaws.glue.accesscontrol.AWSLakeFormati
--conf spark.hadoop.fs.s3.useDirectoryHeaderAsFolderObject=true
--conf spark.hadoop.fs.s3.folderObject.autoAction.disabled=true
--conf spark.sql.catalog.skipLocationValidationOnCreateTable.enabled=true
--conf spark.sql.catalog.createDirectoryAfterTable.enabled=true
--conf spark.sql.catalog.dropDirectoryBeforeTable.enabled=true
```

Hudi

```
--conf
 spark.hadoop.fs.s3.credentialsResolverClass=com.amazonaws.glue.accesscontrol.AWSLakeFormati
--conf spark.hadoop.fs.s3.useDirectoryHeaderAsFolderObject=true
--conf spark.hadoop.fs.s3.folderObject.autoAction.disabled=true
--conf spark.sql.catalog.skipLocationValidationOnCreateTable.enabled=true
--conf spark.sql.catalog.createDirectoryAfterTable.enabled=true
--conf spark.sql.catalog.dropDirectoryBeforeTable.enabled=true
--conf spark.jars=/usr/lib/hudi/hudi-spark-bundle.jar
--conf spark.sql.extensions=org.apache.spark.sql.hudi.HoodieSparkSessionExtension
--conf
 spark.sql.catalog.spark_catalog=org.apache.spark.sql.hudi.catalog.HoodieCatalog
--conf spark.serializer=org.apache.spark.serializer.KryoSerializer
```

- `spark.hadoop.fs.s3.credentialsResolverClass=com.amazonaws.glue.accesscontrol.AW` Configure EMR Filesystem (EMRFS) or EMR S3A to use AWS Lake Formation S3 credentials for Lake Formation registered tables. If the table is not registered, use the job's runtime role credentials.
- `spark.hadoop.fs.s3.useDirectoryHeaderAsFolderObject=true` and `spark.hadoop.fs.s3.folderObject.autoAction.disabled=true`: Configure EMRFS to use content type header application/x-directory instead of $folder$ suffix when creating S3 folders. This is required when reading Lake Formation tables, as Lake Formation credentials do not allow reading table folders with $folder$ suffix.
- `spark.sql.catalog.skipLocationValidationOnCreateTable.enabled=true`: Configure Spark to skip validating the table location's emptiness before creation. This is

necessary for Lake Formation registered tables, as Lake Formation credentials to verify the empty location are available only after Glue Data Catalog table creation. Without this configuration, the job's runtime role credentials will validate the empty table location.

- `spark.sql.catalog.createDirectoryAfterTable.enabled=true`: Configure Spark to create the Amazon S3 folder after table creation in the Hive metastore. This is required for Lake Formation registered tables, as Lake Formation credentials to create the S3 folder are available only after Glue Data Catalog table creation.
- `spark.sql.catalog.dropDirectoryBeforeTable.enabled=true`: Configure Spark to drop the S3 folder before table deletion in the Hive metastore. This is necessary for Lake Formation registered tables, as Lake Formation credentials to drop the S3 folder are not available after table deletion from the Glue Data Catalog.
- `spark.sql.catalog.<catalog>.glue.lakeformation-enabled=true`: Configure Iceberg catalog to use AWS Lake Formation S3 credentials for Lake Formation registered tables. If the table is not registered, use default environment credentials.

Configure full table access mode in SageMaker Unified Studio

To access Lake Formation registered tables from interactive Spark sessions in JupyterLab notebooks, use compatibility permission mode. Use the %%configure magic command to set up your Spark configuration. Choose the configuration based on your table type:

For Hive tables

```
%%configure -f
{
    "conf": {
        "spark.hadoop.fs.s3.credentialsResolverClass":
 "com.amazonaws.glue.accesscontrol.AWSLakeFormationCredentialResolver",
        "spark.hadoop.fs.s3.useDirectoryHeaderAsFolderObject": true,
        "spark.hadoop.fs.s3.folderObject.autoAction.disabled": true,
        "spark.sql.catalog.skipLocationValidationOnCreateTable.enabled": true,
        "spark.sql.catalog.createDirectoryAfterTable.enabled": true,
        "spark.sql.catalog.dropDirectoryBeforeTable.enabled": true
    }
}
```

For Iceberg tables

```
%%configure -f
```

```
{
    "conf": {
        "spark.sql.catalog.spark_catalog":
 "org.apache.iceberg.spark.SparkSessionCatalog",
        "spark.sql.catalog.spark_catalog.warehouse": "S3_DATA_LOCATION",
        "spark.sql.catalog.spark_catalog.client.region": "REGION",
        "spark.sql.catalog.spark_catalog.type": "glue",
        "spark.sql.catalog.spark_catalog.glue.account-id": "ACCOUNT_ID",
        "spark.sql.catalog.spark_catalog.glue.lakeformation-enabled": "true",
        "spark.sql.catalog.dropDirectoryBeforeTable.enabled": "true",
    }
}
```

For Delta Lake tables

```
%%configure -f
{
    "conf": {
        "spark.hadoop.fs.s3.credentialsResolverClass":
 "com.amazonaws.glue.accesscontrol.AWSLakeFormationCredentialResolver",
        "spark.hadoop.fs.s3.useDirectoryHeaderAsFolderObject": true,
        "spark.hadoop.fs.s3.folderObject.autoAction.disabled": true,
        "spark.sql.catalog.skipLocationValidationOnCreateTable.enabled": true,
        "spark.sql.catalog.createDirectoryAfterTable.enabled": true,
        "spark.sql.catalog.dropDirectoryBeforeTable.enabled": true
    }
}
```

For Hudi tables

```
%%configure -f
{
    "conf": {
        "spark.hadoop.fs.s3.credentialsResolverClass":
 "com.amazonaws.glue.accesscontrol.AWSLakeFormationCredentialResolver",
        "spark.hadoop.fs.s3.useDirectoryHeaderAsFolderObject": true,
        "spark.hadoop.fs.s3.folderObject.autoAction.disabled": true,
        "spark.sql.catalog.skipLocationValidationOnCreateTable.enabled": true,
        "spark.sql.catalog.createDirectoryAfterTable.enabled": true,
        "spark.sql.catalog.dropDirectoryBeforeTable.enabled": true,
        "spark.jars": "/usr/lib/hudi/hudi-spark-bundle.jar",
        "spark.sql.extensions":
 "org.apache.spark.sql.hudi.HoodieSparkSessionExtension",
        "spark.sql.catalog.spark_catalog":
 "org.apache.spark.sql.hudi.catalog.HoodieCatalog",
        "spark.serializer": "org.apache.spark.serializer.KryoSerializer"
    }
}
```

Replace the placeholders:

- `S3_DATA_LOCATION`: Your S3 bucket path
- `REGION`: AWS region (e.g., us-east-1)
- `ACCOUNT_ID`: Your AWS account ID

Note

You must set these configurations before executing any Spark operations in your notebook.

Supported Operations

These operations will use AWS Lake Formation credentials to access the table data.

- CREATE TABLE
- ALTER TABLE
- INSERT INTO
- INSERT OVERWRITE
- UPDATE
- MERGE INTO
- DELETE FROM
- ANALYZE TABLE
- REPAIR TABLE
- DROP TABLE
- Spark datasource queries
- Spark datasource writes

Note

Operations not listed above will continue to use IAM permissions to access table data.

Considerations

- If a Hive table is created using a job that doesn't have full table access enabled, and no records are inserted, subsequent reads or writes from a job with full table access will fail. This is because EMR Spark without full table access adds the `$folder$` suffix to the table folder name. To resolve this, you can either:
  - Insert at least one row into the table from a job that does not have FTA enabled.
  - Configure the job that does not have FTA enabled to not use `$folder$` suffix in folder name in S3. This can be achieved by setting Spark configuration `spark.hadoop.fs.s3.useDirectoryHeaderAsFolderObject=true`.
  - Create a S3 folder at the table location `s3://path/to/table/table_name` using the AWS S3 console or AWS S3 CLI.
- Full Table Access is supported with the EMR Filesystem (EMRFS) starting in Amazon EMR release 7.8.0, and with the S3A filesystem starting in Amazon EMR release 7.10.0.
- Full Table Access is supported for Hive, Iceberg, Delta, and Hudi tables.
- **Hudi FTA Write Support considerations:**
  - Hudi FTA writes require using HoodieCredentialedHadoopStorage for credential vending during job execution. Set the following configuration when running Hudi jobs: `hoodie.storage.class=org.apache.spark.sql.hudi.storage.HoodieCredentialedHado`
  - Full Table Access (FTA) write support for Hudi is available starting from Amazon EMR release 7.12.
  - Hudi FTA write support currently works only with the default Hudi configurations. Custom or non-default Hudi settings may not be fully supported and could result in unexpected behavior.
  - Clustering for Hudi Merge-On-Read (MOR) tables is not supported at this point under FTA write mode.
- Jobs referencing tables with Lake Formation Fine-Grained Access Control (FGAC) rules or Glue Data Catalog Views will fail. To query a table with an FGAC rules or a Glue Data Catalog View, you must use the FGAC mode. You can enable FGAC mode by following the steps outlined in the AWS documentation: Using EMR Serverless with AWS Lake Formation for fine-grained access control.

- Full table access does not support Spark Streaming.
- When writing Spark DataFrame to a Lake Formation table, only APPEND mode is supported for Hive and Iceberg tables: `df.write.mode("append").saveAsTable(table_name)`
- Creating external tables requires IAM permissions.
- Because Lake Formation temporarily caches credentials within a Spark job, a Spark batch job or interactive session that is currently running might not reflect permission changes.
- You must use user defined role and not a service-linked role:Lake Formation requirements for roles.

Hudi FTA Write Support - Supported Operations

The following table shows the supported write operations for Hudi Copy-On-Write (COW) and Merge-On-Read (MOR) tables under Full Table Access mode:

Hudi FTA Supported Write Operations

Table Type	Operation	SQL Write Command	Status
COW	INSERT	INSERT INTO TABLE	Supported
COW	INSERT	INSERT INTO TABLE - PARTITION (Static, Dynamic)	Supported
COW	INSERT	INSERT OVERWRITE	Supported
COW	INSERT	INSERT OVERWRITE - PARTITION (Static, Dynamic)	Supported
UPDATE	UPDATE	UPDATE TABLE	Supported

Table Type	Operation	SQL Write Command	Status
COW	UPDATE	UPDATE TABLE - Change Partition	Not Supported
DELETE	DELETE	DELETE FROM TABLE	Supported
ALTER	ALTER	ALTER TABLE - RENAME TO	Not Supported
COW	ALTER	ALTER TABLE - SET TBLPROPER TIES	Supported
COW	ALTER	ALTER TABLE - UNSET TBLPROPERTIES	Supported
COW	ALTER	ALTER TABLE - ALTER COLUMN	Supported
COW	ALTER	ALTER TABLE - ADD COLUMNS	Supported
COW	ALTER	ALTER TABLE - ADD PARTITION	Supported
COW	ALTER	ALTER TABLE - DROP PARTITION	Supported
COW	ALTER	ALTER TABLE - RECOVER PARTITIONS	Supported

Table Type	Operation	SQL Write Command	Status
COW	ALTER	REPAIR TABLE SYNC PARTITIONS	Supported
DROP	DROP	DROP TABLE	Supported
COW	DROP	DROP TABLE - PURGE	Supported
CREATE	CREATE	CREATE TABLE - Managed	Supported
COW	CREATE	CREATE TABLE - PARTITION BY	Supported
COW	CREATE	CREATE TABLE IF NOT EXISTS	Supported
COW	CREATE	CREATE TABLE LIKE	Supported
COW	CREATE	CREATE TABLE AS SELECT	Supported
CREATE	CREATE	CREATE TABLE with LOCATION - External Table	Not Supported
DATAFRAME (INSERT)	DATAFRAME(INSERT)	saveAsTable.Overwrite	Supported
COW	DATAFRAME(INSERT)	saveAsTable.Append	Not Supported
COW	DATAFRAME(INSERT)	saveAsTable.Ignore	Supported

Table Type	Operation	SQL Write Command	Status
COW	DATAFRAME(INSERT)	saveAsTab le.ErrorIfExists	Supported
COW	DATAFRAME(INSERT)	saveAsTable - External table (Path)	Not Supported
COW	DATAFRAME(INSERT)	save(path) - DF v1	Not Supported
MOR	INSERT	INSERT INTO TABLE	Supported
MOR	INSERT	INSERT INTO TABLE - PARTITION (Static, Dynamic)	Supported
MOR	INSERT	INSERT OVERWRITE	Supported
MOR	INSERT	INSERT OVERWRITE - PARTITION (Static, Dynamic)	Supported
UPDATE	UPDATE	UPDATE TABLE	Supported
MOR	UPDATE	UPDATE TABLE - Change Partition	Not Supported
DELETE	DELETE	DELETE FROM TABLE	Supported
ALTER	ALTER	ALTER TABLE - RENAME TO	Not Supported

Table Type	Operation	SQL Write Command	Status
MOR	ALTER	ALTER TABLE - SET TBLPROPERTIES	Supported
MOR	ALTER	ALTER TABLE - UNSET TBLPROPERTIES	Supported
MOR	ALTER	ALTER TABLE - ALTER COLUMN	Supported
MOR	ALTER	ALTER TABLE - ADD COLUMNS	Supported
MOR	ALTER	ALTER TABLE - ADD PARTITION	Supported
MOR	ALTER	ALTER TABLE - DROP PARTITION	Supported
MOR	ALTER	ALTER TABLE - RECOVER PARTITIONS	Supported
MOR	ALTER	REPAIR TABLE SYNC PARTITIONS	Supported
DROP	DROP	DROP TABLE	Supported
MOR	DROP	DROP TABLE - PURGE	Supported
CREATE	CREATE	CREATE TABLE - Managed	Supported

Table Type	Operation	SQL Write Command	Status
MOR	CREATE	CREATE TABLE - PARTITION BY	Supported
MOR	CREATE	CREATE TABLE IF NOT EXISTS	Supported
MOR	CREATE	CREATE TABLE LIKE	Supported
MOR	CREATE	CREATE TABLE AS SELECT	Supported
CREATE	CREATE	CREATE TABLE with LOCATION - External Table	Not Supported
DATAFRAME (UPSERT)	DATAFRAME(UPSERT)	saveAsTable.Overwrite	Supported
MOR	DATAFRAME(UPSERT)	saveAsTable.Append	Not Supported
MOR	DATAFRAME(UPSERT)	saveAsTable.Ignore	Supported
MOR	DATAFRAME(UPSERT)	saveAsTable.ErrorIfExists	Supported
MOR	DATAFRAME(UPSERT)	saveAsTable - External table (Path)	Not Supported
MOR	DATAFRAME(UPSERT)	save(path) - DF v1	Not Supported

Table Type	Operation	SQL Write Command	Status
DATAFRAME (DELETE)	DATAFRAME(DELETE)	saveAsTable.Append	Not Supported
MOR	DATAFRAME(DELETE)	saveAsTable - External table (Path)	Not Supported
MOR	DATAFRAME(DELETE)	save(path) - DF v1	Not Supported
DATAFRAME (BULK_INSERT)	DATAFRAME(BULK_INSERT)	saveAsTable.Overwrite	Supported
MOR	DATAFRAME(BULK_INSERT)	saveAsTable.Append	Not Supported
MOR	DATAFRAME(BULK_INSERT)	saveAsTable.Ignore	Supported
MOR	DATAFRAME(BULK_INSERT)	saveAsTable.ErrorIfExists	Supported
MOR	DATAFRAME(BULK_INSERT)	saveAsTable - External table (Path)	Not Supported
MOR	DATAFRAME(BULK_INSERT)	save(path) - DF v1	Not Supported

Using EMR Serverless with AWS Lake Formation for fine-grained access control

Overview

With Amazon EMR releases 7.2.0 and higher, leverage AWS Lake Formation to apply fine-grained access controls on Data Catalog tables that are backed by S3. This capability lets you configure table, row, column, and cell level access controls for read queries within your Amazon EMR Serverless Spark jobs. To configure fine-grained access control for Apache Spark batch jobs and interactive sessions, use EMR Studio. See the following sections to learn more about Lake Formation and how to use it with EMR Serverless.

Using Amazon EMR Serverless with AWS Lake Formation incurs additional charges. For more information, refer to Amazon EMR pricing.

How EMR Serverless works with AWS Lake Formation

Using EMR Serverless with Lake Formation lets you enforce a layer of permissions on each Spark job to apply Lake Formation permissions control when EMR Serverless executes jobs. EMR Serverless uses Spark resource profiles to create two profiles to effectively execute jobs. The user profile executes user-supplied code, while the system profile enforces Lake Formation policies. For more information, refer to What is AWS Lake Formation and Considerations and limitations.

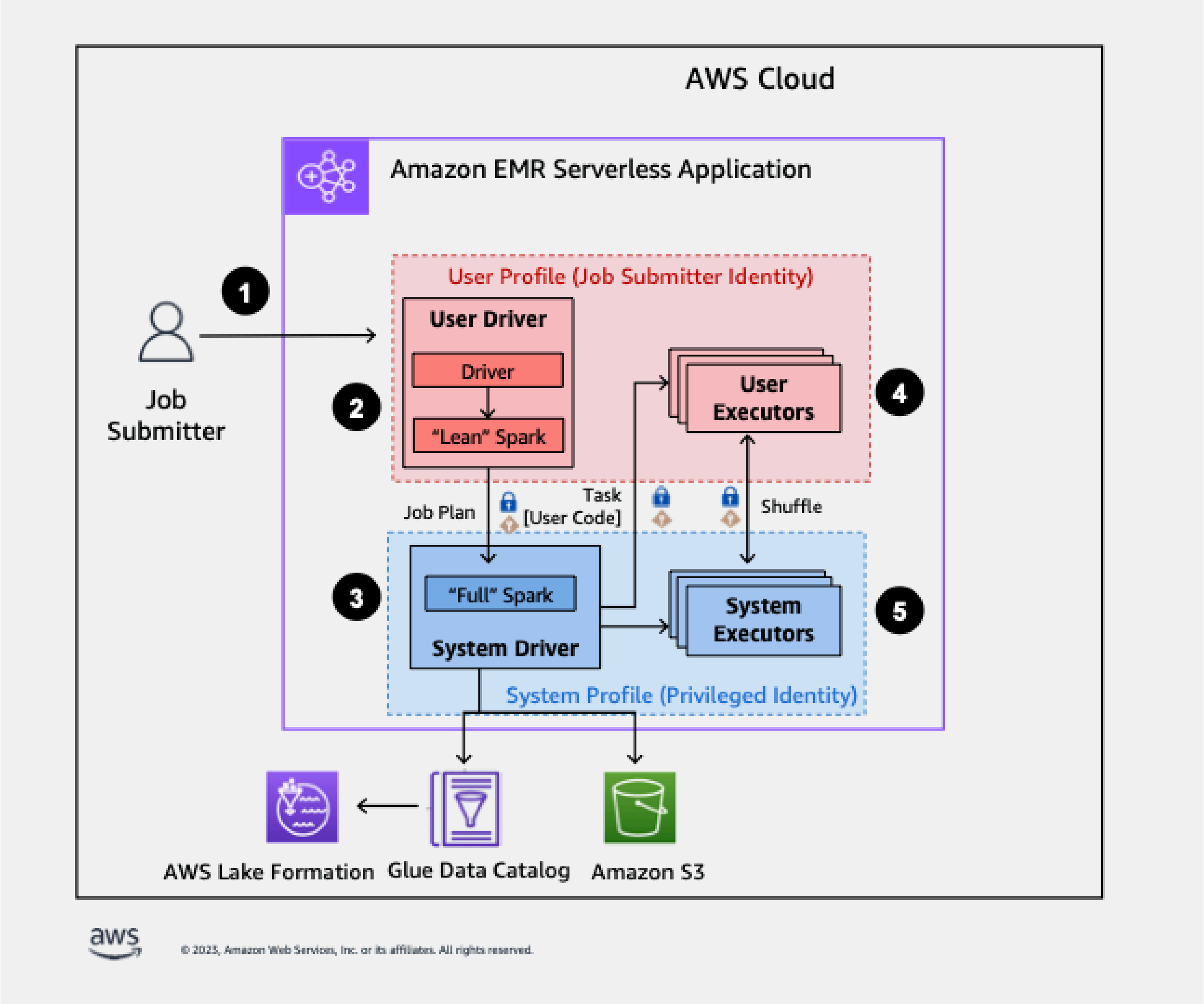
When you use pre-initialized capacity with Lake Formation, we suggest that you have a minimum of two Spark drivers. Each Lake Formation-enabled job utilizes two Spark drivers, one for the user profile and one for the system profile. For the best performance, use double the number of drivers for Lake Formation-enabled jobs compared to if you don't use Lake Formation.

When you run Spark jobs on EMR Serverless, also consider the impact of dynamic allocation on resource management and cluster performance. The configuration `spark.dynamicAllocation.maxExecutors` of the maximum number of executors per resource profile applies to user and system executors. If you configure that number to be equal to the maximum allowed number of executors, your job run might get stuck because of one type of executor that uses all available resources, which prevents the other executor when you run jobs jobs.

So you don't run out of resources, EMR Serverless sets the default maximum number of executors per resource profile to 90% of the `spark.dynamicAllocation.maxExecutors` value. You can override this configuration when you specify `spark.dynamicAllocation.maxExecutorsRatio` with a value between 0 and 1. Additionally, also configure the following properties to optimize resource allocation and overall performance:

- `spark.dynamicAllocation.cachedExecutorIdleTimeout`
- `spark.dynamicAllocation.shuffleTracking.timeout`
- `spark.cleaner.periodicGC.interval`

The following is a high-level overview of how EMR Serverless gets access to data protected by Lake Formation security policies.



1. A user submits Spark job to an AWS Lake Formation-enabled EMR Serverless application.

2. EMR Serverless sends the job to a user driver and runs the job in the user profile. The user driver runs a lean version of Spark that has no ability to launch tasks, request executors, access S3 or the Glue Catalog. It builds a job plan.
3. EMR Serverless sets up a second driver called the system driver and runs it in the system profile (with a privileged identity). EMR Serverless sets up an encrypted TLS channel between the two drivers for communication. The user driver uses the channel to send the job plans to the system driver. The system driver does not run user-submitted code. It runs full Spark and communicates with S3, and the Data Catalog for data access. It request executors and compiles the Job Plan into a sequence of execution stages.
4. EMR Serverless then runs the stages on executors with the user driver or system driver. User code in any stage is run exclusively on user profile executors.
5. Stages that read data from Data Catalog tables protected by AWS Lake Formation or those that apply security filters are delegated to system executors.

Enabling Lake Formation in Amazon EMR

To enable Lake Formation, set `spark.emr-serverless.lakeformation.enabled` to `true` under `spark-defaults` classification for the runtime-configuration parameter when creating an EMR Serverless application.

```
aws emr-serverless create-application \
    --release-label emr-7.12.0 \
    --runtime-configuration '{
     "classification": "spark-defaults",
     "properties": {
       "spark.emr-serverless.lakeformation.enabled": "true"
       }
    }' \
    --type "SPARK"
```

You can also enable Lake Formation when you create a new application in EMR Studio. Choose **Use Lake Formation for fine-grained access control**, available under **Additional configurations**.

Inter-worker encryption is enabled by default when you use Lake Formation with EMR Serverless, so you do not need to explicitly enable inter-worker encryption again.

Enabling Lake Formation for Spark jobs

To enable Lake Formation for individual Spark jobs, set `spark.emr-serverless.lakeformation.enabled` to true when using `spark-submit`.

```
--conf spark.emr-serverless.lakeformation.enabled=true
```

Job runtime role IAM permissions

Lake Formation permissions control access to AWS Glue Data Catalog resources, Amazon S3 locations, and the underlying data at those locations. IAM permissions control access to the Lake Formation and AWS Glue APIs and resources. Although you might have the Lake Formation permission to access a table in the Data Catalog (SELECT), your operation fails if you don't have the IAM permission on the `glue:Get*` API operation.

The following is an example policy of how to provide IAM permissions to access a script in S3, uploading logs to S3, AWS Glue API permissions, and permission to access Lake Formation.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Sid": "ScriptAccess",
      "Effect": "Allow",
      "Action": [
        "s3:GetObject",
        "s3:ListBucket"
      ],
      "Resource": [
        "arn:aws:s3:::*.amzn-s3-demo-bucket/scripts",
        "arn:aws:s3:::*.amzn-s3-demo-bucket/*"
      ]
    },
    {
      "Sid": "LoggingAccess",
      "Effect": "Allow",
      "Action": [
        "s3:PutObject"
      ],
      "Resource": [
        "arn:aws:s3:::amzn-s3-demo-bucket/logs/*"
      ]
    },
    {
      "Sid": "GlueCatalogAccess",
      "Effect": "Allow",
      "Action": [
        "glue:Get*",
        "glue:Create*",
        "glue:Update*"
      ],
      "Resource": [
        "*"
      ]
    },
    {
      "Sid": "LakeFormationAccess",
      "Effect": "Allow",
      "Action": [
        "lakeformation:GetDataAccess"
      ],
      "Resource": [
        "*"
      ]
    }
  ]
}
```

Setting up Lake Formation permissions for job runtime role

First, register the location of your Hive table with Lake Formation. Then create permissions for your job runtime role on your desired table. For more details about Lake Formation, refer to What is AWS Lake Formation? in the *AWS Lake Formation Developer Guide*.

After you set up the Lake Formation permissions, submit Spark jobs on Amazon EMR Serverless. For more information about Spark jobs, refer to Spark examples.

Submitting a job run

After you finish setting up the Lake Formation grants, you can submit Spark jobs on EMR Serverless. The section that follows shows examples of how to configure and submit job run properties.

Permission requirements

Tables not registered in AWS Lake Formation

For tables not registered with AWS Lake Formation, the job runtime role accesses both the AWS Glue Data Catalog and the underlying table data in Amazon S3. This requires the job runtime role to have appropriate IAM permissions for both AWS Glue and Amazon S3 operations.

Tables registered in AWS Lake Formation

For tables registered with AWS Lake Formation, the job runtime role accesses the AWS Glue Data Catalog metadata, while temporary credentials vended by Lake Formation access the underlying table data in Amazon S3. The Lake Formation permissions required to execute an operation depend on the AWS Glue Data Catalog and Amazon S3 API calls that the Spark job initiates and can be summarized as follows:

- **DESCRIBE** permission allows the runtime role to read table or database metadata in the Data Catalog
- **ALTER** permission allows the runtime role to modify table or database metadata in the Data Catalog
- **DROP** permission allows the runtime role to delete table or database metadata from the Data Catalog
- **SELECT** permission allows the runtime role to read table data from Amazon S3
- **INSERT** permission allows the runtime role to write table data to Amazon S3
- **DELETE** permission allows the runtime role to delete table data from Amazon S3

> **Note**
>
> Lake Formation evaluates permissions lazily when a Spark job calls AWS Glue to retrieve table metadata and Amazon S3 to retrieve table data. Jobs that use a runtime role with insufficient permissions will not fail until Spark makes an AWS Glue or Amazon S3 call that requires the missing permission.

> **Note**
>
> In the following supported table matrix:

- Operations marked as **Supported** exclusively use Lake Formation credentials to access table data for tables registered with Lake Formation. If Lake Formation permissions are insufficient, the operation will not fall back to runtime role credentials. For tables not registered with Lake Formation, the job runtime role credentials access the table data.
- Operations marked as **Supported with IAM permissions on Amazon S3 location** do not use Lake Formation credentials to access underlying table data in Amazon S3. To run these operations, the job runtime role must have the necessary Amazon S3 IAM permissions to access the table data, regardless of whether the table is registered with Lake Formation.

Hive

Operation	AWS Lake Formation permissions	Support status
SELECT	SELECT	Supported
CREATE TABLE	CREATE_TABLE	Supported
CREATE TABLE LIKE	CREATE_TABLE	Supported with IAM permissions on Amazon S3 location
CREATE TABLE AS SELECT	CREATE_TABLE	Supported with IAM permissions on Amazon S3 location
DESCRIBE TABLE	DESCRIBE	Supported
SHOW TBLPROPERTIES	DESCRIBE	Supported
SHOW COLUMNS	DESCRIBE	Supported
SHOW PARTITIONS	DESCRIBE	Supported
SHOW CREATE TABLE	DESCRIBE	Supported

Operation	AWS Lake Formation permissions	Support status
ALTER TABLE `tablename`	SELECT and ALTER	Supported
ALTER TABLE `tablename` SET LOCATION	-	Not supported
ALTER TABLE `tablename` ADD PARTITION	SELECT, INSERT and ALTER	Supported
REPAIR TABLE	SELECT and ALTER	Supported
LOAD DATA		Not supported
INSERT	INSERT and ALTER	Supported
INSERT OVERWRITE	SELECT, INSERT, DELETE and ALTER	Supported
DROP TABLE	SELECT, DROP, DELETE and ALTER	Supported
TRUNCATE TABLE	SELECT, INSERT, DELETE and ALTER	Supported
Dataframe Writer V1	Same as corresponding SQL operation	Supported when appending data to an existing table. Refer to considerations and limitations for more information
Dataframe Writer V2	Same as corresponding SQL operation	Supported when appending data to an existing table. Refer to considerations and limitations for more information

Iceberg

Operation	AWS Lake Formation permissions	Support status
SELECT	SELECT	Supported
CREATE TABLE	CREATE_TABLE	Supported
CREATE TABLE LIKE	CREATE_TABLE	Supported with IAM permissions on Amazon S3 location
CREATE TABLE AS SELECT	CREATE_TABLE	Supported with IAM permissions on Amazon S3 location
REPLACE TABLE AS SELECT	SELECT, INSERT and ALTER	Supported
DESCRIBE TABLE	DESCRIBE	Supported with IAM permissions on Amazon S3 location
SHOW TBLPROPERTIES	DESCRIBE	Supported with IAM permissions on Amazon S3 location
SHOW CREATE TABLE	DESCRIBE	Supported with IAM permissions on Amazon S3 location
ALTER TABLE	SELECT, INSERT and ALTER	Supported
ALTER TABLE SET LOCATION	SELECT, INSERT and ALTER	Supported with IAM permissions on Amazon S3 location
ALTER TABLE WRITE ORDERED BY	SELECT, INSERT and ALTER	Supported with IAM permissions on Amazon S3 location
ALTER TABLE WRITE DISTRIBUTED BY	SELECT, INSERT, and ALTER	Supported with IAM permissions on Amazon S3 location

Operation	AWS Lake Formation permissions	Support status
ALTER TABLE RENAME TABLE	CREATE_TABLE, and DROP	Supported
INSERT INTO	SELECT, INSERT and ALTER	Supported
INSERT OVERWRITE	SELECT, INSERT and ALTER	Supported
DELETE	SELECT, INSERT and ALTER	Supported
UPDATE	SELECT, INSERT and ALTER	Supported
MERGE INTO	SELECT, INSERT and ALTER	Supported
DROP TABLE	SELECT, DELETE and DROP	Supported
DataFrame Writer V1	-	Not supported
DataFrame Writer V2	Same as corresponding SQL operation	Supported when appending data to an existing table. Refer to considerations and limitations for more information.
Metadata tables	SELECT	Supported. Certain tables are hidden. Refer to considerations and limitations for more information.

Operation	AWS Lake Formation permissions	Support status
Stored procedures	-	Supported for tables that meet the following conditions: • Tables not registered in AWS Lake Formation • Tables that do not use `register_table` and `migrate` Refer to considerations and limitations for more information.

Spark configuration for Iceberg: The following sample shows how to configure Spark with Iceberg. To run Iceberg jobs, provide the following `spark-submit` properties.

```
--conf spark.sql.catalog.spark_catalog=org.apache.iceberg.spark.SparkSessionCatalog
--conf spark.sql.catalog.spark_catalog.warehouse=<S3_DATA_LOCATION>
--conf spark.sql.catalog.spark_catalog.glue.account-id=<ACCOUNT_ID>
--conf spark.sql.catalog.spark_catalog.client.region=<REGION>
--conf spark.sql.catalog.spark_catalog.glue.endpoint=https://
glue.<REGION>.amazonaws.com
```

Hudi

Operation	AWS Lake Formation permissions	Support status
SELECT	SELECT	Supported
CREATE TABLE	CREATE_TABLE	Supported with IAM permissions on Amazon S3 location
CREATE TABLE LIKE	CREATE_TABLE	Supported with IAM permissions on Amazon S3 location

Operation	AWS Lake Formation permissions	Support status
CREATE TABLE AS SELECT	-	Not supported
DESCRIBE TABLE	DESCRIBE	Supported with IAM permissions on Amazon S3 location
SHOW TBLPROPERTIES	DESCRIBE	Supported with IAM permissions on Amazon S3 location
SHOW COLUMNS	DESCRIBE	Supported with IAM permissions on Amazon S3 location
SHOW CREATE TABLE	DESCRIBE	Supported with IAM permissions on Amazon S3 location
ALTER TABLE	SELECT	Supported with IAM permissions on Amazon S3 location
INSERT INTO	SELECT and ALTER	Supported with IAM permissions on Amazon S3 location
INSERT OVERWRITE	SELECT and ALTER	Supported with IAM permissions on Amazon S3 location
DELETE	-	Not supported
UPDATE	-	Not supported
MERGE INTO	-	Not supported

Operation	AWS Lake Formation permissions	Support status
DROP TABLE	SELECT and DROP	Supported with IAM permissions on Amazon S3 location
DataFrame Writer V1	-	Not supported
DataFrame Writer V2	Same as corresponding SQL operation	Supported with IAM permissions on Amazon S3 location
Metadata tables	-	Not supported
Table maintenance and utility features	-	Not supported

The following samples configure Spark with Hudi, specifying file locations and other properties necessary for use.

Spark config for Hudi: This snippet when used in a notebook specifies the path to the Hudi Spark bundle JAR file, which enables Hudi functionality in Spark. It also configures Spark to use the AWS Glue Data Catalog as the metastore.

```
%%configure -f
{
    "conf": {
        "spark.jars": "/usr/lib/hudi/hudi-spark-bundle.jar",
        "spark.hadoop.hive.metastore.client.factory.class":
 "com.amazonaws.glue.catalog.metastore.AWSGlueDataCatalogHiveClientFactory",
        "spark.serializer": "org.apache.spark.serializer.JavaSerializer",
        "spark.sql.catalog.spark_catalog":
 "org.apache.spark.sql.hudi.catalog.HoodieCatalog",
        "spark.sql.extensions":
 "org.apache.spark.sql.hudi.HoodieSparkSessionExtension"
    }
}
```

Spark config for Hudi with AWS Glue: This snippet when used in a notebook enables Hudi as a supported data-lake format and ensures that Hudi libraries and dependencies are available.

```
%%configure
{
    "--conf": "spark.serializer=org.apache.spark.serializer.JavaSerializer --conf 
spark.sql.catalog.spark_catalog=org.apache.spark.sql.hudi.catalog.HoodieCatalog --
conf 
spark.sql.extensions=org.apache.spark.sql.hudi.HoodieSparkSessionExtension",
    "--datalake-formats": "hudi",
    "--enable-glue-datacatalog": True,
    "--enable-lakeformation-fine-grained-access": "true"
}
```

Delta Lake

Operation	AWS Lake Formation permissions	Support status
SELECT	SELECT	Supported
CREATE TABLE	CREATE_TABLE	Supported
CREATE TABLE LIKE	-	Not supported
CREATE TABLE AS SELECT	CREATE_TABLE	Supported
REPLACE TABLE AS SELECT	SELECT, INSERT and ALTER	Supported
DESCRIBE TABLE	DESCRIBE	Supported with IAM permissions on Amazon S3 location
SHOW TBLPROPERTIES	DESCRIBE	Supported with IAM permissions on Amazon S3 location
SHOW COLUMNS	DESCRIBE	Supported with IAM permissions on Amazon S3 location

Operation	AWS Lake Formation permissions	Support status
SHOW CREATE TABLE	DESCRIBE	Supported with IAM permissions on Amazon S3 location
ALTER TABLE	SELECT and INSERT	Supported
ALTER TABLE SET LOCATION	SELECT and INSERT	Supported with IAM permissions on Amazon S3 location
ALTER TABLE `tablename` CLUSTER BY	SELECT and INSERT	Supported with IAM permissions on Amazon S3 location
ALTER TABLE `tablename` ADD CONSTRAINT	SELECT and INSERT	Supported with IAM permissions on Amazon S3 location
ALTER TABLE `tablename` DROP CONSTRAINT	SELECT and INSERT	Supported with IAM permissions on Amazon S3 location
INSERT INTO	SELECT and INSERT	Supported
INSERT OVERWRITE	SELECT and INSERT	Supported
DELETE	SELECT and INSERT	Supported
UPDATE	SELECT and INSERT	Supported
MERGE INTO	SELECT and INSERT	Supported
DROP TABLE	SELECT, DELETE and DROP	Supported
DataFrame Writer V1	-	Not supported

Operation	AWS Lake Formation permissions	Support status
DataFrame Writer V2	Same as corresponding SQL operation	Supported
Table maintenance and utility features	-	Not supported

EMR Serverless with Delta Lake: To use Delta Lake with Lake Formation on EMR Serverless, run the following command:

```
spark-sql \
  --conf
 spark.sql.extensions=io.delta.sql.DeltaSparkSessionExtension,com.amazonaws.emr.recordserver
 \
  --conf
 spark.sql.catalog.spark_catalog=org.apache.spark.sql.delta.catalog.DeltaCatalog \
```

Debugging jobs

Note

With this feature, access **stdout** and **stderr** logs for the system profile workers that may contain sensitive, unfiltered information. The following permission should be used only for accessing non-production data. For applications created for use with production jobs, we strongly suggest that you add these permissions only to administrators or users with elevated data access.

With EMR-7.3.0 and later, EMR Serverless is enabling self-debugging capability for Lake Formation-enabled batch jobs. To do so, use the new parameter **accessSystemProfileLogs** in the GetDashboardForJobRun API. If **accessSystemProfileLogs** is set to **true**, you can access the **stdout** and **stderr** logs for the system profile workers, which can be used for debugging a Lake Formation-enabled EMR Serverless batch job.

```
aws emr-serverless get-dashboard-for-job-run \
  --application-id application-id
  --job-run-id job-run-id
  --access-system-profile-logs
```

Required permissions

The principal who wants to debug Lake Formation-enabled batch jobs using **GetDashboardForJobRun** must have the following additional permissions:

```
{
    "Sid": "AccessSystemProfileLogs",
    "Effect": "Allow",
    "Action": [
        "emr-serverless:GetDashboardForJobRun",
        "emr-serverless:AccessSystemProfileLogs",
        "glue:GetDatabases",
        "glue:SearchTables"
    ],
    "Resource": [
        "arn:aws:emr-serverless:region:account-id:/applications/applicationId/
jobruns/jobid",
        "arn:aws:glue:region:account-id:catalog",
        "arn:aws:glue:region:account-id:database/*",
        "arn:aws:glue:region:account-id:table/*/*"
    ]
}
```

Considerations

System profile logs for debugging are visible for jobs that access databases or tables in Lake Formation within the same account as the job. They are not visible in the following scenarios:

- If the data catalog managed using Lake Formation permissions has cross-account databases and tables
- If the data catalog managed using Lake Formation permissions has resource links

Working with Glue Data Catalog views

You can create and manage views in the AWS Glue Data Catalog for use with EMR Serverless. These are known commonly as AWS Glue Data Catalog views. These views are useful because they support multiple SQL query engines, so you can access the same view across different AWS services, such as EMR Serverless, Amazon Athena, and Amazon Redshift.

By creating a view in the Data Catalog, use resource grants and tag-based access controls in AWS Lake Formation to grant access to it. Using this method of access control, you do not need to configure additional access to the tables you referenced when creating the view. This method of granting permissions is called definer semantics, and these views are called definer views. For more information about access control in Lake Formation, see Granting and revoking permissions on Data Catalog resources in the AWS Lake Formation Developer Guide.

Data Catalog views are useful for the following use cases:

- **Granular access control** – You can create a view that restricts data access based on the permissions the user needs. For example, you can use views in the Data Catalog to prevent employees who don't work in the HR department from seeing personally identifiable information (PII).
- **Complete view definition** – By applying filters on your view in the Data Catalog, you make sure that data records available in a view in the Data Catalog are always complete.
- **Enhanced security** – The query definition used to create the view must be complete. This benefit means that views in the Data Catalog are less susceptible to SQL commands from malicious actors.
- **Simple sharing data** – Share data with other AWS accounts without moving data. For more information, refer to Cross-account data sharing in Lake Formation.

Creating a Data Catalog view

There are different ways to create a Data Catalog view. These include using the AWS CLI or Spark SQL. A few examples follow.

Using SQL

The following demonstrates the syntax for creating a Data Catalog view. Note the `MULTI DIALECT` view type. This distinguishes the Data Catalog view from other views. The `SECURITY` predicate is specified as `DEFINER`. This indicates a Data Catalog view with `DEFINER` semantics.

```
CREATE [ OR REPLACE ] PROTECTED MULTI DIALECT VIEW [IF NOT EXISTS] view_name
[(column_name [COMMENT column_comment], ...) ]
[ COMMENT view_comment ]
```

```
[TBLPROPERTIES (property_name = property_value, ... )]
SECURITY DEFINER
AS query;
```

The following is a sample CREATE statement, following the syntax:

```
CREATE PROTECTED MULTI DIALECT VIEW catalog_view
SECURITY DEFINER
AS
SELECT order_date, sum(totalprice) AS price
FROM source_table
GROUP BY order_date
```

You can also create a view in dry-run mode, using SQL, to test view creation, without actually creating the resource. Using this option results in a "dry run" that validates the input and, if the validation succeeds, returns the JSON of the AWS Glue table object that will represent the view. In this case, The actual view isn't created.

```
CREATE [ OR REPLACE ] PROTECTED MULTI DIALECT VIEW view_name
SECURITY DEFINER
[ SHOW VIEW JSON ]
AS view-sql
```

Using the AWS CLI

Note

When you use the CLI command, the SQL used to create the view isn't parsed. This can result in a case where the view is created, but queries aren't successful. Be sure to test your SQL syntax prior to creating the view.

You use the following CLI command to create a view:

```
aws glue create-table --cli-input-json '{
  "DatabaseName": "database",
  "TableInput": {
    "Name": "view",
    "StorageDescriptor": {
      "Columns": [
        {
          "Name": "col1",
          "Type": "data-type"
        },
        ...
        {
          "Name": "col_n",
          "Type": "data-type"
        }
      ],
      "SerdeInfo": {}
    },
    "ViewDefinition": {
      "SubObjects": [
        "arn:aws:glue:aws-region:aws-account-id:table/database/referenced-table1",
        ...
        "arn:aws:glue:aws-region:aws-account-id:table/database/referenced-tableN",
       ],
      "IsProtected": true,
      "Representations": [
        {
          "Dialect": "SPARK",
          "DialectVersion": "1.0",
          "ViewOriginalText": "Spark-SQL",
          "ViewExpandedText": "Spark-SQL"
        }
      ]
    }
  }
}'
```

Supported view operations

The following command fragments show you various ways to work with Data Catalog views:

- **CREATE VIEW**

  Creates a data-catalog view. The following is a sample that shows creating a view from an existing table:

  ```
  CREATE PROTECTED MULTI DIALECT VIEW catalog_view
  SECURITY DEFINER AS SELECT * FROM my_catalog.my_database.source_table
  ```

- **ALTER VIEW**

  Available syntax:

  - `ALTER VIEW view_name [FORCE] ADD DIALECT AS query`
  - `ALTER VIEW view_name [FORCE] UPDATE DIALECT AS query`
  - `ALTER VIEW view_name DROP DIALECT`

  You can use the `FORCE ADD DIALECT` option to force update the schema and sub objects as per the new engine dialect. Note that doing this can result in query errors if you don't also use `FORCE` to update other engine dialects. The following demonstrates a sample:

  ```
  ALTER VIEW catalog_view FORCE ADD DIALECT
  AS
  SELECT order_date, sum(totalprice) AS price
  FROM source_table
  GROUP BY orderdate;
  ```

  The following demonstrates how to alter a view to update the dialect:

  ```
  ALTER VIEW catalog_view UPDATE DIALECT AS
  SELECT count(*) FROM my_catalog.my_database.source_table;
  ```

- **DESCRIBE VIEW**

  Available syntax for describing a view:

  - `SHOW COLUMNS {FROM|IN} view_name [{FROM|IN} database_name]` – If the user has the required AWS Glue and Lake Formation permissions to describe the view, they can list the columns. The following demonstrates a couple sample commands for showing columns:

    ```
    SHOW COLUMNS FROM my_database.source_table;
    SHOW COLUMNS IN my_database.source_table;
    ```

  - `DESCRIBE view_name` – If the user has the required AWS Glue and Lake Formation permissions to describe the view, they can list the columns in the view along with its metadata.

- **DROP VIEW**

  Available syntax:

  - `DROP VIEW [ IF EXISTS ] view_name`

The following sample shows a DROP statement that tests if a view exists prior to dropping it:

```
DROP VIEW IF EXISTS catalog_view;
```

- **SHOW CREATE VIEW**
  - `SHOW CREATE VIEW view_name` – Shows the SQL statement that creates the specified view. The following is a sample that shows creating a data-catalog view:

```
SHOW CREATE TABLE my_database.catalog_view;
CREATE PROTECTED MULTI DIALECT VIEW my_catalog.my_database.catalog_view (
  net_profit,
  customer_id,
  item_id,
  sold_date)
TBLPROPERTIES (
  'transient_lastDdlTime' = '1736267222')
SECURITY DEFINER AS SELECT * FROM
my_database.store_sales_partitioned_lf WHERE customer_id IN (SELECT customer_id
 from source_table limit 10)
```

- **SHOW VIEWS**

  List all views in the catalog such asregular views, multi-dialect views (MDV), and MDV without Spark dialect. Available syntax is the following:

  - `SHOW VIEWS [{ FROM | IN } database_name] [LIKE regex_pattern]`:

    The following demonstrates a sample command to show views:

```
SHOW VIEWS IN marketing_analytics LIKE 'catalog_view*';
```

For more information about creating and configuring data-catalog views, refer to Building AWS Glue Data Catalog views in the AWS Lake Formation Developer Guide.

Querying a Data Catalog view

After creating a Data Catalog view, you can query it using an Amazon EMR Serverless Spark job that has AWS Lake Formation fine-grained access control enabled. The job runtime role must have the Lake Formation SELECT permission on the Data Catalog view. You don't need to grant access to the underlying tables referenced in the view.

Once you have everything set up, you can query your view. For example, after creating an EMR Serverless application in EMR Studio, run the following query to access a view.

```
SELECT * from my_database.catalog_view LIMIT 10;
```

A helpful function is the `invoker_principal`. It returns the unique identifier of the EMRS job runtime role. This can be used to control the view output, based on the invoking principal. You can use this to add a condition in your view that refines query results, based on the calling role. The job runtime role must have permission to the `LakeFormation:GetDataLakePrincipal` IAM action to use this function.

```
select invoker_principal();
```

You can add this function to a `WHERE` clause, for instance, to refine query results.

Considerations and limitations

When you create Data Catalog views, the following apply:

- You can only create Data Catalog views with Amazon EMR 7.6 and above.
- The Data Catalog view definer must have `SELECT` access to the underlying base tables accessed by the view. Creating the Data Catalog view fails if a specific base table has any Lake Formation filters imposed on the definer role.
- Base tables must not have the `IAMAllowedPrincipals` data lake permission in Lake Formation. If present, the error *Multi Dialect views may only reference tables without IAMAllowedPrincipals permissions* occurs.
- The table's Amazon S3 location must be registered as a Lake Formation data lake location. If the table isn't registered, the error *Multi Dialect views may only reference Lake Formation managed tables* occurs. For information about how to register Amazon S3 locations in Lake Formation, refer to Registering an Amazon S3 location in the AWS Lake Formation Developer Guide.
- You can only create `PROTECTED` Data Catalog views. `UNPROTECTED` views aren't supported.
- You can't reference tables in another AWS account in a Data Catalog view definition. You also can't reference a table in the same account that's in a separate region.
- To share data across an account or region, the entire view must be be shared cross account and cross region, using Lake Formation resource links.
- User-defined functions (UDFs) aren't supported.

- You can use views based on Iceberg tables. The open-table formats Apache Hudi and Delta Lake are also supported.
- You can't reference other views in Data Catalog views.
- An AWS Glue Data Catalog view schema is always stored using lowercase. For example, if you use a DDL statement to create a Glue Data Catalog view with a column named `Castle`, the column created in the Glue Data Catalog will be made lowercase, to `castle`. If you then specify the column name in a DML query as `Castle` or `CASTLE`, EMR Spark will make the name lowercase for you to run the query. But the column heading displays using the casing that you specified in the query.

  If you want a query to fail in a case where a column name specified in the DML query does not match the column name in the Glue Data Catalog, set `spark.sql.caseSensitive=true`.

Open-table format support

EMR Serverless supports SELECT queries on Apache Hive, Apache Iceberg, Delta Lake (7.6.0+), and Apache Hudi (7.6.0+). Starting with EMR 7.12, DML and DDL operations that modify table data are supported for Apache Hive, Apache Iceberg, and Delta Lake tables using Lake Formation vended credentials.

Considerations and limitations

General

Review the following limitations when using Lake Formation with EMR Serverless.

> **Note**
>
> When you enable Lake Formation for a Spark job on EMR Serverless, the job launches a system driver and a user driver. If you specified pre-initialized capacity at launch, the drivers provision from the pre-initialized capacity, and the number of system drivers is equal to the number of user drivers that you specify. If you choose On Demand capacity, EMR Serverless launches a system driver in addition to a user driver. To estimate the costs associated with your EMR Serverless with Lake Formation job, use the AWS Pricing Calculator.

- Amazon EMR Serverless with Lake Formation is available in all supported EMR Serverless Regions.

- Lake Formation-enabled applications don’t support usage of customized EMR Serverless images.
- You can't turn off `DynamicResourceAllocation` for Lake Formation jobs.
- You can only use Lake Formation with Spark jobs.
- EMR Serverless with Lake Formation only supports a single Spark session throughout a job.
- EMR Serverless with Lake Formation only supports cross-account table queries shared through resource links.
- The following aren't supported:
  - Resilient distributed datasets (RDD)
  - Spark streaming
  - Access control for nested columns
- EMR Serverless blocks functionalities that might undermine the complete isolation of system driver, including the following:
  - UDTs, HiveUDFs, and any user-defined function that involves custom classes
  - Custom data sources
  - Supply of additional jars for Spark extension, connector, or metastore
  - `ANALYZE TABLE` command
- If your EMR Serverless application is in a private subnet with VPC endpoints for Amazon S3 and you attach an endpoint policy to control access, before your jobs can send log data to AWS Managed Amazon S3, include the permissions detailed in Managed storage in your VPC policy to S3 gateway endpoint. For troubleshooting requests, contact AWS support.
- Starting with Amazon EMR 7.9.0, Spark FGAC supports S3AFileSystem when used with the s3a:// scheme.
- Amazon EMR 7.11 supports creating managed tables using CTAS.
- Amazon EMR 7.12 supports creating managed and external tables using CTAS.

Permissions

- To enforce access controls, EXPLAIN PLAN and DDL operations such as DESCRIBE TABLE don't expose restricted information.
- When you register a table location with Lake Formation, data access uses Lake Formation stored credentials instead of the EMR Serverless job runtime role's IAM permissions. Jobs will fail if the registered role for table location is misconfigured, even when the runtime role has S3 IAM permissions for that location.

- Starting with Amazon EMR 7.12, you can write to existing Hive and Iceberg tables using DataFrameWriter (V2) with Lake Formation credentials in append mode. For overwrite operations or when creating new tables, EMR uses the runtime role credentials to modify table data.
- The following limitations apply when using views or cached tables as source data (these limitations do not apply to AWS Glue Data Catalog views):
  - For MERGE, DELETE, and UPDATE operations
    - Supported: Using views and cached tables as source tables.
    - Not supported: Using views and cached tables in assignment and condition clauses.
  - For CREATE OR REPLACE and REPLACE TABLE AS SELECT operations:
    - Not supported: Using views and cached tables as source tables.
- Delta Lake tables with UDFs in source data support MERGE, DELETE, and UPDATE operations only when deletion vector is enabled.

Logs and debugging

- EMR Serverless restricts access to system driver Spark logs on Lake Formation-enabled applications. Since the system driver runs with elevated permissions, events and logs that the system driver generates can include sensitive information. To prevent unauthorized users or code from accessing this sensitive data, EMR Serverless disables access to system driver logs.
- System profile logs are always persisted in managed storage – this is a mandatory setting that cannot be disabled. These logs are stored securely and encrypted using either a Customer Managed KMS key or an AWS Managed KMS keys.

Iceberg

Review the following considerations when using Apache Iceberg:

- You can only use Apache Iceberg with session catalog and not arbitrarily named catalogs.
- Iceberg tables that are registered in Lake Formation only support the metadata tables `history`, `metadata_log_entries`, `snapshots`, `files`, `manifests`, and `refs`. Amazon EMR hides the columns that might have sensitive data, such as `partitions`, `path`, and `summaries`. This limitation doesn't apply to Iceberg tables that aren't registered in Lake Formation.
- Tables that not registered in Lake Formation support all Iceberg stored procedures. The `register_table` and `migrate` procedures aren't supported for any tables.
- We suggest that you use Iceberg DataFrameWriterV2 instead of V1.

Troubleshooting

See the following sections for troubleshooting solutions.

Logging

EMR Serverless uses Spark resources profiles to split job execution. EMR Serverless uses the user profile to run the code you supplied, while the system profile enforces Lake Formation policies. You can access the logs for the tasks ran as the user profile.

For more information about debugging Lake Formation-enabled jobs, refer to Debugging jobs.

Live UI and Spark History Server

The Live UI and the Spark History Server have all Spark events generated from the user profile and redacted events generated from the system driver.

You can see all of the tasks from the user and system drivers in the **Executors** tab. However, log links are available only for the user profile. Also, some information is redacted from Live UI, such as the number of output records.

Job failed with insufficient Lake Formation permissions

Make sure that your job runtime role has the permissions to run SELECT and DESCRIBE on the table that you are accessing.

Job with RDD execution failed

EMR Serverless currently doesn't support resilient distributed dataset (RDD) operations on Lake Formation-enabled jobs.

Unable to access data files in Amazon S3

Make sure you have registered the location of the data lake in Lake Formation.

Security validation exception

EMR Serverless detected a security validation error. Contact AWS support for assistance.

Sharing AWS Glue Data Catalog and tables across accounts

You can share databases and tables across accounts and still use Lake Formation. For more information, refer to Cross-account data sharing in Lake Formation and How do I share AWS Glue Data Catalog and tables cross-account using AWS Lake Formation?.

Spark native fine-grained access control alllowlisted PySpark API

To maintain security and data access controls, Spark fine-grained access control (FGAC) restricts certain PySpark functions. These restrictions are enforced through:

- Explicit blocking that prevents function execution
- Architecture incompatibilities that make functions non-functional
- Functions that may throw errors, return access denied messages, or do nothing when called

The following PySpark features aren't supported in Spark FGAC:

- RDD operations (blocked with SparkRDDUnsupportedException)
- Spark Connect (unsupported)
- Spark Streaming (unsupported)

While we've tested the listed functions in a Native Spark FGAC environment and confirmed they work as expected, our testing typically covers only basic usage of each API. Functions with multiple input types or complex logic paths may have untested scenarios.

For any functions not listed here and not clearly part of the unsupported categories above, we recommend:

- Testing them first in a gamma environment or small-scale deployment
- Verifying their behavior before using them in production

> **Note**
>
> If you see a class method listed but not its base class, the method should still work—it just means we haven't explicitly verified the base class constructor.

The PySpark API is organized into modules. General support for methods within each module is detailed in the table below.

Module name	Status	Notes
pyspark_core	Supported	This module contains the main RDD classes, and these functions are mostly unsupported.
pyspark_sql	Supported	
pyspark_testing	Supported	
pyspark_resource	Supported	
pyspark_streaming	Blocked	Streaming usage is blocked in Spark FGAC.
pyspark_mllib	Experimental	This module contains RDD based ML operation s, and these functions are mostly unsupported. This module isn't thoroughly tested.
pyspark_ml	Experimental	This module containes DataFrame based ML operations, and these functions are mostly supported. This module isn't thoroughly tested.
pyspark_pandas	Supported	
pyspark_pandas_slow	Supported	
pyspark_connect	Blocked	Spark Connect usage is blocked in Spark FGAC.
pyspark_pandas_connect	Blocked	Spark Connect usage is blocked in Spark FGAC.

Module name	Status	Notes
pyspark_pandas_slow_connect	Blocked	Spark Connect usage is blocked in Spark FGAC.
pyspark_errors	Experimental	This module is not thoroughly tested. Custom error classes can't be utilized.

API Allowlist

For a downloadable and easier to search list, a file with the modules and classes is available at Python functions allowed in Native FGAC.

Inter-worker encryption

With Amazon EMR versions 6.15.0 and higher, enable mutual-TLS encrypted communication between workers in your Spark job runs. When enabled, EMR Serverless automatically generates and distributes a unique certificate for each worker provisioned under your job runs. When these workers communicate to exchange control messages or transfer shuffle data, they establish a mutual TLS connection and use the configured certificates to verify the identity of each other. If a worker is unable to verify another certificate, the TLS handshake fails, and EMR Serverless aborts the connection between them.

If you're using Lake Formation with EMR Serverless, mutual-TLS encryption is enabled by default.

Enabling mutual-TLS encryption on EMR Serverless

To enable mutual TLS encryption on your spark application, set `spark.ssl.internode.enabled` to true when creating EMR Serverless application. If you're using the AWS console to create an EMR Serverless application, choose **Use custom settings**, then expand **Application configuration**, and enter your `runtimeConfiguration`.

```
aws emr-serverless create-application \
--release-label emr-6.15.0 \
--runtime-configuration '{
  "classification": "spark-defaults",
  "properties": {"spark.ssl.internode.enabled": "true"}
}' \
--type "SPARK"
```

If you want to enable mutual TLS encryption for individual spark job runs, set `spark.ssl.internode.enabled` to true when using `spark-submit`.

```
--conf spark.ssl.internode.enabled=true
```

Disk Encryption with KMS CMK

EMR Serverless encrypts all disks attached to workers by default using service-owned encryption keys. You can optionally choose to encrypt these disks using your own AWS KMS customer managed keys (CMKs). This provides you with more control over your encryption keys, including the ability to establish and maintain key policies, and audit key usage.

You can configure disk encryption either when creating an application or when submitting individual jobs. When enabled at the application level, all jobs on that application inherit the encryption settings. You can also override the application's default by specifying a disk encryption configuration when submitting a job.

> **Note**
>
> EMR Serverless disk encryption only supports symmetric KMS keys. Asymmetric KMS keys are not supported. You must use a symmetric encryption KMS key that was created in AWS KMS. For more information on AWS KMS, see What is AWS KMS?

Using Encryption Context

Optionally, EMR Serverless uses encryption context to provide additional authenticated data for encryption operations. The encryption context is a set of key-value pairs that can contain non-secret additional authenticated data. The encryption context is cryptographically bound to the encrypted data, so the same encryption context is required to decrypt the data.

In EMR Serverless, you can specify the custom encryption context when configuring disk encryption. This encryption context is included in AWS CloudTrail logs to help you identify and understand your KMS operations.

Note

Do not store sensitive information in encryption context as it appears in plaintext in AWS CloudTrail logs.

Configuring Disk Encryption with Customer Managed Keys

CreateApplication

To encrypt disks with your own KMS key, include the `diskEncryptionConfiguration` parameter when creating an EMR Serverless application.

```
aws emr-serverless create-application \
  --type TYPE \
  --name APPLICATION_ID \
  --release-label RELEASE_LABEL \
  --region AWS_REGION \
  --disk-encryption-configuration '{
        "encryptionKeyArn": "key-arn",
        "encryptionContext": {
            "key": "value"
        }
  }'
```

UpdateApplication

To update the KMS key ARN and/or encryption context, specify the `diskEncryptionConfiguration` parameter with the new values when updating an application.

```
aws emr-serverless update-application \
  --name APPLICATION_ID \
  --region AWS_REGION \
  --disk-encryption-configuration '{
        "encryptionKeyArn": "key-arn",
        "encryptionContext": {
            "key": "value"
        }
  }'
```

Note

To unset configured disk encryption on an application, pass an empty `diskEncryptionConfiguration` during update application.

StartJobRun

To encrypt disks with your own KMS key, use the `diskEncryptionConfiguration` configuration when you submit a job run.

```
--configuration-overrides '{
        "diskEncryptionConfiguration": {
            "encryptionKeyArn": "key-arn",
            "encryptionContext": {
                "key": "value"
            }
        }
    }'
```

Public Livy endpoints

To encrypt disks with your own KMS key when creating Spark sessions through public Livy endpoints, specify the encryption configuration in the session's `conf` object.

```
data = {
    "kind": "pyspark",
    "heartbeatTimeoutInSecond": 60,
    "conf": {
        "emr-serverless.session.executionRoleArn": "role_arn",
        "spark.emr-serverless.disk.encryptionKeyArn": "key-arn",
        "spark.emr-serverless.disk.encryptionContext": "key1:value1,key2:value2"   #
 Optional
    }
}

# Send request to create a session with the Livy API endpoint
request = AWSRequest(method='POST', url=endpoint + "/sessions", data=json.dumps(data),
 headers=headers)
```

Required permissions for disk encryption

Encryption key permissions for EMR Serverless

When you encrypt disks with your own encryption key, you must configure the following KMS key permissions for the `emr-serverless.amazonaws.com` principal:

- `kms:GenerateDataKey` : To generate data keys for encrypting disk volumes
- `kms:Decrypt` : To decrypt data keys when accessing encrypted disk contents

```
{
    "Effect": "Allow",
    "Principal":{
        "Service": "emr-serverless.amazonaws.com"
    },
    "Action": [
        "kms:Decrypt",
        "kms:GenerateDataKey"
    ],
    "Resource": "*",
    "Condition": {
        "StringLike": {
            "aws:SourceArn": "arn:aws:emr-serverless:region:aws-account-id:/
applications/application-id"
        },
        "StringEquals": {
            "kms:EncryptionContext:applicationId": "application-id",
            "aws:SourceAccount": "aws-account-id"
        }
    }
}
```

As a security best practice, we recommend that you add an `aws:SourceArn` condition key to the KMS key policy. The IAM global condition key `aws:SourceArn` helps ensure that EMR Serverless uses the KMS key only for an application ARN. Additionally, including the `aws:SourceAccount` condition key provides another layer of security by restricting the use of your KMS key to requests originating from the AWS account ID specified in the condition.

The job runtime role must have the following permissions in its IAM policy:

```
{
    "Sid": "Enable GDK and Decrypt",
    "Version": "2012-10-17",
    "Statement": {
        "Effect": "Allow",
        "Action": [
            "kms:GenerateDataKey",
            "kms:Decrypt"
        ],
        "Resource": "key-arn"
    }
}
```

Required user permissions

The user who submits the job must have permissions to use the key. You can specify the permissions in either the KMS key policy or the IAM policy for the user, group, or role. If the user who submits the job lacks the KMS key permissions, EMR Serverless rejects the job run submission.

Example key policy

The following key policy provides the permissions to `kms:DescribeKey`, `kms:GenerateDataKey` and `kms:Decrypt`:

- `kms:DescribeKey` : To verify that the customer managed KMS key is enabled and SYMMETRIC before using it.

```
{
    "Sid": "Enable DescribeKey",
    "Effect": "Allow",
    "Principal":{
        "AWS": "arn:aws:iam::111122223333:user/user-name"
    },
    "Action": [
        "kms:DescribeKey"
    ],
    "Resource": "*"
},
{
    "Sid": "Enable GDK and Decrypt",
    "Effect": "Allow",
    "Principal":{
        "AWS": "arn:aws:iam::111122223333:user/user-name"
    },
    "Action": [
        "kms:GenerateDataKey",
        "kms:Decrypt"
    ],
    "Resource": "*",
    "Condition": {
        "StringEquals": {
            "kms:ViaService": "emr-serverless.region.amazonaws.com",
            "kms:EncryptionContext:key": "value"
        }
    }
}
```

As a security best practice, we recommend that you add an `kms:viaService` condition key to the KMS key policy. It limits use of the KMS key to validation requests from just emr-serverless.

Example IAM policy

The following IAM policy provides the permissions to `kms:DescribeKey`, `kms:GenerateDataKey` and `kms:Decrypt`.

```
{
    "Version": "2012-10-17",
    "Statement": {
        "Effect": "Allow",
        "Action": [
            "kms:DescribeKey",
            "kms:GenerateDataKey",
            "kms:Decrypt"
        ],
        "Resource": "key-arn"
    }
}
```

Monitoring Key Usage

You can monitor the use of your customer managed keys in EMR Serverless through AWS CloudTrail. AWS CloudTrail captures all API calls to AWS KMS as events, including calls from the EMR Serverless console, EMR Serverless API, AWS CLI, or AWS SDK.

The information captured includes the encryption context you specified, which can help you identify and audit the specific EMR Serverless resources that used your KMS key. For example, you might see events similar to the following in AWS CloudTrail. For more information about using AWS CloudTrail, see the AWS CloudTrail User Guide.

GenerateDataKey

Sample event for GenerateDataKey operations when EMR Serverless is creating encrypted disk volumes

```
{
    "eventVersion": "1.11",
    "userIdentity": {
        "type": "AWSService",
        "principalId": "user",
        "invokedBy": "AWS Internal"
    },
    "eventTime": "2025-07-28T21:43:51Z",
    "eventSource": "kms.amazonaws.com",
    "eventName": "GenerateDataKey",
    "awsRegion": "us-west-2",
    "sourceIPAddress": "ipAddress",
    "userAgent": "userAgent",
    "requestParameters": {
        "encryptionContext": {
            "applicationId": "test"
        },
        "keyId": "arn:aws:kms:region:accountId:key/ffffffff-fffff-aaaaa-eeee-sample",
        "keySpec": "AES_256"
    },
    "responseElements": null,
    "additionalEventData": {
        "keyMaterialId": 
 "145c963debe558dfb01848d2a4539da940f3478852f86cfe2f52d5df796a5a02"
    },
    "requestID": "cc9d1c5e-97c4-4a4f-ae7a-e576sample",
    "eventID": "0b0fef09-f28d-4da8-a5a1-17b74sample",
    "readOnly": true,
    "resources": [
        {
            "accountId": "account",
            "type": "AWS::KMS::Key",
            "ARN": "arn:aws:kms:region:accountId:key/ffffffff-fffff-aaaaa-eeee-sample"
        }
    ],
    "eventType": "AwsApiCall",
    "managementEvent": true,
    "recipientAccountId": "accountId",
    "eventCategory": "Management"
}
```

Decrypt

Sample event for Decrypt operations when EMR Serverless is accessing encrypted data.

```
{
    "eventVersion": "1.11",
    "userIdentity": {
        "type": "AWSService",
        "principalId": "user",
        "invokedBy": "AWS Internal"
    },
    "eventTime": "2025-07-28T21:43:51Z",
    "eventSource": "kms.amazonaws.com",
    "eventName": "Decrypt",
    "awsRegion": "us-west-2",
    "sourceIPAddress": "ipAddress",
    "userAgent": "userAgent",
    "requestParameters": {
        "encryptionContext": {
            "applicationId": "test"
        },
        "keyId": "arn:aws:kms:region:accountId:key/ffffffff-fffff-aaaaa-eeee-sample",
        "keySpec": "AES_256"
    },
    "responseElements": null,
    "additionalEventData": {
        "keyMaterialId": 
 "145c963debe558dfb01848d2a4539da940f3478852f86cfe2f52d5df796a5a02"
    },
    "requestID": "cc9d1c5e-97c4-4a4f-ae7a-e576sample",
    "eventID": "0b0fef09-f28d-4da8-a5a1-17b74sample",
    "readOnly": true,
    "resources": [
        {
            "accountId": "account",
            "type": "AWS::KMS::Key",
            "ARN": "arn:aws:kms:region:accountId:key/ffffffff-fffff-aaaaa-eeee-sample"
        }
    ],
    "eventType": "AwsApiCall",
    "managementEvent": true,
    "recipientAccountId": "accountId",
    "eventCategory": "Management"
}
```

Learn More

The following resources provide more information about data encryption at rest.

- For more information about AWS KMS basic concepts, see the AWS KMS Developer Guide.
- For more information about Security best practices for AWS KMS, see the AWS KMS Developer Guide.

Secrets Manager for data protection with EMR Serverless

AWS Secrets Manager is a secret storage service for protecting database credentials, API keys, and other secret information. Then in your code, replace hardcoded credentials with an API call to Secrets Manager. This helps ensure that the secret can't be compromised by someone examining your code, because the secret isn't there. For an overview, refer to the AWS Secrets Manager User Guide.

Secrets Manager encrypts secrets using AWS Key Management Service keys. For more information, refer to Secret encryption and decryption in the *AWS Secrets Manager User Guide*.

You can configure Secrets Manager to automatically rotate secrets for you according to a schedule that you specify. This enables you to replace long-term secrets with short-term ones, which helps to significantly reduce the risk of compromise. For more information, refer to Rotate AWS Secrets Manager secrets in the *AWS Secrets Manager User Guide*.

Amazon EMR Serverless integrates with AWS Secrets Manager so that you can store your data in Secrets Manager and use the secret ID in your configurations.

How EMR Serverless uses secrets

When you store your data in Secrets Manager and use the secret ID in your configurations for EMR Serverless, you don't pass sensitive configuration data to EMR Serverless in plain text and expose it to external APIs. If you indicate that a key-value pair contains a secret ID for a secret that you stored in Secrets Manager, EMR Serverless retrieves the secret when it sends configuration data to workers for running jobs.

To indicate that a key-value pair for a configuration contains a reference to a secret stored in Secrets Manager, add the `EMR.secret@` annotation to the configuration value. For any configuration property with secret Id annotation, EMR Serverless calls Secrets Manager and resolves the secret at the time of job execution.

How to create a secret

To create a secret, follow the steps in Create an AWS Secrets Manager secret in the *AWS Secrets Manager User Guide*. In **Step 3**, choose the **Plaintext** field to enter your sensitive value.

Provide a secret in a configuration classification

The following examples demonstrate how to provide a secret in a configuration classification at `StartJobRun`. If you want to configure classifications for Secrets Manager at the application level, refer to Default application configuration for EMR Serverless.

In the examples, replace *`SecretName`* with the name of the secret to retrieve. . For more information, refer to How to create a secret.

In this section

- Specify secret references - Spark
- Specify secret references - Hive

Specify secret references - Spark

Example– Specify secret references in the external Hive metastore configuration for Spark

```
aws emr-serverless start-job-run \
  --application-id "application-id" \
  --execution-role-arn "job-role-arn" \
  --job-driver '{
        "sparkSubmit": {
            "entryPoint": "s3://amzn-s3-demo-bucket/scripts/spark-jdbc.py",
            "sparkSubmitParameters": "--jars s3://amzn-s3-demo-bucket/mariadb-
connector-java.jar
            --conf
 spark.hadoop.javax.jdo.option.ConnectionDriverName=org.mariadb.jdbc.Driver
            --conf spark.hadoop.javax.jdo.option.ConnectionUserName=connection-user-
name
            --conf
 spark.hadoop.javax.jdo.option.ConnectionPassword=EMR.secret@SecretName
            --conf spark.hadoop.javax.jdo.option.ConnectionURL=jdbc:mysql://db-host:db-
port/db-name
            --conf spark.driver.cores=2
            --conf spark.executor.memory=10G
            --conf spark.driver.memory=6G
            --conf spark.executor.cores=4"
        }
    }' \
    --configuration-overrides '{
        "monitoringConfiguration": {
        "s3MonitoringConfiguration": {
            "logUri": "s3://amzn-s3-demo-bucket/spark/logs/"
        }
    }
}'
```

Example– Specify secret references for the external Hive metastore configuration in the spark-defaults classification

```
{
        "classification": "spark-defaults",
        "properties": {

 "spark.hadoop.javax.jdo.option.ConnectionDriverName":"org.mariadb.jdbc.Driver"
            "spark.hadoop.javax.jdo.option.ConnectionURL":"jdbc:mysql://db-host:db-
port/db-name"
            "spark.hadoop.javax.jdo.option.ConnectionUserName":"connection-user-name"
            "spark.hadoop.javax.jdo.option.ConnectionPassword":
 "EMR.secret@SecretName",
        }
    }
```

Specify secret references - Hive

Example– Specify secret references in the external Hive metastore configuration for Hive

```
aws emr-serverless start-job-run \
  --application-id "application-id" \
  --execution-role-arn "job-role-arn" \
    --job-driver '{
        "hive": {
        "query": "s3://amzn-s3-demo-bucket/emr-serverless-hive/query/hive-query.ql",
        "parameters": "--hiveconf hive.exec.scratchdir=s3://amzn-s3-demo-bucket/emr-
serverless-hive/hive/scratch
                    --hiveconf hive.metastore.warehouse.dir=s3://amzn-s3-demo-bucket/
emr-serverless-hive/hive/warehouse
                    --hiveconf javax.jdo.option.ConnectionUserName=username
                    --hiveconf
 javax.jdo.option.ConnectionPassword=EMR.secret@SecretName
                    --hiveconf
 hive.metastore.client.factory.class=org.apache.hadoop.hive.ql.metadata.SessionHiveMetaStoreCli
                    --hiveconf
 javax.jdo.option.ConnectionDriverName=org.mariadb.jdbc.Driver
                    --hiveconf javax.jdo.option.ConnectionURL=jdbc:mysql://db-host:db-
port/db-name"
        }
    }' \
    --configuration-overrides '{
        "monitoringConfiguration": {
        "s3MonitoringConfiguration": {
            "logUri": "s3://amzn-s3-demo-bucket"
        }
    }
}'
```

Example– Specify secret references for the external Hive metastore configuration in the hive-site classification

```
{
    "classification": "hive-site",
    "properties": {
        "hive.metastore.client.factory.class":
 "org.apache.hadoop.hive.ql.metadata.SessionHiveMetaStoreClientFactory",
        "javax.jdo.option.ConnectionDriverName": "org.mariadb.jdbc.Driver",
        "javax.jdo.option.ConnectionURL": "jdbc:mysql://db-host:db-port/db-name",
        "javax.jdo.option.ConnectionUserName": "username",
        "javax.jdo.option.ConnectionPassword": "EMR.secret@SecretName"
    }
}
```

Grant access for EMR Serverless to retrieve the secret

To allow EMR Serverless to retrieve the secret value from Secrets Manager, add the following policy statement to your secret when you create it. You must create your secret with the customer-managed KMS key for EMR Serverless to read the secret value. For more information, refer to Permissions for the KMS key in the *AWS Secrets Manager User Guide*.

In the following policy, replace *applicationId* with the ID for your application.

Resource policy for the secret

You must include the following permissions in the resource policy for the secret in AWS Secrets Manager to allow EMR Serverless to retrieve secret values. To ensure that only a specific application can retrieve this secret, you can optionally specify the EMR Serverless application ID as a condition in the policy.

JSON

```
{
  "Version":"2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "secretsmanager:GetSecretValue",
        "secretsmanager:DescribeSecret"
      ],
      "Resource": [
        "*"
      ],
      "Condition": {
        "StringEquals": {
          "aws:SourceArn": "arn:aws:emr-serverless:*:123456789012:/applications/
*"
        }
      },
      "Sid": "AllowSECRETSMANAGERGetsecretvalue"
    }
  ]
}
```

Create your secret with the following policy for the customer-managed AWS Key Management Service (AWS KMS) key:

Policy for customer-managed AWS KMS key

```
{
    "Sid": "Allow EMR Serverless to use the key for decrypting secrets",
    "Effect": "Allow",
    "Principal": {
        "Service": [
            "emr-serverless.amazonaws.com"
        ]
    },
    "Action": [
        "kms:Decrypt",
        "kms:DescribeKey"
    ],
    "Resource": "*",
    "Condition": {
        "StringEquals": {
            "kms:ViaService": "secretsmanager.AWS Region.amazonaws.com"
        }
    }
}
```

Rotating the secret

Rotation is when you periodically update a secret. You can configure AWS Secrets Manager to automatically rotate the secret for you on a schedule that you specify. This way, you can replace long-term secrets with short-term ones. This helps to reduce the risk of compromise. EMR Serverless retrieves the secret value from an annotated configuration when the job transitions to a running state. If you or a process updates the secret value in Secrets Manager, you must submit a new job so that the job can fetch the updated value.

Note

Jobs that are already in a running state can't fetch an updated secret value. This might result in job failure.

Using Amazon S3 Access Grants with EMR Serverless

S3 Access Grants overview for EMR Serverless

With Amazon EMR releases 6.15.0 and higher, Amazon S3 Access Grants provide a scalable access control solution for augmenting access to your Amazon S3 data from EMR Serverless. If you have a complex or large permission configuration for your S3 data, use Access Grants to scale S3 data permissions for users, roles, and applications.

Use S3 Access Grants to augment access to Amazon S3 data beyond the permissions granted by the runtime role or the IAM roles that are attached to the identities with access to your EMR Serverless application.

For more information, refer to Managing access with S3 Access Grants for Amazon EMR in the *Amazon EMR Management Guide* and Managing access with S3 Access Grants in the *Amazon Simple Storage Service User Guide*.

This section describes how to launch an EMR Serverless application that uses S3 Access Grants to provide access to data in Amazon S3. For steps to use S3 Access Grants with other Amazon EMR deployments, see the following documentation:

- Using S3 Access Grants with Amazon EMR
- Using S3 Access Grants with Amazon EMR on EKS

Launch an EMR Serverless application with S3 Access Grants for data management

You can enable S3 Access Grants on EMR Serverless and launch a Spark application. When your application makes a request for S3 data, Amazon S3 provides temporary credentials that are scoped to the specific bucket, prefix, or object.

1. Set up a job execution role for your EMR Serverless application. Include the required IAM permissions that you must run Spark jobs and use S3 Access Grants, `s3:GetDataAccess` and `s3:GetAccessGrantsInstanceForPrefix`:

```
{
    "Effect": "Allow",
    "Action": [
    "s3:GetDataAccess",
    "s3:GetAccessGrantsInstanceForPrefix"
    ],
    "Resource": [     //LIST ALL INSTANCE ARNS THAT THE ROLE IS ALLOWED TO QUERY
         "arn:aws_partition:s3:Region:account-id1:access-grants/default",
         "arn:aws_partition:s3:Region:account-id2:access-grants/default"
    ]
}
```

> **Note**
>
> If you specify IAM roles for job execution that have additional permissions to access S3 directly, then users can access the data permitted by the role even if they don't have permission from S3 Access Grants.

2. Launch your EMR Serverless application with an Amazon EMR release label of 6.15.0 or higher and the `spark-defaults` classification, as the following example shows. Replace the values in *red text* with the appropriate values for your usage scenario.

```
aws emr-serverless start-job-run \
  --application-id application-id \
  --execution-role-arn job-role-arn \
  --job-driver '{
        "sparkSubmit": {
            "entryPoint": "s3://us-east-1.elasticmapreduce/emr-containers/samples/
wordcount/scripts/wordcount.py",
            "entryPointArguments": ["s3://amzn-s3-demo-destination-bucket1/
wordcount_output"],
            "sparkSubmitParameters": "--conf spark.executor.cores=1 --conf
 spark.executor.memory=4g --conf spark.driver.cores=1 --conf spark.driver.memory=4g
 --conf spark.executor.instances=1"
        }
    }' \
  --configuration-overrides '{
    "applicationConfiguration": [{
        "classification": "spark-defaults",
        "properties": {
          "spark.hadoop.fs.s3.s3AccessGrants.enabled": "true",
          "spark.hadoop.fs.s3.s3AccessGrants.fallbackToIAM": "false"
         }
      }]
}'
```

S3 Access Grants considerations with EMR Serverless

For important support, compatibility, and behavioral information when you use Amazon S3 Access Grants with EMR Serverless, refer to S3 Access Grants considerations with Amazon EMR in the *Amazon EMR Management Guide*.

Logging Amazon EMR Serverless API calls using AWS CloudTrail

Amazon EMR Serverless is integrated with AWS CloudTrail, a service that provides a record of actions taken by a user, role, or an AWS service in EMR Serverless. CloudTrail captures all API calls for EMR Serverless as events. The calls captured include calls from the EMR Serverless console and code calls to the EMR Serverless API operations. If you create a trail, enable continuous delivery of CloudTrail events to an Amazon S3 bucket, including events for EMR Serverless. If you don't configure a trail, you can still access 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 EMR Serverless, the IP address from which the request was made, who made the request, when it was made, and additional details.

To learn more, refer to the AWS CloudTrail User Guide.

EMR Serverless information in CloudTrail

CloudTrail is enabled on your AWS account when you create the account. When activity occurs in EMR Serverless, that activity is recorded in a CloudTrail event along with other AWS service events in **Event history**. You can access, search, and download recent events in your AWS account. For more information, refer to Viewing events with CloudTrail Event history.

For an ongoing record of events in your AWS account, including events for EMR Serverless, 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, configure other AWS services to further analyze and act upon the event data collected in CloudTrail logs. For more information, refer to the following:

- Overview for creating a trail
- 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 EMR Serverless actions are logged by CloudTrail and are documented in the EMR Serverless API Reference. For example, calls to the `CreateApplication`, `StartJobRun` and `CancelJobRun` 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 AWS Identity and Access Management (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, refer to the CloudTrail userIdentity element.

Understanding EMR Serverless 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 `CreateApplication` action.

```
{
    "eventVersion": "1.08",
    "userIdentity": {
        "type": "AssumedRole",
        "principalId": "AIDACKCEVSQ6C2EXAMPLE:admin",
        "arn": "arn:aws:sts::012345678910:assumed-role/Admin/admin",
        "accountId": "012345678910",
        "accessKeyId": "AKIAIOSFODNN7EXAMPLE",
        "sessionContext": {
            "sessionIssuer": {
                "type": "Role",
                "principalId": "AIDACKCEVSQ6C2EXAMPLE",
                "arn": "arn:aws:iam::012345678910:role/Admin",
                "accountId": "012345678910",
                "userName": "Admin"
            },
            "webIdFederationData": {},
            "attributes": {
                "creationDate": "2022-06-01T23:46:52Z",
                "mfaAuthenticated": "false"
            }
        }
    },
    "eventTime": "2022-06-01T23:49:28Z",
    "eventSource": "emr-serverless.amazonaws.com",
    "eventName": "CreateApplication",
    "awsRegion": "us-west-2",
    "sourceIPAddress": "203.0.113.0",
    "userAgent": "PostmanRuntime/7.26.10",
    "requestParameters": {
        "name": "my-serverless-application",
        "releaseLabel": "emr-6.6",
        "type": "SPARK",
        "clientToken": "0a1b234c-de56-7890-1234-567890123456"
    },
    "responseElements": {
        "name": "my-serverless-application",
        "applicationId": "1234567890abcdef0",
        "arn": "arn:aws:emr-serverless:us-west-2:555555555555:/
applications/1234567890abcdef0"
    },
    "requestID": "890b8639-e51f-11e7-b038-EXAMPLE",
    "eventID": "874f89fa-70fc-4798-bc00-EXAMPLE",
    "readOnly": false,
    "eventType": "AwsApiCall",
    "managementEvent": true,
    "recipientAccountId": "012345678910",
    "eventCategory": "Management"
}
```

Compliance validation for Amazon EMR Serverless

The security and compliance of EMR Serverless is assessed by third-party auditors as part of multiple AWS compliance programs, including the following:

- System and Organization Controls (SOC)
- Payment Card Industry Data Security Standard (PCI DSS)
- Federal Risk and Authorization Management Program (FedRAMP) Moderate
- Health Insurance Portability and Accountability Act (HIPAA)

AWS provides a frequently updated list of AWS services in scope of specific compliance programs at AWS Services in Scope by Compliance Program.

Third-party audit reports are available for you to download using AWS Artifact. For more information, refer to Downloading Reports in AWS Artifact.

For more information about AWS compliance programs, refer to AWS Compliance Programs.

Your compliance responsibility when using EMR Serverless is determined by the sensitivity of your data, your organization’s compliance objectives, and applicable laws and regulations. If your use of EMR Serverless is subject to compliance with standards like HIPAA, PCI, or FedRAMP Moderate, AWS provides resources to help:

- Security and Compliance Quick Start Guides that discuss architectural considerations and steps for deploying security- and compliance-focused baseline environments on AWS.
- AWS Customer Compliance Guides can help you 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)).
- AWS Config can be used to assess how well your resource configurations comply with internal practices, industry guidelines, and regulations.
- AWS Compliance Resources is a collection of workbooks and guides might apply to your industry and location.

- AWS Security Hub provides you with a comprehensive view of your security state within AWS and helps you check your compliance with security industry standards and best practices.
- 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 Amazon EMR Serverless

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, design and operate applications and databases that automatically fail over between 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, refer to AWS Global Infrastructure.

In addition to the AWS global infrastructure, Amazon EMR Serverless offers integration with Amazon S3 through EMRFS to help support your data resiliency and backup needs.

Infrastructure security in Amazon EMR Serverless

As a managed service, Amazon EMR is protected by AWS global network security. For information about AWS security services and how AWS protects infrastructure, see AWS Cloud Security. To design your AWS environment using the best practices for infrastructure security, see Infrastructure Protection in *Security Pillar AWS Well‐Architected Framework*.

You use AWS published API calls to access Amazon EMR through the network. Clients must support the following:

- Transport Layer Security (TLS). We require TLS 1.2 and recommend TLS 1.3.
- Cipher suites with perfect forward secrecy (PFS) such as DHE (Ephemeral Diffie-Hellman) or ECDHE (Elliptic Curve Ephemeral Diffie-Hellman). Most modern systems such as Java 7 and later support these modes.

Configuration and vulnerability analysis in Amazon EMR Serverless

AWS handles basic security tasks like guest operating system (OS) and database patching, firewall configuration, and disaster recovery. These procedures have been reviewed and certified by the appropriate third parties. For more details, refer to the following resources:

- Compliance validation for Amazon EMR Serverless
- Shared Responsibility Model
- Amazon Web Services: Overview of Security Processes

Endpoints and quotas for EMR Serverless

Service endpoints

To connect programmatically to an AWS service, you use an *endpoint*. An endpoint is the URL of the entry point for an AWS web service. In addition to the standard AWS endpoints, some AWS services offer FIPS endpoints in selected Regions. The following table lists the service endpoints for EMR Serverless. For more information, refer to AWS service endpoints.

EMR Serverless service endpoints

Region name	Region	Endpoint	Protocol
US East (Ohio)	`us-east-2` (limited to the following Availability Zones: `use2-az1`, `use2-az2`, and `use2-az3`)	`emr-serverless.us-east-2.amazonaws.com`	HTTPS
US East (N. Virginia)	`us-east-1` (limited to the following Availability Zones: `use1-az1`, `use1-az2`, `use1-az4`, `use1-az5`, and `use1-az6`)	`emr-serverless.us-east-1.amazonaws.com` `emr-serverless-fips.us-east-1.amazonaws.com`	HTTPS
US West (N. California)	`us-west-1`	`emr-serverless.us-west-1.amazonaws.com`	HTTPS
US West (Oregon)	`us-west-2`	`emr-serverless.us-west-2.amazonaws.com`	HTTPS

Region name	Region	Endpoint	Protocol
		emr-serverless-fips.us-west-2.amazonaws.com	
Africa (Cape Town)	af-south-1	emr-serverless.af-south-1.amazonaws.com	HTTPS
Asia Pacific (Hong Kong)	ap-east-1	emr-serverless.ap-east-1.amazonaws.com	HTTPS
Asia Pacific (Jakarta)	ap-southeast-3	emr-serverless.ap-southeast-3.amazonaws.com	HTTPS
Asia Pacific (Melbourne)	ap-southeast-4	emr-serverless.ap-southeast-4.amazonaws.com	HTTPS
Asia Pacific (Malaysia)	ap-southeast-5	emr-serverless.ap-southeast-5.amazonaws.com	HTTPS

Region name	Region	Endpoint	Protocol
Asia Pacific (Mumbai)	ap-south-1	emr-serverless.ap-south-1.amazonaws.com	HTTPS
Asia Pacific (Osaka)	ap-northeast-3	emr-serverless.ap-northeast-3.amazonaws.com	HTTPS
Asia Pacific (Seoul)	ap-northeast-2	emr-serverless.ap-northeast-2.amazonaws.com	HTTPS
Asia Pacific (Singapore)	ap-southeast-1	emr-serverless.ap-southeast-1.amazonaws.com	HTTPS
Asia Pacific (Sydney)	ap-southeast-2	emr-serverless.ap-southeast-2.amazonaws.com	HTTPS
Asia Pacific (Tokyo)	ap-northeast-1	emr-serverless.ap-northeast-1.amazonaws.com	HTTPS

Region name	Region	Endpoint	Protocol
Canada (Central)	ca-central-1 (limited to the following Availability Zones: cac1-az1 and cac1-az2)	emr-serverless.ca-central-1.amazonaws.com	HTTPS
Canada West (Calgary)	ca-west-1	emr-serverless.ca-west-1.amazonaws.com	HTTPS
Europe (Frankfurt)	eu-central-1	emr-serverless.eu-central-1.amazonaws.com	HTTPS
Europe (Zurich)	eu-central-2	emr-serverless.eu-central-2.amazonaws.com	HTTPS
Europe (Ireland)	eu-west-1	emr-serverless.eu-west-1.amazonaws.com	HTTPS
Europe (London)	eu-west-2	emr-serverless.eu-west-2.amazonaws.com	HTTPS
Europe (Milan)	eu-south-1	emr-serverless.eu-south-1.amazonaws.com	HTTPS

Region name	Region	Endpoint	Protocol
Europe (Paris)	`eu-west-3`	`emr-serverless.eu-west-3.amazonaws.com`	HTTPS
Europe (Spain)	`eu-south-2`	`emr-serverless.eu-south-2.amazonaws.com`	HTTPS
Europe (Stockholm)	`eu-north-1`	`emr-serverless.eu-north-1.amazonaws.com`	HTTPS
Israel (Tel Aviv)	`il-central-1`	`emr-serverless.il-central-1.amazonaws.com`	HTTPS
Middle East (Bahrain)	`me-south-1`	`emr-serverless.me-south-1.amazonaws.com`	HTTPS
Middle East (UAE)	`me-central-1`	`emr-serverless.me-central-1.amazonaws.com`	HTTPS
South America (São Paulo)	`sa-east-1`	`emr-serverless.sa-east-1.amazonaws.com`	HTTPS

Region name	Region	Endpoint	Protocol
China (Beijing)	`cn-north-1` (limited to the following Availability Zones: `cnn1-az1`, `cnn1-az2`)	`emr-serverless.cn-north-1.amazonaws.com.cn`	HTTPS
AWS GovCloud (US-East)	`us-gov-east-1`	`emr-serverless.us-gov-east-1.amazonaws.com`	HTTPS
AWS GovCloud (US-West)	`us-gov-west-1`	`emr-serverless.us-gov-west-1.amazonaws.com`	HTTPS

Service quotas

Service quotas, also known as *limits*, are the maximum number of service resources or operations that your AWS account can use. EMR Serverless collects service quota usage metrics every minute and publishes them in the `AWS/Usage` namespace.

> **Note**
>
> New AWS accounts have initial lower quotas that can increase over time. Amazon EMR Serverless monitors account usage within each AWS Region, and then automatically increases the quotas based on your usage.

The following table lists the service quotas for EMR Serverless. For more information, refer to AWS service quotas.

Name	Default limit	Adjustable?	Description
Max concurrent vCPUs per account	16	Yes	The maximum number of vCPUs that can concurrently run for the account in the current AWS Region.
Max Queued Jobs Per Account	2000	Yes	The maximum number of queued jobs for the account in the current AWS Region.

API limits

The following describes the API limits per Region for your AWS account.

Resource	Default quota
ListApplications	10 transactions per second. Burst of 50 transactions per second.
CreateApplication	1 transaction per second. Burst of 25 transacti ons per second.
DeleteApplication	1 transaction per second. Burst of 25 transacti ons per second.
GetApplication	10 transactions per second. Burst of 50 transactions per second.
UpdateApplication	1 transaction per second. Burst of 25 transacti ons per second.

Resource	Default quota
ListJobRuns	1 transaction per second. Burst of 25 transactions per second.
StartJobRun	1 transaction per second. Burst of 25 transactions per second.
GetDashboardForJobRun	1 transaction per second. Burst of 2 transactions per second.
CancelJobRun	1 transaction per second. Burst of 25 transactions per second.
GetJobRun	10 transactions per second. Burst of 50 transactions per second.
StartApplication	1 transaction per second. Burst of 25 transactions per second.
StopApplication	1 transaction per second. Burst of 25 transactions per second.

Other considerations

The following list contains other considerations with EMR Serverless.

- EMR Serverless is available in the following AWS Regions:
  - US East (Ohio)
  - US East (N. Virginia)
  - US West (N. California)
  - US West (Oregon)
  - Africa (Cape Town)
  - Asia Pacific (Hong Kong)
  - Asia Pacific (Jakarta)
  - Asia Pacific (Mumbai)
  - Asia Pacific (Osaka)
  - Asia Pacific (Seoul)
  - Asia Pacific (Singapore)
  - Asia Pacific (Sydney)
  - Asia Pacific (Tokyo)
  - Canada (Central)
  - Europe (Frankfurt)
  - Europe (Ireland)
  - Europe (London)
  - Europe (Milan)
  - Europe (Paris)
  - Europe (Spain)
  - Europe (Stockholm)
  - Middle East (Bahrain)
  - Middle East (UAE)
  - South America (São Paulo)
  - AWS GovCloud (US-East)
  - AWS GovCloud (US-West)

For a list of endpoints associated with these Regions, refer to Service endpoints.

- The default timeout for a job run is 12 hours. You can change this setting with the `executionTimeoutMinutes` property in the `startJobRun` API or the AWS SDK. You can set `executionTimeoutMinutes` to 0 if you want your job run to never time out. For example, if you have a streaming application, set `executionTimeoutMinutes` to 0 to allow the streaming job to run continuously.
- The `billedResourceUtilization` property in the `getJobRun` API shows the aggregate vCPU, memory, and storage that AWS has billed for the job run. Billed resources include a 1-minute minimum usage for workers, plus additional storage over 20 GB per worker. These resources don't include usage for idle pre-initialized workers.
- Without VPC connectivity, a job can access some AWS service endpoints in the same AWS Region. These services include Amazon S3, AWS Glue, AWS Lake Formation, Amazon CloudWatch Logs, AWS KMS, AWS Security Token Service, Amazon DynamoDB, and AWS Secrets Manager. You can enable VPC connectivity to access other AWS services through AWS PrivateLink, but you aren't required to do this. To access external services, create your application with a VPC.
- EMR Serverless doesn't support HDFS. The local disks on workers are temporary storage that EMR Serverless uses to shuffle and process data during job runs.

Amazon EMR Serverless release versions

An Amazon EMR release is a set of open source applications from the big data ecosystem. Each release includes big data applications, components, and features that you select to have Amazon EMR Serverless deploy and configure when you run your job.

With Amazon EMR 6.6.0 and higher, deploy EMR Serverless. This deployment option isn't available with earlier Amazon EMR release versions. When you submit your job, specify one of the following supported releases.

Topics

- EMR Serverless 6.9.0
- EMR Serverless 6.8.0
- EMR Serverless 6.7.0
- EMR Serverless 6.6.0

AWS runtime for Apache Spark (emr-spark-8.0-preview)

The following table lists the application versions available with AWS runtime for Apache Spark (emr-spark-8.0-preview).

Application version information

Application	Version
Spark	4.0.1-amzn-0

AWS runtime for Apache Spark (emr-spark-8.0-preview) release notes

- **Preview release** – This is a preview release of AWS runtime for Apache Spark featuring Apache Spark 4.0.1. This preview is available on EMR Serverless only.
- **Regional Availability** - This preview release is available in all AWS Regions where EMR Serverless is available, except China and AWS GovCloud (US) regions.
- **Application version information** - This release ships with the following application versions:
  - AWS SDK for Java 2.35.5, 1.12.792
  - Python **3.9**, 3.11, 3.12
  - Scala 2.13.16
  - AmazonCloudWatchAgent 1.300034.0-amzn-0
  - Delta 4.0.0-amzn-0-spark
  - Iceberg 1.10.0-amzn-spark-0
  - This release ships with Amazon Corretto **17** (built on OpenJDK) by default for applications that support Corretto 17 (JDK 17).
- **Preview limitations** - The following capabilities are not available in this preview release:
  - **Interactive and Integration Features**: SageMaker Unified Studio, EMR Studio integration, Spark Connect, Livy, and JupyterEnterpriseGateway are not supported.

  - **Table Formats and Access Control**: Hudi, Delta Universal Format, and fine-grained access control (FGAC) with row-level or column-level filtering and DDL/DML operators are not supported.
  - **Data Connectors**: spark-sql-kinesis, emr-dynamodb, and spark-redshift connectors are not available.
  - **History Server**: The Persistent Spark History Server is not available in this preview release. Users can still access the live Spark UI to monitor and debug active serverless jobs in real-time.
  - **Specialized Features**: Materialized Views are not available.
- **Preview capabilities** - You can test the following capabilities in this preview release. This preview release is not recommended for production workloads:
  - **SQL Features**: ANSI SQL mode with stricter type handling, SQL PIPE syntax (|>) for chaining operations, VARIANT data type for semi-structured JSON data, SQL scripting with control flow statements and session variables, and SQL user-defined functions.
  - **Streaming Enhancements**: Arbitrary Stateful Processing API v2 with transformWithState operator, State Data Source Reader for queryable streaming state (experimental), and enhanced state store with improved RocksDB changelog checkpointing.
  - **Table Format Support**: Apache Iceberg v3 with VARIANT data type support, AWS S3 Tables integration, and Full Table Access (FTA) with AWS Lake Formation for Iceberg, Delta Lake, and Hive tables.
- **Additional Documentation** - For additional Apache Spark documentation, see Apache Spark 4.0.1 Release Documentation.

Getting Started

To get started with Apache Spark 4.0.1 preview, create an EMR Serverless application using the AWS CLI:

```
aws emr-serverless create-application --type spark \
  --release-label emr-spark-8.0-preview \
  --region us-east-1 --name spark4-preview
```

EMR Serverless 7.12.0

The following table lists the application versions available with EMR Serverless 7.12.0.

Application	Version
Apache Spark	3.5.6
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 7.12.0 release notes

- **New features**
  - **Serverless storage for EMR Serverless –** Amazon EMR serverless introduces serverless storage, with EMR release 7.12 and later, that eliminates local disk provisioning for Apache Spark workloads. EMR Serverless automatically handles intermediate data operation such as shuffle with no storage charges. Serverless storage decouples storage from compute, allowing Spark to release workers immediately when idle rather than keeping them active to preserve temporary data. To learn more, see aws.amazon.com/serverless-storage-for-emr-serverless.
  - **Iceberg Materialized Views** - Starting Amazon EMR 7.12.0, Amazon EMR Spark supports creation and management of Iceberg Materialized Views (MV)
  - **Hudi Full Table Access** - Starting Amazon EMR 7.12.0, Amazon EMR now supports Full Table Access (FTA) control for Apache Hudi in Apache Spark based on your policies defined in Lake Formation. This feature enables read and write operations from your Amazon EMR Spark jobs on Lake Formation registered tables when the job role has full table access.
  - **Iceberg version upgrade** - Amazon EMR 7.12.0 supports Apache Iceberg version 1.10

EMR Serverless 7.11.0

The following table lists the application versions available with EMR Serverless 7.11.0.

Application	Version
Apache Spark	3.5.6
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 7.11.0 release notes

- **Maximum Job execution time –** The maximum value for `executionTimeoutMinutes` in `StartJobRun` action for BATCH jobs is 7 days from this release onwards. `executionTimeoutMinutes` can no longer be set to `0` i.e. no timeout, for batch job runs.

EMR Serverless 7.10.0

The following table lists the application versions available with EMR Serverless 7.10.0.

Application	Version
Apache Spark	3.5.5
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 7.10.0 release notes

- **Metrics for EMR Serverless –** Monitoring metrics are restructured to focus on the `ApplicationName` and `JobName` dimensions. Older metrics will no longer be updated, going forward. For more information, refer to Monitoring EMR Serverless applications and jobs.

EMR Serverless 7.9.0

The following table lists the application versions available with EMR Serverless 7.9.0.

Application	Version
Apache Spark	3.5.5
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 7.8.0

The following table lists the application versions available with EMR Serverless 7.8.0.

Application	Version
Apache Spark	3.5.4
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 7.7.0

The following table lists the application versions available with EMR Serverless 7.7.0.

Application	Version
Apache Spark	3.5.3
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 7.6.0

The following table lists the application versions available with EMR Serverless 7.6.0.

Application	Version
Apache Spark	3.5.3
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 7.5.0

The following table lists the application versions available with EMR Serverless 7.5.0.

Application	Version
Apache Spark	3.5.2
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 7.4.0

The following table lists the application versions available with EMR Serverless 7.4.0.

Application	Version
Apache Spark	3.5.2
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 7.3.0

The following table lists the application versions available with EMR Serverless 7.3.0.

Application	Version
Apache Spark	3.5.1
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 7.3.0 release notes

- **Job concurrency and queuing with EMR Serverless** – Job concurrency and queuing is enabled by default when you create a new EMR Serverless application on Amazon EMR release 7.3.0 or higher. For more information, refer to the section called "Job concurrency and queuing", which details how to get started with concurrency and queuing and also contains a list of feature considerations.

EMR Serverless 7.2.0

The following table lists the application versions available with EMR Serverless 7.2.0.

Application	Version
Apache Spark	3.5.1
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 7.2.0 release notes

- **Lake Formation with EMR Serverless** – you can now use AWS Lake Formation to apply fine-grained access controls on Data Catalog tables that are backed by S3. This capability lets you configure table, row, column, and cell level access controls for read queries within your EMR Serverless Spark jobs. For more information, refer to the section called "Lake Formation for FGAC" and the section called "Considerations and limitations".

EMR Serverless 7.1.0

The following table lists the application versions available with EMR Serverless 7.1.0.

Application	Version
Apache Spark	3.5.0
Apache Hive	3.1.3

Application	Version
Apache Tez	0.10.2

EMR Serverless 7.0.0

The following table lists the application versions available with EMR Serverless 7.0.0.

Application	Version
Apache Spark	3.5.0
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 6.15.0

The following table lists the application versions available with EMR Serverless 6.15.0.

Application	Version
Apache Spark	3.4.1
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 6.15.0 release notes

- **TLS support –** With Amazon EMR Serverless releases 6.15.0 and higher, enable mutual-TLS encrypted communication between workers in your Spark job runs. When enabled, EMR Serverless automatically generates a unique certificate for each worker that it provisions under a job runs that workers utilize during TLS handshake to authenticate each other and establish an encrypted channel to process data securely. For more information about mutual-TLS encryption, refer to Inter-worker encryption.

EMR Serverless 6.14.0

The following table lists the application versions available with EMR Serverless 6.14.0.

Application	Version
Apache Spark	3.4.1
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 6.13.0

The following table lists the application versions available with EMR Serverless 6.13.0.

Application	Version
Apache Spark	3.4.1
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 6.12.0

The following table lists the application versions available with EMR Serverless 6.12.0.

Application	Version
Apache Spark	3.4.0
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 6.11.0

The following table lists the application versions available with EMR Serverless 6.11.0.

Application	Version
Apache Spark	3.3.2
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 6.11.0 release notes

- **Access S3 resources in other accounts** - With releases 6.11.0 and higher, you can configure multiple IAM roles to assume when you access Amazon S3 buckets in different AWS accounts from EMR Serverless.

EMR Serverless 6.10.0

The following table lists the application versions available with EMR Serverless 6.10.0.

Application	Version
Apache Spark	3.3.1
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 6.10.0 release notes

- For EMR Serverless applications with release 6.10.0 or higher, the default value for the `spark.dynamicAllocation.maxExecutors` property is `infinity`. Earlier releases default to `100`. For more information, refer to Spark job properties.

EMR Serverless 6.9.0

The following table lists the application versions available with EMR Serverless 6.9.0.

Application	Version
Apache Spark	3.3.0
Apache Hive	3.1.3
Apache Tez	0.10.2

EMR Serverless 6.9.0 release notes

- The Amazon Redshift integration for Apache Spark is included in Amazon EMR releases 6.9.0 and later. Previously an open-source tool, the native integration is a Spark connector that you can use to build Apache Spark applications that read from and write to data in Amazon Redshift and Amazon Redshift Serverless. For more information, see Using Amazon Redshift integration for Apache Spark on Amazon EMR Serverless.
- EMR Serverless release 6.9.0 adds support for AWS Graviton2 (arm64) architecture. You can use the `architecture` parameter for the `create-application` and `update-application` APIs to choose the arm64 architecture. For more information, refer to Amazon EMR Serverless architecture options.
- You can now export, import, query, and join Amazon DynamoDB tables directly from your EMR Serverless Spark and Hive applications. For more information, refer to Connecting to DynamoDB with Amazon EMR Serverless.

Known issues

- If you use the Amazon Redshift integration for Apache Spark and have a time, timetz, timestamp, or timestamptz with microsecond precision in Parquet format, the connector rounds the time values to the nearest millisecond value. As a workaround, use the text unload format `unload_s3_format` parameter.

EMR Serverless 6.8.0

The following table lists the application versions available with EMR Serverless 6.8.0.

Application	Version
Apache Spark	3.3.0
Apache Hive	3.1.3
Apache Tez	0.9.2

EMR Serverless 6.7.0

The following table lists the application versions available with EMR Serverless 6.7.0.

Application	Version
Apache Spark	3.2.1
Apache Hive	3.1.3
Apache Tez	0.9.2

Engine-specific changes, enhancements, and resolved issues

The following table lists a new engine-specific feature.

Change	Description
Feature	Tez scheduler now supports preemption of Tez task instead of preemption of container

EMR Serverless 6.6.0

The following table lists the application versions available with EMR Serverless 6.6.0.

Application	Version
Apache Spark	3.2.0
Apache Hive	3.1.2
Apache Tez	0.9.2

EMR Serverless initial release notes

- EMR Serverless supports the Spark configuration classification `spark-defaults`. This classification changes values in Spark's `spark-defaults.conf` XML file. Configuration classifications allow you to customize applications. For more information, refer to Configure applications.
- EMR Serverless supports the Hive configuration classifications `hive-site`, `tez-site`, `emrfs-site`, and `core-site`. This classification can change the values in Hive's `hive-site.xml` file, Tez's `tez-site.xml` file, Amazon EMR's EMRFS settings, or Hadoop's `core-site.xml` file, respectively. Configuration classifications allow you to customize applications. For more information, refer to Configure applications.

Engine-specific changes, enhancements, and resolved issues

- The following table lists Hive and Tez backports.

Hive and Tez changes

Change	Description
Backport	TEZ-4430: Fixed issue with `tez.task.launch.cmd-opts` property
Backport	HIVE-25971: Fixed Tez task shutdown delays due to open cached thread pool

Document history

The following table describes the important changes to the documentation since the last release of EMR Serverless. For more information about updates to this documentation, you can subscribe to an RSS feed.

Change	Description	Date
New preview release	`AWS runtime for Apache Spark` (emr-spark-8.0-preview)	November 21, 2025
New release	EMR Serverless 7.2.0	July 25, 2024
New release	EMR Serverless 7.1.0	April 17, 2024
Update to an existing policy.	Added the new Sid `CloudWatchPolicyStatement` and `EC2PolicyStatement` to the AmazonEMRServerlessServiceRolePolicy policy.	January 25, 2024
New release	EMR Serverless 7.0.0	December 29, 2023
New release	EMR Serverless 6.15.0	November 17, 2023
New feature	Configure multiple IAM roles to assume when you access Amazon S3 buckets in different accounts from EMR Serverless (6.11 and higher)	October 18, 2023
New release	EMR Serverless 6.14.0	October 17, 2023
New feature	Default application configuration for EMR Serverless	September 25, 2023

Update to default Hive properties	Updated the default values for `hive.driver.disk` , `hive.tez.disk.size` , `hive.tez.auto.reducer.parallelism` , and `tez.grouping.min-size` Hive job properties.	September 12, 2023
New release	EMR Serverless 6.13.0	September 11, 2023
New release	EMR Serverless 6.12.0	July 21, 2023
New release	EMR Serverless 6.11.0	June 8, 2023
Update to service-linked role policy	Updated the `AmazonEMRServerlessServiceRolePolicy` SLR role to publish account-level usage in `"AWS/Usage"` namespace.	April 20, 2023
EMR Serverless general availability (GA)	This is the first public release of EMR Serverless.	June 1, 2022