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What is Amazon EMR Serverless?

Amazon EMR Serverless is a new deployment option for Amazon EMR. EMR Serverless provides a serverless runtime environment that 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’ll 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, you must 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, see Amazon EMR Serverless release versions (p. 153).

Application

With EMR Serverless, you can create one or more EMR Serverless applications that use open source analytics frameworks. To create an application, you must 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, see Amazon EMR Serverless release versions (p. 153).
- The specific runtime that you want your application to use, such as Apache Spark or Apache Hive.

After you create an application, you can 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, you can 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 need to 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, see Interacting with an application (p. 21).

Job run

A job run is a request submitted to an EMR Serverless application that the application asynchronously 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, see Running jobs (p. 41).

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, you can 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, see Configuring an application (p. 24).

EMR Studio

EMR Studio is the user console that you can use to manage 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. You can access EMR Studio either from the Amazon EMR console, or you can 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, see Interacting with your application from the EMR Studio console (p. 22) and Running jobs from the EMR Studio console (p. 42).
Setting up

Topics

• Sign up for an AWS account (p. 4)
• Create an administrative user (p. 4)
• Grant permissions (p. 5)
• Install and configure the AWS CLI (p. 7)
• Open the console (p. 8)

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

2. Follow the online instructions.

Part of the sign-up procedure involves receiving a phone call 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 an administrative 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 an administrative user

After you sign up for an AWS account, 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.
Grant permissions

In production environments, we recommend that you use finer-grained policies. For examples of such policies, see User access policy examples for EMR Serverless (p. 134). To learn more about access management, see 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"
                }
            }
        }
    ]
}
```
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.

<table>
<thead>
<tr>
<th>Which user needs programmatic access?</th>
<th>To</th>
<th>By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workforce identity</td>
<td>Use temporary credentials to sign programmatic requests to the AWS CLI, AWS SDKs, or AWS APIs.</td>
<td>Following the instructions for the interface that you want to use.</td>
</tr>
<tr>
<td>(Users managed in IAM Identity Center)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IAM</td>
<td>Use temporary credentials to sign programmatic requests to the AWS CLI, AWS SDKs, or AWS APIs.</td>
<td>Following the instructions in Using temporary credentials with AWS resources in the IAM User Guide.</td>
</tr>
</tbody>
</table>
Install and configure the AWS CLI

If you want to use EMR Serverless APIs, you must 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 you can get started without the CLI by following the steps in Getting started with EMR Serverless from the console (p. 13).

To set up the AWS CLI

1. To install the latest version of the AWS CLI for macOS, Linux, or Windows, see 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, see Quick configuration with aws configure.
3. To verify the setup, enter the following DataBrew command at the command prompt.

   ```bash
   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, you can 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.

Topics
- Prerequisites (p. 9)
- Getting started with EMR Serverless from the console (p. 13)
- Getting started from the AWS CLI (p. 16)

Prerequisites

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

Topics
- Grant permissions to use EMR Serverless (p. 9)
- Prepare storage for EMR Serverless (p. 9)
- Create an EMR Studio to run interactive workloads (p. 9)
- Create a job runtime role (p. 9)

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 (p. 5).

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 DOC-EXAMPLE-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 (p. 73).

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 DOC-EXAMPLE-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

2. In the left navigation pane, choose Roles.
3. Choose Create role.
4. 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",
      "Principal": {
        "Service": "emr-serverless.amazonaws.com"
      },
      "Action": "sts:AssumeRole"
    }
  ]
}
```

5. Choose Next to navigate to the Add permissions page, then choose Create policy.
6. The Create policy page opens on a new tab. Paste the policy JSON below.

**Important**
Replace `DOC-EXAMPLE-BUCKET` in the policy below with the actual bucket name created in Prepare storage for EMR Serverless (p. 9). This is a basic policy for S3 access. For more job runtime role examples, see Job runtime roles for Amazon EMR Serverless (p. 132).

```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:::DOC-EXAMPLE-BUCKET",
        "arn:aws:s3:::DOC-EXAMPLE-BUCKET/*"
      ]
    }
  ]
}
```
7. On the **Review policy** page, enter a name for your policy, such as `EMRServerlessS3AndGlueAccessPolicy`.

8. Refresh the **Attach permissions policy** page, and choose `EMRServerlessS3AndGlueAccessPolicy`.

9. 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",
            "Principal": {
                "Service": "emr-serverless.amazonaws.com"
            }
        }
    ]
}
```

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

```bash
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 `DOC-EXAMPLE-BUCKET`.

**Important**

Replace `DOC-EXAMPLE-BUCKET` in the policy below with the actual bucket name created in [Prepare storage for EMR Serverless](p. 9). 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](p. 132).

```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:::DOC-EXAMPLE-BUCKET",
                "arn:aws:s3:::DOC-EXAMPLE-BUCKET/*"
            ]
        },
        {
            "Sid": "GlueCreateAndReadDataCatalog",
            "Effect": "Allow",
            "Action": [
                "glue:GetDatabase",
                "glue:CreateDatabase",
                "glue:GetDataBases",
                "glue:GetTable",
                "glue:GetPartition",
                "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.

```bash
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.

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

---

**Getting started with EMR Serverless from the console**

**Steps to complete**

- **Step 1:** Create an EMR Serverless application (p. 13)
- **Step 2:** Submit a job run or interactive workload (p. 14)
- **Step 3:** View application UI and logs (p. 16)
- **Step 4:** Clean up (p. 16)

**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](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.
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.

   ```bash
   aws s3 cp s3://us-east-1.elasticmapreduce/emr-containers/samples/wordcount/scripts/wordcount.py s3://DOC-EXAMPLE-BUCKET/scripts/
   ```

2. Completing Step 1: Create an EMR Serverless application (p. 13) 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.

   a. In the Name field, enter the name that you want to call your job run.
   b. In the Runtime role field, enter the name of the role that you created in Create a job runtime role (p. 9).
   c. In the Script location field, enter `s3://DOC-EXAMPLE-BUCKET/scripts/wordcount.py` as the S3 URI.
   d. In the Script arguments field, enter `"["s3://DOC-EXAMPLE-BUCKET/emr-serverless-spark/output"]`.
   e. 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.

   ```sql
   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://DOC-EXAMPLE-BUCKET/emr-serverless-hive/query/hive-query.ql

3. Completing Step 1: Create an EMR Serverless application (p. 13) 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 (p. 9).
   - In the Script location field, enter s3://DOC-EXAMPLE-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.

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

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 (p. 73).

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 Spark jobs (p. 45) and Hive jobs (p. 50).

---

**Getting started from the AWS CLI**

**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.

```bash
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 (p. 17), make sure that your application has reached the CREATED state with the `get-application` API.

```bash
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 (p. 24).

**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.

```bash
aws s3 cp s3://us-east-1.elasticmapreduce/emr-containers/samples/wordcount/scripts/wordcount.py s3://DOC-EXAMPLE-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 (p. 9). Substitute `job-run-name` with the name you want to call your job run. Replace all `DOC-EXAMPLE-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.

```bash
aws emr-serverless start-job-run \
  --application-id application-id \
  --execution-role-arn job-role-arn \
  --name job-run-name \
  --job-driver '{
    "sparkSubmit": {
```
Step 2: Submit a job run

```
"entryPoint": "s3://DOC-EXAMPLE-BUCKET/scripts/wordcount.py",
"entryPointArguments": ["s3://DOC-EXAMPLE-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://DOC-EXAMPLE-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 (p. 9). Replace all `DOC-EXAMPLE-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://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",
   ```
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://DOC-EXAMPLE-BUCKET/emr-serverless-spark/logs`, you can find the logs for this specific job run under `s3://DOC-EXAMPLE-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://DOC-EXAMPLE-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://DOC-EXAMPLE-BUCKET/emr-serverless-hive/logs`, you can find the logs for this specific job run under `s3://DOC-EXAMPLE-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.

```bash
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 `DOC-EXAMPLE-BUCKET` with the actual name of the S3 bucket created in Prepare storage for EMR Serverless (p. 9).

```bash
aws s3 rm s3://DOC-EXAMPLE-BUCKET --recursive
aws s3api delete-bucket --bucket DOC-EXAMPLE-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.

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

To delete the role, use the following command.

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

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

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

For more examples of running Spark and Hive jobs, see Spark jobs (p. 45) and Hive jobs (p. 50).
Interacting with an application

This section covers how you can interact with your Amazon EMR Serverless application with the AWS CLI and the defaults for Spark and Hive engines.

Topics
- Application states (p. 21)
- Interacting with your application from the EMR Studio console (p. 22)
- Interacting with your application on the AWS CLI (p. 23)
- Configuring an application (p. 24)
- Customizing an EMR Serverless image (p. 31)
- Configuring VPC access (p. 36)
- Amazon EMR Serverless architecture options (p. 38)

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:

<table>
<thead>
<tr>
<th>State</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creating</td>
<td>The application is being prepared and isn't ready to use yet.</td>
</tr>
<tr>
<td>Created</td>
<td>The application has been created but hasn't provisioned capacity yet. You can modify the application to change its initial capacity configuration.</td>
</tr>
<tr>
<td>Starting</td>
<td>The application is starting and is provisioning capacity.</td>
</tr>
<tr>
<td>Started</td>
<td>The application is ready to accept new jobs. The application only accepts jobs when it's in this state.</td>
</tr>
<tr>
<td>Stopping</td>
<td>All jobs have completed and the application is releasing its capacity.</td>
</tr>
<tr>
<td>Stopped</td>
<td>The application is stopped and no resources are running on the application. You can modify the application to change its initial capacity configuration.</td>
</tr>
</tbody>
</table>
Using the EMR Studio console

<table>
<thead>
<tr>
<th>State</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminated</td>
<td>The application has been terminated and doesn't appear on your application list.</td>
</tr>
</tbody>
</table>

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

---

**Interacting with your application from the EMR Studio console**

From the EMR Studio console, you can create, view, 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, you can 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, see [Amazon EMR Serverless architecture options](#) (p. 38).
   - **arm64** — 64-bit ARM architecture; to use AWS Graviton2 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 you can assign to the application.

For more information about pre-initialized capacity, application limits, and application behavior, see Configuring an application (p. 24). For more information about network connectivity, see Configuring VPC access (p. 36).

6. To create the application, choose Create application.

List applications

You can view 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

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 should have no running jobs in order to be stopped. To learn more about application state transitions, see Application states (p. 21).

Configure application

Edit the optional settings for an application from the Configure application page. You can change most application settings. For example, you can change the release label for an application to upgrade it to a different version of Amazon EMR, or you can 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, see Create an application (p. 22).

Delete application

Choose this option to manually delete an application. You must stop an application in order to delete it. To learn more about application state transitions, see Application states (p. 21).

Interacting with your application on the AWS CLI

From the AWS CLI, you can create, describe, and delete individual applications. You can also list all of your applications so that you can view them at a glance. This section describes how to perform these actions. For more application operations, such as starting, stopping, and updating your application, see the EMR Serverless API Reference. For examples of how to use the EMR Serverless API using the AWS SDK for Java, see Java examples in our GitHub repository. For examples of how to use the EMR Serverless API using the AWS SDK for Python (Boto), see 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.
Configuring an application

With EMR Serverless, you can configure the applications that you use. For example, you can 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 (p. 24)
- Pre-initialized capacity (p. 25)
- Default application configuration for EMR Serverless (p. 27)

Understanding application behavior

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**

We recommend configuring 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 shows supported worker configurations and sizes that you can specify for EMR Serverless. You can configure different sizes for drivers and executors based on the need of your workload.

<table>
<thead>
<tr>
<th>CPU</th>
<th>Memory</th>
<th>Default ephemeral storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 vCPU</td>
<td>Minimum 2 GB, maximum 8 GB, in 1 GB increments</td>
<td>20 GB - 200 GB</td>
</tr>
<tr>
<td>2 vCPU</td>
<td>Minimum 4 GB, maximum 16 GB, in 1 GB increments</td>
<td>20 GB - 200 GB</td>
</tr>
<tr>
<td>4 vCPU</td>
<td>Minimum 8 GB, maximum 30 GB, in 1 GB increments</td>
<td>20 GB - 200 GB</td>
</tr>
<tr>
<td>8 vCPU</td>
<td>Minimum 16 GB, maximum 60 GB, in 4 GB increments</td>
<td>20 GB - 200 GB</td>
</tr>
<tr>
<td>16 vCPU</td>
<td>Minimum 32 GB, maximum 120 GB, in 8 GB increments</td>
<td>20 GB - 200 GB</td>
</tr>
</tbody>
</table>

**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 you should 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 would be 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**

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, you can 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.

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 you can 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, you should 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 recommend 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, you can specify how many workers start as drivers and how many start as executors. Similarly, when you use Apache Hive, you can 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"
```
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.

```bash
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. (p. 28)
- Override default configurations during job run. (p. 29)

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, see Storing logs (p. 76).

**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, see Hive configuration override parameter (p. 51) and Spark configuration override parameter (p. 46).

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, see Spark job properties (p. 46) and Hive job properties (p. 51).

You can also configure Apache Log4j2 properties (p. 83), AWS Secrets Manager for data protection (p. 144), and Java 17 runtime (p. 95) 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",
            "kms:Decrypt"
         ],
         "Resource": "arn:aws:secretsmanager:your-secret-arn"
      }
   ]
}
```

For more information on creating custom policies for secrets, see 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.

```bash
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://DOC-EXAMPLE-BUCKET-LOGGING/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 supersedes the configurations that you provide at the application level.

For more information priority rankings, see Hive configuration override parameter (p. 51) and Spark configuration override parameter (p. 46).
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`.

```bash
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://DOC-EXAMPLE-BUCKET-OUTPUT/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"
    }
  ]
```

Customizing an EMR Serverless image

Starting with Amazon EMR 6.9.0, you can 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 might not be 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 you can 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](https://amzn.to/3D1Uk6l). 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.
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, see 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": "ecr-repository-arn"
        }
    ]
}
```

For more examples of Amazon ECR identity-based policies, see 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, you can include any modification that you want to make to the image. The base image automatically sets the USER to hadoop. This setting might 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 see samples for common use cases, see Using custom images with EMR Serverless (p. 103).

```
# Dockerfile
FROM public.ecr.aws/emr-serverless/spark/emr-6.9.0:latest
USER root
# MODIFICATIONS GO HERE
# EMRS will run the image as hadoop
USER hadoop:hadoop
```
After you have the Dockerfile, build the image with the following command.

```bash
# 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, see [the Amazon EMR Serverless Image CLI GitHub](#).

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

```bash
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
```

You should see an output 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 hive-bin-files in /usr/bin: PASS
[INFO] File Structure Test for java-bin in /etc/alternatives/jre/bin: 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, see [Pushing an image](#) in the [Amazon ECR User Guide](#).

```bash
# login to ECR repo
```
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.

```bash
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"
  }

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

```
{
   "Version": "2012-10-17",
   "Statement": [
     {
       "Sid": "Emr Serverless Custom Image Support",
       "Effect": "Allow",
       "Principal": {
         "Service": "emr-serverless.amazonaws.com"
       },
       "Action": [
         "ecr:BatchGetImage",
         "ecr:DescribeImages",
         "ecr:GetDownloadUrlForLayer"
       ],
       "Condition":{
         "StringEquals":{
           "aws:SourceArn": "arn:aws:emr-serverless:region:aws-account-id:/applications/application-id"
        }
      }
    }
  ]
}
```

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, see 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].
• You shouldn't modify environment variables JAVA_HOME, SPARK_HOME, HIVE_HOME, TEZ_HOME when you create a custom image.
• Custom images can't exceed 5 GB in size.
• If you modify binaries or jars in the Amazon EMR base images, it might cause application or job launch failures.
• The Amazon ECR repository should be in the same AWS Region that you use to launch EMR Serverless applications.

Configuring VPC access

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.

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, see Metastore configuration.

Create application

On the Create application page, you can 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.

The subnets selected must be private subnets. This means that the associated route tables for the subnets should not have internet gateways.

For outbound connectivity to the internet, the subnets must have outbound routes using a NAT Gateway. To configure a NAT Gateway, see Work with NAT gateways.

For Amazon S3 connectivity, the subnets must have a NAT Gateway or a VPC endpoint configured. To configure an S3 VPC endpoint, see Create a gateway endpoint.

For connectivity to other AWS services outside the VPC, such as Amazon DynamoDB, you must configure either VPC endpoints or a NAT gateway. To configure VPC endpoints for AWS services, see Work with VPC endpoints.

Note
We recommend that you select multiple subnets across multiple Availability Zones. This is because the subnets that you choose determine the Availability Zones that are available for an EMR Serverless application to launch. Each worker will consume 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, see Best practices for subnet planning.

Note
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.
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 recommend that you create a separate security group for EMR Serverless applications. This makes isolating and managing network rules more efficient. For example, to communicate with Amazon Redshift clusters, you can define the traffic rules between the Redshift and EMR Serverless security groups, as demonstrated in the example below.

Example 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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Protocol</th>
<th>Port range</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>All TCP</td>
<td>TCP</td>
<td>5439</td>
<td>emr-serverless-security-group</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Type</th>
<th>Protocol</th>
<th>Port range</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>All traffic</td>
<td>TCP</td>
<td>ALL</td>
<td>0.0.0.0/0</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Protocol</th>
<th>Port range</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>All TCP</td>
<td>TCP</td>
<td>5439</td>
<td>redshift-security-group</td>
</tr>
</tbody>
</table>

Configure application

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

View job run details

On the Job run detail page, you can view 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 will require at most 1,000 workers for a total of 1,000 network interfaces. We recommend 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 will 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.

<table>
<thead>
<tr>
<th>Subnet ID</th>
<th>Subnet Address</th>
<th>Subnet Mask</th>
<th>IP Address Range</th>
<th>Available IP Addresses</th>
<th>Usable IP Addresses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.0.0.0</td>
<td>255.255.252.0/22</td>
<td>10.0.0.0 - 10.0.3.255</td>
<td>1,024</td>
<td>1,019</td>
</tr>
<tr>
<td>2</td>
<td>10.0.4.0</td>
<td>255.255.252.0/22</td>
<td>10.0.4.0 - 10.0.7.255</td>
<td>1,024</td>
<td>1,019</td>
</tr>
<tr>
<td>3</td>
<td>10.0.8.0</td>
<td>255.255.252.0/22</td>
<td>10.0.8.0 - 10.0.11.255</td>
<td>1,024</td>
<td>1,019</td>
</tr>
<tr>
<td>4</td>
<td>10.0.12.0</td>
<td>255.255.252.0/22</td>
<td>10.0.12.0 - 10.0.15.255</td>
<td>1,024</td>
<td>1,019</td>
</tr>
</tbody>
</table>

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 will require 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 will require 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, see 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.
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 you can switch to arm64 to use AWS Graviton2 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 (AWS Graviton2)

AWS Graviton2 processors are custom designed by AWS with 64-bit ARM Neoverse cores. The arm64 architecture (also known as AArch64 or 64-bit ARM) uses AWS Graviton2 processors to deliver better price performance for Spark and Hive workloads on Amazon EMR Serverless when compared with equivalent workloads running on the x86_64 architecture option.

Launching new applications with AWS Graviton2 support

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

AWS CLI

   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 AWS Graviton2 processors from EMR Studio, choose arm64 as the Architecture option when you create or update an application.
Configuring existing applications to use AWS Graviton2

You can configure your existing Amazon EMR Serverless applications to use the AWS Graviton2 (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 AWS Graviton2, 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 AWS Graviton2**

Before you launch an EMR Serverless application using arm64 for AWS Graviton2 support, confirm the following.

**Library compatibility**

When you select AWS Graviton2 (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, see Using Python libraries with EMR Serverless (p. 97).

To learn more about how to configure a Spark or Hive workload to use 64-bit ARM, see the AWS Graviton Getting Started repository on GitHub. This repository contains essential resources that can help you get started with the ARM-based AWS Graviton2.
Running jobs

After you provision your application, you can 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 (p. 41)
- Running jobs from the EMR Studio console (p. 42)
- Running jobs from the AWS CLI (p. 44)
- Spark jobs (p. 45)
- Hive jobs (p. 50)
- Metastore configuration (p. 59)
- Accessing S3 data in another AWS account from EMR Serverless (p. 66)
- Troubleshooting errors in EMR Serverless (p. 71)

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:

<table>
<thead>
<tr>
<th>State</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submitted</td>
<td>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.</td>
</tr>
<tr>
<td>Pending</td>
<td>The scheduler is evaluating the job run to prioritize and schedule the run for the application.</td>
</tr>
<tr>
<td>Scheduled</td>
<td>EMR Serverless has scheduled the job run for the application, and is allocating resources to execute the job.</td>
</tr>
<tr>
<td>Running</td>
<td>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.</td>
</tr>
<tr>
<td>Failed</td>
<td>EMR Serverless failed to submit the job run to the application, or it completed unsuccessfully. See</td>
</tr>
</tbody>
</table>
Running jobs from the EMR Studio console

You can submit job runs to EMR Serverless applications and view 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, you can 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, see Job runtime roles for Amazon EMR Serverless (p. 132).
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, you must 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, see
### View job runs

From the **Job runs** tab on an application's **Details** page, you can view 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, see **Job run states (p. 41)**.

- **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 view 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, see Spark jobs (p. 45). For Hive examples, see Hive jobs (p. 50). 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, you can 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://DOC-EXAMPLE-BUCKET/scripts/create_table.sql",
      "parameters": "--hiveconf hive.exec.scratchdir=s3://DOC-EXAMPLE-BUCKET/hive/scratch --hiveconf hive.metastore.warehouse.dir=s3://DOC-EXAMPLE-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 see all of your jobs, you can specify the maximum number of jobs you want to see, up to 50. The following example specifies that you want to see 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, see the EMR Serverless API Reference.
Spark 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, see Amazon EMR Serverless release versions (p. 153).

Spark job parameters

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

Required parameters

- Spark job runtime role (p. 45)
- Spark job driver parameter (p. 45)
- Spark configuration override parameter (p. 46)

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 S3MonitoringConfigurations 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, see Job runtime roles for Amazon EMR Serverless (p. 132) and Storing logs (p. 76).

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, SparkR, 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, see 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, see Default application configuration for EMR Serverless (p. 27).

Spark job properties

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

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>spark.archives</td>
<td>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 to extract, add # after the file name that you want to extract. For example, file.zip#directory. This configuration is experimental.</td>
<td>NULL</td>
</tr>
<tr>
<td><strong>Key</strong></td>
<td><strong>Description</strong></td>
<td><strong>Default value</strong></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>spark.authenticate</td>
<td>Option that turns on authentication of Spark's internal connections.</td>
<td>TRUE</td>
</tr>
<tr>
<td>spark.driver.cores</td>
<td>The number of cores that the driver uses.</td>
<td>4</td>
</tr>
<tr>
<td>spark.driver.extraJavaOptions</td>
<td>Extra Java options for the Spark driver.</td>
<td>NULL</td>
</tr>
<tr>
<td>spark.driver.memory</td>
<td>The amount of memory that the driver uses.</td>
<td>14G</td>
</tr>
<tr>
<td>spark.dynamicAllocation.enabled</td>
<td>Option that turns on dynamic resource allocation. This option scales up or down the number of executors registered with the application, based on the workload.</td>
<td>TRUE</td>
</tr>
<tr>
<td>spark.dynamicAllocation.executorIdleTimeout</td>
<td>The length of time that an executor can remain idle before Spark removes it. This only applies if you turn on dynamic allocation.</td>
<td>60s</td>
</tr>
<tr>
<td>spark.dynamicAllocation.initialExecutors</td>
<td>The initial number of executors to run if you turn on dynamic allocation.</td>
<td>3</td>
</tr>
<tr>
<td>spark.dynamicAllocation.maxExecutors</td>
<td>The upper bound for the number of executors if you turn on dynamic allocation.</td>
<td>For 6.10.0 and higher, infinity For 6.9.0 and lower, 100</td>
</tr>
<tr>
<td>spark.dynamicAllocation.minExecutors</td>
<td>The lower bound for the number of executors if you turn on dynamic allocation.</td>
<td>0</td>
</tr>
<tr>
<td>spark.emr-serverless.allocation.batch.size</td>
<td>The number of containers to request in each cycle of executor allocation. There is a one-second gap between each allocation cycle.</td>
<td>20</td>
</tr>
<tr>
<td>spark.emr-serverless.driver.disk</td>
<td>The Spark driver disk.</td>
<td>20G</td>
</tr>
<tr>
<td>spark.emr-serverless.driverEnv.[KEY]</td>
<td>Option that adds environment variables to the Spark driver.</td>
<td>NULL</td>
</tr>
<tr>
<td>spark.emr-serverless.executor.disk</td>
<td>The Spark executor disk.</td>
<td>20G</td>
</tr>
<tr>
<td>spark.emr-serverless.memoryOverheadFactor</td>
<td>Sets the memory overhead to add to the driver and executor container memory.</td>
<td>0.1</td>
</tr>
</tbody>
</table>
### Spark properties

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>spark.executor.cores</td>
<td>The number of cores that each executor uses.</td>
<td>4</td>
</tr>
<tr>
<td>spark.executor.extraJavaOptions</td>
<td>Extra Java options for the Spark executor.</td>
<td>NULL</td>
</tr>
<tr>
<td>spark.executor.instances</td>
<td>The number of Spark executor containers to allocate.</td>
<td>3</td>
</tr>
<tr>
<td>spark.executor.memory</td>
<td>The amount of memory that each executor uses.</td>
<td>14G</td>
</tr>
<tr>
<td>spark.executorEnv.[KEY]</td>
<td>Option that adds environment variables to the Spark executors.</td>
<td>NULL</td>
</tr>
<tr>
<td>spark.files</td>
<td>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).</td>
<td>NULL</td>
</tr>
<tr>
<td>spark.hadoop.hive.metastore.client.factory.class</td>
<td>The Hive metastore implementation class.</td>
<td>NULL</td>
</tr>
<tr>
<td>spark.jars</td>
<td>Additional jars to add to the runtime classpath of the driver and executors.</td>
<td>NULL</td>
</tr>
<tr>
<td>spark.network.crypto.enabled</td>
<td>Option that turns on AES-based RPC encryption. This includes the authentication protocol added in Spark 2.2.0.</td>
<td>FALSE</td>
</tr>
<tr>
<td>spark.sql.warehouse.dir</td>
<td>The default location for managed databases and tables.</td>
<td>The value of $PWD/spark-warehouse</td>
</tr>
<tr>
<td>spark.submit.pyFiles</td>
<td>A comma-separated list of .zip, .egg, or .py files to place in the PYTHONPATH for Python apps.</td>
<td>NULL</td>
</tr>
</tbody>
</table>

The following table lists the default Spark submit parameters.

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>archives</td>
<td>A comma-separated list of archives that Spark extracts into each executor's working directory.</td>
<td>NULL</td>
</tr>
<tr>
<td>class</td>
<td>The application's main class (for Java and Scala apps).</td>
<td>NULL</td>
</tr>
<tr>
<td>conf</td>
<td>An arbitrary Spark configuration property.</td>
<td>NULL</td>
</tr>
<tr>
<td>Key</td>
<td>Description</td>
<td>Default value</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>driver-cores</td>
<td>The number of cores that the driver uses.</td>
<td>4</td>
</tr>
<tr>
<td>driver-memory</td>
<td>The amount of memory that the driver uses.</td>
<td>14G</td>
</tr>
<tr>
<td>executor-cores</td>
<td>The number of cores that each executor uses.</td>
<td>4</td>
</tr>
<tr>
<td>executor-memory</td>
<td>The amount of memory that the executor uses.</td>
<td>14G</td>
</tr>
<tr>
<td>files</td>
<td>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(file_name).</td>
<td>NULL</td>
</tr>
<tr>
<td>jars</td>
<td>A comma-separated list of jars to include on the driver and executor classpaths.</td>
<td>NULL</td>
</tr>
<tr>
<td>num-executors</td>
<td>The number of executors to launch.</td>
<td>3</td>
</tr>
<tr>
<td>py-files</td>
<td>A comma-separated list of .zip, .egg, or .py files to place on the PYTHONPATH for Python apps.</td>
<td>NULL</td>
</tr>
<tr>
<td>verbose</td>
<td>Option that turns on additional debug output.</td>
<td>NULL</td>
</tr>
</tbody>
</table>

### 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, see Getting started with Amazon EMR Serverless (p. 9). You can find additional examples of how to run PySpark jobs and add Python dependencies in the EMR Serverless Samples GitHub repository.

```bash
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://DOC-EXAMPLE-BUCKET-OUTPUT/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.
Hive 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, see Amazon EMR Serverless release versions (p. 153).

Hive job parameters

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

Required parameters

- Hive job runtime role (p. 50)
- Hive job driver parameter (p. 51)
- Hive configuration override parameter (p. 51)

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, see Job runtime roles for Amazon EMR Serverless (p. 132).
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 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 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, see [Default application configuration for EMR Serverless (p. 27)](#).

Hive job properties

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

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>hive.exec.scratchdir</td>
<td>The Amazon S3 location where EMR Serverless creates temporary files during the Hive job execution.</td>
<td></td>
</tr>
<tr>
<td>hive.metastore.warehouse.dir</td>
<td>The Amazon S3 location of databases for managed tables in Hive.</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>fs.s3.customAWSCredentialsProvider</td>
<td>The AWS Credentials provider you want to use.</td>
<td>com.amazonaws.auth.DefaultAWSCredentialsProviderChain</td>
</tr>
<tr>
<td>fs.s3a.aws.credentials.provider</td>
<td>The AWS Credentials provider you want to use with a S3A file system.</td>
<td>com.amazonaws.auth.DefaultAWSCredentialsProviderChain</td>
</tr>
<tr>
<td>hive.auto.convert.join</td>
<td>Option that turns on auto-conversion of common joins into mapjoins, based on the input file size.</td>
<td>TRUE</td>
</tr>
<tr>
<td>hive.auto.convert.join.noconditionaltask</td>
<td>Option that turns on optimization when Hive converts a common join into a mapjoin based on the input file size.</td>
<td>TRUE</td>
</tr>
<tr>
<td>hive.auto.convert.join.noconditionaltask.size</td>
<td>A join converts directly to a mapjoin below this size. Optimal value is calculated based on Tez task memory.</td>
<td></td>
</tr>
<tr>
<td>hive.cbo.enable</td>
<td>Option that turns on cost-based optimizations with the Calcite framework.</td>
<td>TRUE</td>
</tr>
<tr>
<td>hive.cli.tez.session.async</td>
<td>Option to start a background Tez session while your Hive query compiles. When set to false, Tez AM launches after your Hive query compiles.</td>
<td>TRUE</td>
</tr>
<tr>
<td>hive.compute.query.using.stats</td>
<td>Option that activates Hive to answer certain queries 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.</td>
<td>TRUE</td>
</tr>
<tr>
<td>hive.default.fileformat</td>
<td>The default file format for CREATE TABLE statements. You can explicitly override this if you specify STORED AS</td>
<td>TEXTFILE</td>
</tr>
<tr>
<td>Setting</td>
<td>Description</td>
<td>Default value</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>[FORMAT] in your CREATE TABLE command.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hive.driver.cores</td>
<td>The number of cores to use for the Hive driver process.</td>
<td>2</td>
</tr>
<tr>
<td>hive.driver.disk</td>
<td>The disk size for the Hive driver.</td>
<td>20G</td>
</tr>
<tr>
<td>hive.driver.memory</td>
<td>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.</td>
<td>6G</td>
</tr>
<tr>
<td>hive.emr-serverless.launch.env. [KEY]</td>
<td>Option to set the KEY environment variable in all Hive-specific processes, such as your Hive driver, Tez AM, and Tez task.</td>
<td></td>
</tr>
<tr>
<td>hive.exec.dynamic.partition</td>
<td>Options that turns on dynamic partitions in DML/DDL.</td>
<td>TRUE</td>
</tr>
<tr>
<td>hive.exec.dynamic.partition.mode</td>
<td>Option that specifies whether you want to use strict mode or non-strict mode. In strict mode, you must specify at least one static partition in case you accidentally overwrite all partitions. In non-strict mode, all partitions are allowed to be dynamic.</td>
<td>strict</td>
</tr>
<tr>
<td>hive.exec.max.dynamic.partitions</td>
<td>Maximum number of dynamic partitions that Hive creates in total.</td>
<td>1000</td>
</tr>
<tr>
<td>hive.exec.max.dynamic.partitions.pernode</td>
<td>Maximum number of dynamic partitions that Hive creates in each mapper and reducer node.</td>
<td>100</td>
</tr>
<tr>
<td>hive.exec.orc.split.strategy</td>
<td>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 above strategies based on heuristics.</td>
<td>HYBRID</td>
</tr>
<tr>
<td>hive.exec.reducers.bytes.per.reducer</td>
<td>The size of the reducer. The default is 256 MB. If the input size is 1G, the job uses 4 reducers.</td>
<td>2560000000</td>
</tr>
<tr>
<td>Setting</td>
<td>Description</td>
<td>Default value</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>hive.exec.reducers.max</td>
<td>The maximum number of reducers.</td>
<td>256</td>
</tr>
<tr>
<td>hive.exec.stagingdir</td>
<td>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.</td>
<td>hive-staging</td>
</tr>
<tr>
<td>hive.fetch.task.conversion</td>
<td>Expects one of the following values: NONE, MINIMAL, or MORE. Hive can convert select queries to a single FETCH task. This minimizes latency.</td>
<td>MORE</td>
</tr>
<tr>
<td>hive.groupby.position.alias</td>
<td>Option that causes Hive to use a column position alias in GROUP BY statements.</td>
<td>FALSE</td>
</tr>
<tr>
<td>hive.input.format</td>
<td>The default input format. Set to HiveInputFormat if you encounter problems with CombineHiveInputFormat.</td>
<td>org.apache.hadoop.hive.ql.io.CombineHiveInputFormat</td>
</tr>
<tr>
<td>hive.log.explain.output</td>
<td>Option that turns on explanations of extended output for any query in your Hive log.</td>
<td>FALSE</td>
</tr>
<tr>
<td>hive.log.level</td>
<td>The Hive logging level.</td>
<td>INFO</td>
</tr>
<tr>
<td>hive.mapred.reduce.tasks.speculative.execution</td>
<td>Option that turns on speculative launch for reducers. Only supported with Amazon EMR 6.10.x and lower.</td>
<td>TRUE</td>
</tr>
<tr>
<td>hive.max-task-containers</td>
<td>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.</td>
<td>1000</td>
</tr>
<tr>
<td>hive.merge.mapfiles</td>
<td>Option that causes small files to merge at the end of a map-only job.</td>
<td>TRUE</td>
</tr>
<tr>
<td>hive.merge.size.per.task</td>
<td>The size of merged files at the end of the job.</td>
<td>256000000</td>
</tr>
<tr>
<td>hive.merge.tezfiles</td>
<td>Option that turns on a merge of small files at the end of a Tez DAG.</td>
<td>FALSE</td>
</tr>
<tr>
<td>Setting</td>
<td>Description</td>
<td>Default value</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>hive.metastore.client.factory.class</td>
<td>The name of the factory class that produces objects that implement the IMetaStoreClient interface.</td>
<td>com.amazonaws.glue.catalog.metastore.AWSGlueDataCatalogHiveClientFactory</td>
</tr>
<tr>
<td>hive.metastore.glue.catalogid</td>
<td>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.</td>
<td>NULL</td>
</tr>
<tr>
<td>hive.metastore.uris</td>
<td>The thrift URI that the metastore client uses to connect to remote metastore.</td>
<td>NULL</td>
</tr>
<tr>
<td>hive.optimize.ppd</td>
<td>Option that turns on predicate pushdown.</td>
<td>TRUE</td>
</tr>
<tr>
<td>hive.optimize.ppd.storage</td>
<td>Option that turns on predicate pushdown to storage handlers.</td>
<td>TRUE</td>
</tr>
<tr>
<td>hive.orderby.position.alias</td>
<td>Option that causes Hive to use a column position alias in ORDER BY statements.</td>
<td>TRUE</td>
</tr>
<tr>
<td>hive.prewarm.enabled</td>
<td>Option that turns on container prewarm for Tez.</td>
<td>FALSE</td>
</tr>
<tr>
<td>hive.prewarm.numcontainers</td>
<td>The number of containers to pre-warm for Tez.</td>
<td>10</td>
</tr>
<tr>
<td>hive.stats.autogather</td>
<td>Option that causes Hive to gather basic statistics automatically during the INSERT OVERWRITE command.</td>
<td>TRUE</td>
</tr>
<tr>
<td>hive.stats.fetch.column.stats</td>
<td>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.</td>
<td>FALSE</td>
</tr>
<tr>
<td>hive.stats.gather.num.threads</td>
<td>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).</td>
<td>10</td>
</tr>
<tr>
<td>hive.strict.checks.cartesian.product</td>
<td>Option that turns on strict Cartesian join checks. These checks disallow a Cartesian product (a cross join).</td>
<td>FALSE</td>
</tr>
<tr>
<td>Setting</td>
<td>Description</td>
<td>Default value</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>hive.strict.checks.type.safety</td>
<td>Option that turns on strict type safety checks and turns off comparison of bigint with both string and double.</td>
<td>TRUE</td>
</tr>
<tr>
<td>hive.supportquoted.identifiers</td>
<td>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.</td>
<td>COLUMN</td>
</tr>
<tr>
<td>hive.tez.auto.reducer.parallelism</td>
<td>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.</td>
<td>TRUE</td>
</tr>
<tr>
<td>hive.tez.container.size</td>
<td>The amount of memory to use per Tez task process.</td>
<td>6144</td>
</tr>
<tr>
<td>hive.tez.cpu.vcores</td>
<td>The number of cores to use for each Tez task.</td>
<td>2</td>
</tr>
<tr>
<td>hive.tez.disk.size</td>
<td>The disk size for each task container.</td>
<td>20G</td>
</tr>
<tr>
<td>hive.tez.input.format</td>
<td>The input format for splits generation in the Tez AM.</td>
<td>org.apache.hadoop.hive.ql.io.HiveInputFormat</td>
</tr>
</tbody>
</table>
### Hive properties

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>mapreduce.input.fileinputformat.split.maxsize</td>
<td>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.</td>
<td>0</td>
</tr>
<tr>
<td>tez.am.dag.cleanup.on.completion</td>
<td>Option that turns on cleanup of shuffle data when DAG completes.</td>
<td>TRUE</td>
</tr>
<tr>
<td>tez.am.emr-serverless.launch.env. [KEY]</td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>tez.am.log.level</td>
<td>The root logging level that EMR Serverless passes to the Tez app master.</td>
<td>INFO</td>
</tr>
<tr>
<td>tez.am.sleep.time.before.exit.millis</td>
<td>EMR Serverless should push ATS events after this period of time following AM shutdown request.</td>
<td>0</td>
</tr>
<tr>
<td>tez.am.speculation.enabled</td>
<td>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.</td>
<td>FALSE</td>
</tr>
<tr>
<td>tez.am.task.max.failed.attempts</td>
<td>The maximum number of attempts that can fail for a particular task before the task fails. This number doesn't count manually terminated attempts.</td>
<td>3</td>
</tr>
<tr>
<td>tez.am.vertex.cleanup.height</td>
<td>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.</td>
<td>0</td>
</tr>
<tr>
<td>tez.client.asynchronous-stop</td>
<td>Option that causes EMR Serverless to push ATS events before it ends the Hive driver.</td>
<td>FALSE</td>
</tr>
<tr>
<td>tez.grouping.max-size</td>
<td>The upper size limit (in bytes) of a grouped split. This limit prevents excessively large splits.</td>
<td>1073741824</td>
</tr>
</tbody>
</table>
### Hive 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": {
```
Metastore configuration

A Hive metastore is a centralized location that stores structural information about your tables, including schemas, partition names, and data types. With EMR Serverless, you can 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, see Populating the AWS Glue Data Catalog. For information about AWS Glue pricing, see 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, you can 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://DOC-EXAMPLE-BUCKET/code/pyspark/extreme_weather.py",
   "sparkSubmitParameters": "--conf spark.hadoop.hive.metastore.client.factory.class=com.amazonaws.glue.catalog.metastore.AWSGlueDataCatalogHiveClientFactory --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, you must 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.

   ```
   {}   ```
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
```

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

   Spark

   Set the `spark.hadoop.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 '{
      "sparkSubmit": {
      "query": "s3://DOC-EXAMPLE-BUCKET/hive/scripts/create_table.sql",
      "parameters": "--hiveconf hive.exec.scratchdir=s3://DOC-EXAMPLE-BUCKET/hive/scratch --hiveconf hive.metastore.warehouse.dir=s3://DOC-EXAMPLE-BUCKET/hive/warehouse"
     }
   }
   --configuration-overrides '{
      "applicationConfiguration": [{
      "classification": "hive-site",
      "properties": {
      "spark.hadoop.hive.metastore.glue.catalogid": "AccountB-catalog-id" 
      }
      }
   ]
   }'

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://DOC-EXAMPLE-BUCKET/hive/scripts/create_table.sql",
      "parameters": "--hiveconf hive.exec.scratchdir=s3://DOC-EXAMPLE-BUCKET/hive/scratch --hiveconf hive.metastore.warehouse.dir=s3://DOC-EXAMPLE-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, see 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, see Configuring VPC access (p. 36).
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, see 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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Protocol</th>
<th>Port range</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>All TCP</td>
<td>TCP</td>
<td>3306</td>
<td>emr-serverless-security-group</td>
</tr>
</tbody>
</table>

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.

```bash
aws emr-serverless start-job-run \
  --application-id "application-id" \
  --execution-role-arn "job-role-arn" \
  --job-driver '{
    "sparkSubmit": {
      "entryPoint": "s3://DOC-EXAMPLE-BUCKET/scripts/spark-jdbc.py",
    },
    --configuration overrides '{
      "monitoringConfiguration": {
        "s3MonitoringConfiguration": {
          "logUri": "s3://DOC-EXAMPLE-BUCKET/spark/logs/"
        }
      }
    }
  }'
```

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

```python
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 master 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.

```bash
aws emr-serverless start-job-run \
    --application-id "application-id" \
    --execution-role-arn "job-role-arn" \
    --job-driver '{"sparkSubmit": {
        "entryPoint": "s3://DOC-EXAMPLE-BUCKET/thriftscript.py",
        "sparkSubmitParameters": "--jars s3://DOC-EXAMPLE-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:///DOC-EXAMPLE-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.

```python
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:thrift-server-port") \
```
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.

```json
{
  "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 MySQL instance. 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.

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

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.
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, you must 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, you must 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, see [Job runtime roles for Amazon EMR Serverless](p. 132).

- **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": "Example permissions 1",
        "Effect": "Allow",
        "Principal": {
            "AWS": "arn:aws:iam::AccountA:root"
        },
        "Action": [
            "s3:ListBucket"
        ],
        "Resource": [
            "arn:aws:s3:::bucket_name_in_AccountB"
        ]
    },
    {
    }
}
```
Use an assumed role

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, see Creating a bucket in the Amazon Simple Storage Service User Guide. If you want to have cross-account access to DynamoDB, you can also create a DynamoDB table in AccountB. For more information, see 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, see 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, see Creating IAM policies in the IAM User Guide.

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

For more information about S3 cross-account access with S3 bucket policies, see Example 2: Bucket owner granting cross-account bucket permissions in the Amazon Simple Storage Service User Guide.
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, see 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:MyRegion:AccountB:table/CrossAccountTable"
        }
    ]
}
```

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",
            "Principal": {
                "AWS": "arn:aws:iam::AccountA:role/Job-Execution-Role-A"
            },
            "Action": "sts:AssumeRole"
        }
    ]
}
```

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::AccountB:role/Cross-Account-Role-B"
        }
    ]
}
```
Assumed role examples

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

Topics
• Access S3 resources with one assumed role (p. 69)
• Access S3 resources with multiple assumed roles (p. 70)

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.serverless.credentialsprovider.AssumeRoleAWSContextProvider`.
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 master, and Tez task containers.

The following examples show 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.

```bash
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 sparkexecutor.instances=1"
    }
  }' \
  --configuration-overrides '{
    "applicationConfiguration": [{
      "classification": "spark-defaults",
      "properties": {
        "spark.hadoop.fs.s3.customAWSCredentialsProvider": "com.amazonaws.emr.serverless.credentialsprovider.AssumeRoleAWSContextProvider",
        "spark.emr-serverless.driverEnv.ASSUME_ROLE_CREDENTIALS_ROLE_ARN": "arn:aws:iam::AccountB:role/Cross-Account-Role-B"
      }
    }
  }
```

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Assumed role examples

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.

```bash
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 '{
    "classification": "hive-site",
    "properties": {
      "fs.s3.customAWSCredentialsProvider": "com.amazonaws.emr.serverless.credentialsprovider.AssumeRoleAWSCredentialsProvider",
      "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, you can 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.AssumeRoleAWSCredentialsProvider`
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, you can 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 show 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.

```bash
aws emr-serverless start-job-run \
```
Troubleshooting errors in EMR Serverless

Use the following information to help diagnose and fix common issues that you might encounter when you work with Amazon EMR Serverless.

**Topics**
- **Error: Limit exceeded for max allowed capacity.** (p. 72)
- **Error: Configured maximum capacity has been exceeded. Please try again later.** (p. 72)
• **Error: S3 access is denied. Please check S3 access permissions of the job runtime role on the required S3 resources.** (p. 72)

• **Error: ModuleNotFoundError: No module named <module>. Please refer to the user guide on how to use python libraries with EMR Serverless.** (p. 72)

• **Error: Could not assume execution role <role name> because it does not exist or is not set up with the required trust relationship.** (p. 72)

### Error: Limit exceeded for max allowed capacity.

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

### Error: Configured maximum capacity has been exceeded. Please try again later.

This error indicates that EMR Serverless couldn't start a new job because the application has exceeded your configured maximum capacity limits. Increase the maximum capacity limits for the application.

### 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, see [Job runtime roles for Amazon EMR Serverless](p. 132).

### 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, see [Using Python libraries with EMR Serverless](p. 97).

### 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](p. 132).
Run interactive workloads with EMR Serverless through 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, you must 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, see Required permissions for interactive workloads (p. 73).

Required permissions for interactive workloads

In addition to the basic permissions that are required to access EMR Serverless (p. 5), you must 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, see 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, see Create a job runtime role (p. 9).

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:Region:account:/applications/*"
        },
        {
            "Sid": "EMRServerlessRuntimeRoleAccess",
            "Effect": "Allow",
            "Action": "iam:PassRole",
            "Resource": "interactive-execution-role-ARN",
            "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, see 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 are not 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.
Considerations

- There isn't an endpoint or API interface that supports self-hosted Jupyter notebooks with interactive applications.
- For an optimized startup experience, we recommend 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.

```bash
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.
- Once you start an interactive application, EMR Serverless maintains pre-initialized capacity of 1 kernel worker throughout the lifetime of the application. The kernel uses 4 vCPU and 16 GB memory worker configuration, but is subject to change. For current pricing information, see [The Amazon EMR Pricing page](https://aws.amazon.com/emr/pricing).
- You must have sufficient vCPU service quota in your AWS account to run interactive workloads. For the best experience, we recommend at least 24 vCPU.
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 you can more easily debug a multipoint failure if one occurs.

Topics
- Storing logs (p. 76)
- Encrypting logs (p. 79)
- Configure Apache Log4j2 properties for Amazon EMR Serverless (p. 83)
- Monitoring EMR Serverless (p. 86)
- Automating EMR Serverless with Amazon EventBridge (p. 90)

Storing logs

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

With CloudWatch, you can 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, see the section called “Amazon CloudWatch” (p. 77). With managed storage and S3 logging, the following table shows the log locations and UI availability that you can expect if you choose managed storage (p. 76), Amazon S3 buckets (p. 77), or both.

<table>
<thead>
<tr>
<th>Option</th>
<th>Event logs</th>
<th>Container logs</th>
<th>Application UI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managed storage</td>
<td>Stored in managed storage</td>
<td>Stored in managed storage</td>
<td>Supported</td>
</tr>
<tr>
<td>Both managed storage and S3 bucket</td>
<td>Stored in both places</td>
<td>Stored in S3 bucket</td>
<td>Supported</td>
</tr>
<tr>
<td>Amazon S3 bucket</td>
<td>Stored in S3 bucket</td>
<td>Stored in S3 bucket</td>
<td>Not supported</td>
</tr>
</tbody>
</table>

1 We recommend 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.
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": true
    }
  }
}
```

## Logging for EMR Serverless with Amazon S3 buckets

Before your jobs can send log data to Amazon S3, you must include the following permissions in the permissions policy for the job runtime role. Replace `DOC-EXAMPLE-BUCKET-LOGGING` with the name of your logging bucket.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["s3:PutObject"],
      "Resource": ["arn:aws:s3:::DOC-EXAMPLE-BUCKET-LOGGING/*"]
    }
  ]
}
```

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://DOC-EXAMPLE-BUCKET-LOGGING/logs/"
    }
  }
}
```

## Logging for EMR Serverless with Amazon CloudWatch

When you submit a job to an EMR Serverless application, you can 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 view 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, see the configuration in AWS CLI (p. 78).

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 recommend 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, see 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, you must 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:AWS Region:111122223333:*"
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "logs:PutLogEvents",
                "logs:CreateLogGroup",
                "logs:CreateLogStream",
                "logs:DescribeLogStreams"
            ],
            "Resource": [
            ]
        }
    ]
}
```

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, you can 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.

The following shows the minimum configuration that is required to turn on Amazon CloudWatch logging with the default settings for EMR Serverless:

```json
{
```
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.

```json
{
  "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://DOC-EXAMPLE-BUCKET-LOGGING/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 (p. 80)
- Encryption key permissions for Amazon S3 and managed storage (p. 81)
- Encryption key permissions for Amazon CloudWatch (p. 82)

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":{
    "Effect": "Allow",
    "Principal":{
```

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Required permissions

```json
"AWS": "arn:aws:iam::111122223333:user/user-name",
"Action": [
  "kms:GenerateDataKey",
  "kms:Decrypt"
],
"Resource": "*"
}
```

**Example IAM policy**

The following key policy provides the permissions to `kms:GenerateDataKey` and `kms:Decrypt`:

```json
{
  "Version": "2012-10-17",
  "Statement": {
    "Effect": "Allow",
    "Action": [
      "kms:GenerateDataKey",
      "kms:Decrypt"
    ],
    "Resource": "key-arn"
  }
}
```

To launch the Spark or Tez UI, you must 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"
    ]
  }
}
```

**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, you must configure KMS key permissions as follows.

The `emr-serverless.amazonaws.com` principal must have the following permissions in the policy for the KMS key:

```json
{
  "Effect": "Allow",
  "Principal": {
    "Service": "emr-serverless.amazonaws.com"
  },
  "Action": [
    "kms:Decrypt",
    "kms:GenerateDataKey"
  ],
  "Resource": "*"
}
```

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Required permissions

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.

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": "key-arn"
  }
}
```

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": [
    ]
  }
}
```

Configure the KMS key policy to grant KMS permissions to Amazon CloudWatch:

```json
{
  "Version": "2012-10-17",
  "Id": "key-default-1",
  "Statement": {
    "Effect": "Allow",
    "Principal": {
      "Service": "logs.AWS Region.amazonaws.com"
    },
    "Action": [
      "kms:Decrypt",
      "kms:GenerateDataKey"
    ],
    "Resource": "*",
    "Condition": {
      "ArnLike": {
      }
    }
  }
}
```
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, see Default application configuration for EMR Serverless (p. 27).

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 (p. 83)
- Log4j2 configuration example for Spark (p. 83)
- Log4j2 in sample Spark jobs (p. 84)
- Log4j2 considerations for Spark (p. 85)

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, see Default application configuration for EMR Serverless (p. 27).

```bash
aws emr-serverless start-job-run \
   --application-id application-id \
```
Log4j2 and Spark

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

```python
import os
import sys

from pyspark import SparkConf, SparkContext
from pyspark.sql import SparkSession

app_name = "PySparkApp"
if __name__ == "__main__":
    spark = SparkSession\
    .builder\n    .appName(app_name)\n    .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")
```

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.
To customize Log4j2 for the driver when you execute a Spark job, you can use the following configuration:

```json
{
  "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**

```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, you can use the following configuration:

```json
{
  "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`
Monitoring EMR Serverless

This section covers the ways that you can monitor your Amazon EMR Serverless applications and jobs.

Topics
- Monitoring EMR Serverless applications and jobs (p. 86)
- EMR Serverless usage metrics (p. 89)

Monitoring EMR Serverless applications and jobs

Note  
EMR Serverless interactive workloads (p. 73) have only application-level monitoring enabled, and have a new worker type dimension, KERNEL. To monitor and debug your interactive workloads, you can view the logs and Apache Spark UI from within your EMR Studio Workspace.

Application-level monitoring

You can monitor capacity usage at the EMR Serverless application level with Amazon CloudWatch metrics.

EMR Serverless metrics overview

With Amazon CloudWatch request metrics for EMR Serverless, you can receive 1-minute CloudWatch metrics and access CloudWatch dashboards to view near-real-time operations and performance of your EMR Serverless applications.

EMR Serverless sends the following metrics to CloudWatch every minute. EMR Serverless emits some of these metrics (those with a secondary dimension) at the application level as well at the worker-type and capacity-allocation-type levels. This lets you view these metrics both for the application as a whole and for each combination of worker type and capacity allocation.

You can set up a single view to monitor application capacity usage in a CloudWatch dashboard. To get started, use the EMR Serverless CloudWatch dashboard template provided in the EMR Serverless GitHub repository and deploy it.

EMR Serverless application metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
<th>Primary dimension</th>
<th>Secondary dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPUAllocated</td>
<td>The total numbers of vCPUs allocated.</td>
<td>ApplicationId</td>
<td>ApplicationId, WorkerType, CapacityAllocationType</td>
</tr>
</tbody>
</table>
### Metric

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
<th>Primary dimension</th>
<th>Secondary dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>IdleWorkerCount</td>
<td>The number of total workers idle.</td>
<td>ApplicationId</td>
<td>ApplicationId, WorkerType, CapacityAllocationType</td>
</tr>
<tr>
<td>MaxCPUAllowed</td>
<td>The maximum CPU allowed for the application.</td>
<td>ApplicationId</td>
<td>N/A</td>
</tr>
<tr>
<td>MaxMemoryAllowed</td>
<td>The maximum memory in GB allowed for the application.</td>
<td>ApplicationId</td>
<td>N/A</td>
</tr>
<tr>
<td>MaxStorageAllowed</td>
<td>The maximum storage in GB allowed for the application.</td>
<td>ApplicationId</td>
<td>N/A</td>
</tr>
<tr>
<td>MemoryAllocated</td>
<td>The total memory in GB allocated.</td>
<td>ApplicationId</td>
<td>ApplicationId, WorkerType, CapacityAllocationType</td>
</tr>
<tr>
<td>PendingCreationWorkerCount</td>
<td>The number of total workers pending creation.</td>
<td>ApplicationId</td>
<td>ApplicationId, WorkerType, CapacityAllocationType</td>
</tr>
<tr>
<td>RunningWorkerCount</td>
<td>The number of total workers in use by the application.</td>
<td>ApplicationId</td>
<td>ApplicationId, WorkerType, CapacityAllocationType</td>
</tr>
<tr>
<td>StorageAllocated</td>
<td>The total disk storage in GB allocated.</td>
<td>ApplicationId</td>
<td>ApplicationId, WorkerType, CapacityAllocationType</td>
</tr>
<tr>
<td>TotalWorkerCount</td>
<td>The number of total workers available.</td>
<td>ApplicationId</td>
<td>ApplicationId, WorkerType, CapacityAllocationType</td>
</tr>
</tbody>
</table>

### Dimensions for EMR Serverless application metrics

EMR Serverless application metrics use the AWS/EMRServerless namespace and provide metrics for the following dimensions.

### Dimensions for EMR Serverless application metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ApplicationId</td>
<td>Filters for metrics of all capacity usage for a given EMR Serverless application.</td>
</tr>
<tr>
<td>WorkerType</td>
<td>Filters for metrics of all capacity usage by worker type. For example, SPARK_DRIVER and SPARK_EXECUTORS for Spark jobs.</td>
</tr>
<tr>
<td>CapacityAllocationType</td>
<td>Filters for metrics of all capacity usage by capacity allocation type. For example, PreInitCapacity for pre-initialized capacity and OnDemandCapacity for everything else.</td>
</tr>
</tbody>
</table>
### Job-level monitoring

Amazon EMR Serverless sends the following job-level metrics to Amazon CloudWatch every one minute. You can view 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

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
<th>Primary dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>SubmittedJobs</td>
<td>The number of jobs in a Submitted state.</td>
<td>ApplicationId</td>
</tr>
<tr>
<td>PendingJobs</td>
<td>The number of jobs in a Pending state.</td>
<td>ApplicationId</td>
</tr>
<tr>
<td>ScheduledJobs</td>
<td>The number of jobs in a Scheduled state.</td>
<td>ApplicationId</td>
</tr>
<tr>
<td>RunningJobs</td>
<td>The number of jobs in a Running state.</td>
<td>ApplicationId</td>
</tr>
<tr>
<td>SuccessJobs</td>
<td>The number of jobs in a Success state.</td>
<td>ApplicationId</td>
</tr>
<tr>
<td>FailedJobs</td>
<td>The number of jobs in a Failed state.</td>
<td>ApplicationId</td>
</tr>
<tr>
<td>CancellingJobs</td>
<td>The number of jobs in a Cancelling state.</td>
<td>ApplicationId</td>
</tr>
<tr>
<td>CancelledJobs</td>
<td>The number of jobs in a Cancelled state.</td>
<td>ApplicationId</td>
</tr>
</tbody>
</table>

You can monitor engine-specific metrics for both running and completed EMR Serverless jobs with engine-specific application UIs. When you view the UI for a running job, you see the live application UI with real-time updates. When you view the UI for a completed job, you see the persistent app UI.

**Running jobs**

For your running EMR Serverless jobs, you can view 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, you can use the Spark History Server or the Persistent Hive Tez UI to view 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.

The following table contains steps to view both 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 view engine-specific application UIs and logs for a running job:


a. Choose a job with a RUNNING status.

b. Select the job on the Application details page, or navigate to the Job details page for your job.

c. Under the Display UI dropdown menu, choose either Spark UI or Hive Tez UI to navigate to the application UI for your job type.

d. To view Spark engine logs, navigate to the Executors tab in the Spark UI, and choose the Logs link for the driver. To view Hive engine logs, choose the Logs link for the appropriate DAG in the Hive Tez UI.

3. To view engine-specific application UIs and logs for a completed job:

   a. Choose a job with a SUCCESS status.

   b. Select the job on your application's Application details page or navigate to the job's Job details page.

   c. 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.

   d. To view Spark engine logs, navigate to the Executors tab in the Spark UI, and choose the Logs link for the driver. To view 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 you can use to access your application UI for both running and completed jobs, call the GetDashboardForJobRun API.

```bash
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.

**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, see Service Quotas and Amazon CloudWatch alarms in the Service Quotas User Guide.

For more information about EMR Serverless service quotas, see Endpoints and quotas for EMR Serverless (p. 150).

**Service quota usage metrics for EMR Serverless**

EMR Serverless publishes the following service quota usage metrics in the AWS/Usage namespace.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ResourceCount</td>
<td>The total number of the specified resource that is running on your account. The resource is defined</td>
</tr>
</tbody>
</table>
### Dimensions for EMR Serverless service quota usage metrics

You can use the following dimensions to refine the usage metrics that EMR Serverless publishes.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service</td>
<td>EMR Serverless</td>
<td>The name of the AWS service that contains the resource.</td>
</tr>
<tr>
<td>Type</td>
<td>Resource</td>
<td>The type of entity that EMR Serverless is reporting.</td>
</tr>
<tr>
<td>Resource</td>
<td>vCPU</td>
<td>The type of resource that EMR Serverless is tracking.</td>
</tr>
<tr>
<td>Class</td>
<td>None</td>
<td>The class of resource that EMR Serverless is tracking.</td>
</tr>
</tbody>
</table>

### 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 two kinds of events:

- Application state change events – Events that emit every state change of an application. For more information about application states, see [Application states (p. 21)](#).
- Job run state change events – Events that emit every state change of a job run. For more information about, see [Job run states (p. 41)](#).

### 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-1:11112223333:/applications/00f1cbsc6anuij25",
    "releaseLabel": "emr-6.6.0",
    "state": "CREATING",
    "type": "HIVE",
    "createdAt": "2022-05-31T21:16:31.547953Z",
    "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": "00f1cbn5g4bbb0c01",
    "applicationId": "00f1982r1uukb925",
    "arn": "arn:aws:emr-serverless:us-east-1:123456789012:/applications/00f1982r1uukb925/jobruns/00f1cbn5g4bbb0c01",
    "releaseLabel": "emr-6.6.0",
    "state": "RUNNING",
    "previousState": "SCHEDULED",
    "createdBy": "arn:aws:sts::123456789012:assumed-role/TestRole-402dcef3ad14993c15d28263f64381e4cda34775/662b2633b6d4f59c25dd2637346242",
    "updatedAt": "2022-05-31T21:07:42.299487Z",
    "createdAt": "2022-05-31T21:07:25.325900Z"
  }
}
```
Tagging resources

You can 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 you how to create tags.

Topics
- What is a tag? (p. 92)
- Tagging your resources (p. 92)
- Tagging limitations (p. 93)
- Working with tags using the AWS CLI and the Amazon EMR Serverless API (p. 93)

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, you can quickly identify a specific resource based on the tags you've assigned to it. For example, you can define a set of tags for your Amazon EMR Serverless applications to help you track each application's owner and stack level. We recommend 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, you can 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, see Policies for tag-based access control (p. 136).

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.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Supports tags</th>
<th>Supports tag propagation</th>
<th>Supports tagging on creation (Amazon EMR Serverless API, AWS CLI, and AWS SDK)</th>
<th>API for creation (tags can be added during creation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>Yes</td>
<td>No. Tags associated with an</td>
<td>Yes</td>
<td>CreateApplication</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Supports tags</th>
<th>Supports tag propagation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add or overwrite one or more tags</td>
<td>tag-resource</td>
<td>TagResource</td>
</tr>
<tr>
<td>List tags for a resource</td>
<td>list-tags-for-resource</td>
<td>ListTagsForResource</td>
</tr>
<tr>
<td>Delete one or more tags</td>
<td>untag-resource</td>
<td>UntagResource</td>
</tr>
</tbody>
</table>
Working with tags

```
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
```
Using Java 17 with Amazon EMR Serverless

With Amazon EMR releases 6.11.0 and higher, you can 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, you can 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.
Using Apache Hudi with EMR Serverless

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
   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, see Metastore configuration [p. 59].

   Important
   EMR Serverless doesn't support HIVEQL or JDBC as sync mode options for Hive tables to handle Hudi workloads. To learn more, see Sync modes.

When you use the AWS Glue Data Catalog as your metastore, you can 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,
Using Apache Iceberg with EMR Serverless

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, see Metastore configuration (p. 59).

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://DOC-EXAMPLE-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.AWSGlueDataCatalogHiveClientFactory
```

When you use the AWS Glue Data Catalog as your metastore, you can 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://DOC-EXAMPLE-BUCKET/EXAMPLE-PREFIX/
--conf spark.hadoop.hive.metastore.client.factory.class=com.amazonaws.glue.catalog.metastore.AWSGlueDataCatalogHiveClientFactory
```

To learn more about Apache Iceberg releases of Amazon EMR, see Iceberg release history.

Using Python libraries with EMR Serverless

When you run PySpark jobs on Amazon EMR Serverless applications, you can package various Python libraries as dependencies. To do this, you can 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, you can use PySpark to upload Python files (.py), zipped Python packages (.zip), and Egg files (.egg) to Spark executors.

```
--conf spark.submit.pyFiles=s3://DOC-EXAMPLE-BUCKET/EXAMPLE-PREFIX/./.egg|.zip file
```
Building a Python virtual environment

To package multiple Python libraries for a PySpark job, you can 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](https://github.com/aws EMR Serverless Samples).

   ```
   # 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://DOC-EXAMPLE-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://DOC-EXAMPLE-BUCKET/EXAMPLE-PREFIX/pyspark_venv.tar.gz
   --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, see [Using Virtualenv](https://docs.aws.amazon.com EMR Serverless User Guide). For more examples of how to submit Spark jobs, see [Spark jobs](https://docs.aws.amazon.com EMR Serverless User Guide#submit 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 show how to package each Python library for a PySpark job.
NumPy (version 1.21.6)

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:

```python
import numpy
```

Pandas (version 1.3.5)

Pandas is a Python library that is built on top of NumPy. The pandas library provides data scientists with DataFrame data structures and data analysis tools. To use pandas, run the following command:

```python
import pandas
```

PyArrow (version 12.0.1)

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:

```python
import pyarrow
```

Using different Python versions with EMR Serverless

In addition to the use case in Using Python libraries with EMR Serverless (p. 97), 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, you must 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**
   
   You must run the following commands in a similar Amazon Linux 2 environment to the one you use for your EMR Serverless applications.

   ```bash
   # 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.

```bash
# note that the archive suffix "environment" is the same as the directory where you
copied the Python binary.
--conf spark.archives=s3://DOC-EXAMPLE-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, see [Using Virtualenv](#). For more examples of how to submit Spark jobs, see [Spark jobs (p. 45)](#).

---

## Using Delta Lake OSS with EMR Serverless

### How to use Delta Lake OSS with 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.

   ```bash
   --conf spark.jars=s3://DOC-EXAMPLE-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.

   ```python
   from pyspark import SparkConf, SparkContext
   from pyspark.sql import HiveContext, SparkSession
   import uuid

   conf = SparkConf()
   sc = SparkContext(conf=conf)
   sqlContext = HiveContext(sc)

   url = "s3://DOC-EXAMPLE-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, see 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, see Spark jobs (p. 45).

```python
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 = "DOC-EXAMPLE-BUCKET"

DEFAULT_MONITORING_CONFIG = {
    "monitoringConfiguration": {
        "s3MonitoringConfiguration": {"logUri": f"s3://{S3_LOGS_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,
    )
```
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, see Getting started with Amazon EMR Serverless (p. 9).

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. Run `mvn package -DskipTests` to create the JAR file that contains your sample UDFs.

2. Once the JAR file is created, upload it to your S3 bucket with the following command.

   ```bash
   aws s3 cp brickhouse-0.7.1-SNAPSHOT.jar s3://DOC-EXAMPLE-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.

   ```sql
   add jar s3://DOC-EXAMPLE-BUCKET/jars/brickhouse-0.7.1-SNAPSHOT.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.
Using custom images with EMR Serverless

Topics
- Use a custom Python version (p. 103)
- Use a custom Java version (p. 104)
- Build a data science image (p. 104)
- Processing geospatial data with Apache Sedona (p. 105)

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
```
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 sudo amazon-linux-extras install java-openjdk11
# EMR Serverless will run 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 will run 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 will run the image as hadoop
USER hadoop:hadoop
```

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, you can 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 (p. 105)
- Authenticating with the Amazon Redshift integration for Apache Spark (p. 106)
- Reading and writing from and to Amazon Redshift (p. 108)
- Considerations and limitations when using the Spark connector (p. 109)

Launching a Spark application with the Amazon Redshift integration for Apache Spark

To use the integration with EMR Serverless 6.9.0, you must pass the required Spark-Redshift dependencies with your Spark job. Use `--jars` to include Redshift connector related libraries. To see other file locations supported by the `--jars` option, see 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 show 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
  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 SQLContext
import boto3

c = # 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, you can 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, you can specify `jdbc:redshift:iam://` scheme. This commands the JDBC driver to use your EMR Serverless job execution role to fetch the credentials automatically. See [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:

<table>
<thead>
<tr>
<th>Permission</th>
<th>Conditions when required for job execution role</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>redshift:GetClusterCredentials</code></td>
<td>Required for JDBC driver to fetch the credentials from Amazon Redshift</td>
</tr>
<tr>
<td><code>redshift:DescribeCluster</code></td>
<td>Required if you specify the Amazon Redshift cluster and AWS Region in the JDBC URL instead of endpoint</td>
</tr>
<tr>
<td><code>redshift-serverless:GetCredentials</code></td>
<td>Required for JDBC driver to fetch the credentials from Amazon Redshift Serverless</td>
</tr>
<tr>
<td><code>redshift-serverless:GetWorkgroup</code></td>
<td>Required if you are using Amazon Redshift Serverless and you are specifying the URL in terms of workgroup name and Region</td>
</tr>
</tbody>
</table>

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, you must configure VPC connectivity for your Amazon EMR Serverless application to access the resources. For more information on how to configure VPC connectivity on an EMR Serverless application, see [Configuring VPC access (p. 36)](#).
• If your provisioned Amazon Redshift cluster or Amazon Redshift Serverless workgroup is publicly accessible, you can 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 (p. 36). 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.

```python
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.

```python
import boto3
```

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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 {tableName} (country string, data string) 
    USING io.github.spark_redshift_community.spark.redshift 
    OPTIONS (dbtable '{tableName}', 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(tableName, overwrite=False)
df = spark.sql(f"SELECT * FROM {tableName}"

df.show()

Considerations and limitations when using the Spark connector

- We recommend that you turn on SSL for the JDBC connection from Spark on Amazon EMR to Amazon Redshift.
- We recommend that you manage the credentials for the Amazon Redshift cluster in AWS Secrets Manager as a best practice. See Using AWS Secrets Manager to retrieve credentials for connecting to Amazon Redshift for an example.
- We recommend 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 recommend that you block public access to the Amazon Redshift cluster.
  - We recommend that you turn on Amazon Redshift audit logging.
  - We recommend that you turn on Amazon Redshift at-rest encryption.
- Consider the following recommendations for Amazon S3:
  - We recommend that you block public access to Amazon S3 buckets.
  - We recommend that you use Amazon S3 server-side encryption to encrypt the Amazon S3 buckets used.
  - We recommend 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 that you can query.

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 DOC-EXAMPLE-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 view the first few lines in the file:

   unzip features.zip
   head features.txt

   The result should look similar to the following.

   1535908|Big Run|Stream|WV|38.6370428|-80.8595469|794
   875609|Constable Hook|Cape|NJ|40.657881|-74.0990349|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|-117.036113|2605
   1181348|Minnow Run|Stream|PA|40.0820178|-79.380349|1558
   1288759|Hunting Creek|Stream|TN|36.343969|-83.8029682|1024
   533060|Big Charles Bayou|Bay|LA|29.6046517|-91.982865|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://DOC-EXAMPLE-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.

```java
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://DOC-EXAMPLE-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.

```java
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.

```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://DOC-EXAMPLE-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.

```sql
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.
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.

```scala
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://DOC-EXAMPLE-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(line(4)),
          "prim_long_dec" -> new AttributeValue().withN(line(5)),
          "elev_in_ft" -> elevInFt
        ).asJava)

        (new Text(""), item)
      })

    rdd.saveAsHadoopDataset(jobConf)
  }
}
```

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, you can 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.

```scala
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.

```scala
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.

```scala
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.

```scala
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.

```scala
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.

```scala
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, see 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/](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, see Creating IAM roles in the 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.

   ```json
   {"Version": "2012-10-17",
   "Statement": [
     {"Effect": "Allow",
      "Action": "dynamodb:*",
      "Resource": "arn:aws:dynamodb:region:AccountB: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",
      "Principal": {"AWS": "arn:aws:iam::AccountA:role/Job-Execution-Role-A"},
      "Condition": {"StringEquals": {"sts:SessionName": "Cross-Account-Role-B"}}
     }
   ]
   }
   ```
Considerations

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, see 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. Thus, the 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, you can 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 can use securely. Third-party auditors regularly test and verify the effectiveness of our security as part of the AWS compliance programs. To learn about the compliance programs that apply to Amazon EMR Serverless, see AWS services in scope by compliance program.
- **Security in the cloud** – Your responsibility is determined by the AWS service that you use. You are also responsible for other factors including the sensitivity of your data, your company’s requirements, and applicable laws and regulations.

This documentation helps you understand how to apply the shared responsibility model when using Amazon EMR Serverless. The topics in this chapter show you how to configure Amazon EMR Serverless and use other AWS services to meet your security and compliance objectives.

Topics
- Data protection (p. 117)
- Identity and Access Management (IAM) in Amazon EMR Serverless (p. 120)
- Security best practices for Amazon EMR Serverless (p. 142)
- Logging Amazon EMR Serverless API calls using AWS CloudTrail (p. 142)
- Secrets Manager for data protection with EMR Serverless (p. 144)
- Compliance validation for Amazon EMR Serverless (p. 148)
- Resilience in Amazon EMR Serverless (p. 149)
- Infrastructure security in Amazon EMR Serverless (p. 149)
- Configuration and vulnerability analysis in Amazon EMR Serverless (p. 149)

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, see the Data Privacy FAQ. For information about data protection in Europe, see the AWS Shared Responsibility Model and GDPR blog post on the AWS Security Blog.

For data protection purposes, we recommend 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 recommend 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, see Federal Information Processing Standard (FIPS) 140-2.

We strongly recommend 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, see 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, you can 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, see 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, see AWS KMS pricing.

**Amazon S3 server-side encryption**

When you set up Amazon S3 server-side encryption, 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, see 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 encryption for everything that you write to Amazon S3, or you can enable encryption for data that you write to a specific bucket. For more information about the `StartJobRun` API, see 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.<DOC-EXAMPLE-BUCKET>.enableServerSideEncryption=true
--conf spark.hadoop.fs.s3.bucket.<DOC-EXAMPLE-BUCKET>.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, see [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, see [Rotating customer master 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.
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**

- Audience (p. 120)
- Authenticating with identities (p. 121)
- Managing access using policies (p. 123)
- How EMR Serverless works with IAM (p. 124)
- Using service-linked roles for EMR Serverless (p. 129)
- Job runtime roles for Amazon EMR Serverless (p. 132)
- User access policy examples for EMR Serverless (p. 134)
- Policies for tag-based access control (p. 136)
- Identity-based policy examples for EMR Serverless (p. 138)
- Amazon EMR Serverless updates to AWS managed policies (p. 140)
- Troubleshooting Amazon EMR Serverless identity and access (p. 140)

**Audience**

How you use AWS Identity and Access Management (IAM) differs, depending on the work that you do in Amazon EMR Serverless.

**Service user** – If you use the Amazon EMR Serverless service to do your job, then your administrator provides you with the credentials and permissions that you need. As you use more Amazon EMR Serverless features to do your work, you might need additional permissions. Understanding how access is managed can help you request the right permissions from your administrator. If you cannot access a feature in Amazon EMR Serverless, see Troubleshooting Amazon EMR Serverless identity and access (p. 140).

**Service administrator** – If you're in charge of Amazon EMR Serverless resources at your company, you probably have full access to Amazon EMR Serverless. It's your job to determine which Amazon EMR Serverless features and resources your service users should access. You must then submit requests to your IAM administrator to change the permissions of your service users. Review the information on this page to understand the basic concepts of IAM. To learn more about how your company can use IAM with Amazon EMR Serverless, see Identity and Access Management (IAM) in Amazon EMR Serverless (p. 120).

**IAM administrator** – If you're an IAM administrator, you might want to learn details about how you can write policies to manage access to Amazon EMR Serverless. To view example Amazon EMR Serverless policies,
Serverless identity-based policies that you can use in IAM, see Sample identity-based policies for EMR Serverless (p. 125).

**Authenticating with identities**

Authentication is how you sign in to AWS using your identity credentials. You must be authenticated (signed in to AWS) as the AWS account root user, as an IAM user, or by assuming an IAM role.

You can sign in to AWS as a federated identity by using credentials provided through an identity source. AWS IAM Identity Center (IAM Identity Center) users, your company's single sign-on authentication, and your Google or Facebook credentials are examples of federated identities. When you sign in as a federated identity, your administrator previously set up identity federation using IAM roles. When you access AWS by using federation, you are indirectly assuming a role.

Depending on the type of user you are, you can sign in to the AWS Management Console or the AWS access portal. For more information about signing in to AWS, see How to sign in to your AWS account in the AWS Sign-In User Guide.

If you access AWS programmatically, AWS provides a software development kit (SDK) and a command line interface (CLI) to cryptographically sign your requests by using your credentials. If you don't use AWS tools, you must sign requests yourself. For more information about using the recommended method to sign requests yourself, see Signing AWS API requests in the IAM User Guide.

Regardless of the authentication method that you use, you might be required to provide additional security information. For example, AWS recommends that you use multi-factor authentication (MFA) to increase the security of your account. To learn more, see Multi-factor authentication in the AWS IAM Identity Center User Guide and Using multi-factor authentication (MFA) in AWS in the IAM User Guide.

**AWS account root user**

When you create an AWS account, you begin with one sign-in identity that has complete access to all AWS services and resources in the account. This identity is called the AWS account root user and is accessed by signing in with the email address and password that you used to create the account. We strongly recommend that you don't use the root user for your everyday tasks. Safeguard your root user credentials and use them to perform the tasks that only the root user can perform. For the complete list of tasks that require you to sign in as the root user, see Tasks that require root user credentials in the IAM User Guide.

**Federated identity**

As a best practice, require human users, including users that require administrator access, to use federation with an identity provider to access AWS services by using temporary credentials.

A federated identity is a user from your enterprise user directory, a web identity provider, the AWS Directory Service, the Identity Center directory, or any user that accesses AWS services by using credentials provided through an identity source. When federated identities access AWS accounts, they assume roles, and the roles provide temporary credentials.

For centralized access management, we recommend that you use AWS IAM Identity Center. You can create users and groups in IAM Identity Center, or you can connect and synchronize to a set of users and groups in your own identity source for use across all your AWS accounts and applications. For information about IAM Identity Center, see What is IAM Identity Center? in the AWS IAM Identity Center User Guide.

**IAM users and groups**

An IAM user is an identity within your AWS account that has specific permissions for a single person or application. Where possible, we recommend relying on temporary credentials instead of creating IAM
users who have long-term credentials such as passwords and access keys. However, if you have specific use cases that require long-term credentials with IAM users, we recommend that you rotate access keys. For more information, see \textit{Rotate access keys regularly for use cases that require long-term credentials} in the \textit{IAM User Guide}.

An \textit{IAM group} is an identity that specifies a collection of IAM users. You can't sign in as a group. You can use groups to specify permissions for multiple users at a time. Groups make permissions easier to manage for large sets of users. For example, you could have a group named \textit{IAMAdmins} and give that group permissions to administer IAM resources.

Users are different from roles. A user is uniquely associated with one person or application, but a role is intended to be assumable by anyone who needs it. Users have permanent long-term credentials, but roles provide temporary credentials. To learn more, see \textit{When to create an IAM user (instead of a role)} in the \textit{IAM User Guide}.

\section*{IAM roles}

An \textit{IAM role} is an identity within your AWS account that has specific permissions. It is similar to an IAM user, but is not associated with a specific person. You can temporarily assume an IAM role in the AWS Management Console by \textit{switching roles}. You can assume a role by calling an AWS CLI or AWS API operation or by using a custom URL. For more information about methods for using roles, see \textit{Using IAM roles} in the \textit{IAM User Guide}.

IAM roles with temporary credentials are useful in the following situations:

\begin{itemize}
\item **Federated user access** – To assign permissions to a federated identity, you create a role and define permissions for the role. When a federated identity authenticates, the identity is associated with the role and is granted the permissions that are defined by the role. For information about roles for federation, see \textit{Creating a role for a third-party Identity Provider} in the \textit{IAM User Guide}. If you use IAM Identity Center, you configure a permission set. To control what your identities can access after they authenticate, IAM Identity Center correlates the permission set to a role in IAM. For information about permissions sets, see \textit{Permission sets} in the \textit{AWS IAM Identity Center User Guide}.

\item **Temporary IAM user permissions** – An IAM user or role can assume an IAM role to temporarily take on different permissions for a specific task.

\item **Cross-account access** – You can use an IAM role to allow someone (a trusted principal) in a different account to access resources in your account. Roles are the primary way to grant cross-account access. However, with some AWS services, you can attach a policy directly to a resource (instead of using a role as a proxy). To learn the difference between roles and resource-based policies for cross-account access, see \textit{How IAM roles differ from resource-based policies} in the \textit{IAM User Guide}.

\item **Cross-service access** – Some AWS services use features in other AWS services. For example, when you make a call in a service, it's common for that service to run applications in Amazon EC2 or store objects in Amazon S3. A service might do this using the calling principal's permissions, using a service role, or using a service-linked role.

\item **Principal permissions** – When you use an IAM user or role to perform actions in AWS, you are considered a principal. Policies grant permissions to a principal. When you use some services, you might perform an action that then triggers another action in a different service. In this case, you must have permissions to perform both actions. To see whether an action requires additional dependent actions in a policy, see \textit{Actions, resources, and condition keys for Amazon EMR Serverless} in the \textit{Service Authorization Reference}.

\item **Service role** – A service role is an \textit{IAM role} that a service assumes to perform actions on your behalf. An IAM administrator can create, modify, and delete a service role from within IAM. For more information, see \textit{Creating a role to delegate permissions to an AWS service} in the \textit{IAM User Guide}.

\item **Service-linked role** – A service-linked role is a type of service role that is linked to an AWS service. The service can assume the role to perform an action on your behalf. Service-linked roles appear in your AWS account and are owned by the service. An IAM administrator can view, but not edit the permissions for service-linked roles.
\end{itemize}
Managing access using policies

You control access in AWS by creating policies and attaching them to AWS identities or resources. A policy is an object in AWS that, when associated with an identity or resource, defines their permissions. AWS evaluates these policies when a principal (user, root user, or role session) makes a request. Permissions in the policies determine whether the request is allowed or denied. Most policies are stored in AWS as JSON documents. For more information about the structure and contents of JSON policy documents, see Overview of JSON policies in the IAM User Guide.

Administrators can use AWS JSON policies to specify who has access to what. That is, which principal can perform actions on what resources, and under what conditions.

By default, users and roles have no permissions. To grant users permission to perform actions on the resources that they need, an IAM administrator can create IAM policies. The administrator can then add the IAM policies to roles, and users can assume the roles.

IAM policies define permissions for an action regardless of the method that you use to perform the operation. For example, suppose that you have a policy that allows the iam:GetRole action. A user with that policy can get role information from the AWS Management Console, the AWS CLI, or the AWS API.

Identity-based policies

Identity-based policies are JSON permissions policy documents that you can attach to an identity, such as an IAM user, group of users, or role. These policies control what actions users and roles can perform, on which resources, and under what conditions. To learn how to create an identity-based policy, see Creating IAM policies in the IAM User Guide.

Identity-based policies can be further categorized as inline policies or managed policies. Inline policies are embedded directly into a single user, group, or role. Managed policies are standalone policies that you can attach to multiple users, groups, and roles in your AWS account. Managed policies include AWS managed policies and customer managed policies. To learn how to choose between a managed policy or an inline policy, see Choosing between managed policies and inline policies in the IAM User Guide.

Resource-based policies

Resource-based policies are JSON policy documents that you attach to a resource. Examples of resource-based policies are IAM role trust policies and Amazon S3 bucket policies. In services that support resource-based policies, service administrators can use them to control access to a specific resource. For the resource where the policy is attached, the policy defines what actions a specified principal can perform on that resource and under what conditions. You must specify a principal in a resource-based policy. Principals can include accounts, users, roles, federated users, or AWS services.

Resource-based policies are inline policies that are located in that service. You can't use AWS managed policies from IAM in a resource-based policy.
Access control lists (ACLs)

Access control lists (ACLs) control which principals (account members, users, or roles) have permissions to access a resource. ACLs are similar to resource-based policies, although they do not use the JSON policy document format.

Amazon S3, AWS WAF, and Amazon VPC are examples of services that support ACLs. To learn more about ACLs, see Access control list (ACL) overview in the Amazon Simple Storage Service Developer Guide.

Other policy types

AWS supports additional, less-common policy types. These policy types can set the maximum permissions granted to you by the more common policy types.

- **Permissions boundaries** – A permissions boundary is an advanced feature in which you set the maximum permissions that an identity-based policy can grant to an IAM entity (IAM user or role). You can set a permissions boundary for an entity. The resulting permissions are the intersection of an entity’s identity-based policies and its permissions boundaries. Resource-based policies that specify the user or role in the Principal field are not limited by the permissions boundary. An explicit deny in any of these policies overrides the allow. For more information about permissions boundaries, see Permissions boundaries for IAM entities in the IAM User Guide.

- **Service control policies (SCPs)** – SCPs are JSON policies that specify the maximum permissions for an organization or organizational unit (OU) in AWS Organizations. AWS Organizations is a service for grouping and centrally managing multiple AWS accounts that your business owns. If you enable all features in an organization, then you can apply service control policies (SCPs) to any or all of your accounts. The SCP limits permissions for entities in member accounts, including each AWS account root user. For more information about Organizations and SCPs, see How SCPs work in the AWS Organizations User Guide.

- **Session policies** – Session policies are advanced policies that you pass as a parameter when you programmatically create a temporary session for a role or federated user. The resulting session’s permissions are the intersection of the user or role’s identity-based policies and the session policies. Permissions can also come from a resource-based policy. An explicit deny in any of these policies overrides the allow. For more information, see Session policies in the IAM User Guide.

Multiple policy types

When multiple types of policies apply to a request, the resulting permissions are more complicated to understand. To learn how AWS determines whether to allow a request when multiple policy types are involved, see Policy evaluation logic in the IAM User Guide.

How 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 you can use with EMR Serverless

<table>
<thead>
<tr>
<th>IAM feature</th>
<th>Amazon EMR Serverless support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identity-based policies (p. 125)</td>
<td>Yes</td>
</tr>
<tr>
<td>Resource-based policies (p. 125)</td>
<td>No</td>
</tr>
<tr>
<td>Policy actions (p. 126)</td>
<td>Yes</td>
</tr>
<tr>
<td>Policy resources (p. 126)</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Identity-based policies for EMR Serverless

<table>
<thead>
<tr>
<th>IAM feature</th>
<th>Amazon EMR Serverless support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy condition keys (p. 127)</td>
<td>No</td>
</tr>
<tr>
<td>ACLs (p. 127)</td>
<td>No</td>
</tr>
<tr>
<td>ABAC (tags in policies) (p. 127)</td>
<td>Yes</td>
</tr>
<tr>
<td>Temporary credentials (p. 128)</td>
<td>Yes</td>
</tr>
<tr>
<td>Principal permissions (p. 128)</td>
<td>Yes</td>
</tr>
<tr>
<td>Service roles (p. 128)</td>
<td>No</td>
</tr>
<tr>
<td>Service-linked roles (p. 128)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

To get a high-level view of how EMR Serverless and other AWS services work with most IAM features, see AWS services that work with IAM in the IAM User Guide.

Identity-based policies for 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 Creating IAM policies in the IAM User Guide.

With IAM identity-based policies, you can specify allowed or denied actions and resources as well as the conditions under which actions are allowed or denied. You can’t specify the principal in an identity-based policy because it applies to the user or role to which it is attached. To learn about all of the elements that you can use in a JSON policy, see IAM JSON policy elements reference in the IAM User Guide.

Sample identity-based policies for EMR Serverless

To view examples of Amazon EMR Serverless identity-based policies, see Identity-based policy examples for EMR Serverless (p. 138).

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. Adding a cross-account principal to a resource-based policy is only half of establishing the trust relationship. When the principal and the resource are in different AWS accounts, an IAM administrator in the trusted account must also grant the principal entity (user or role) permission to access the resource. They grant permission by attaching an identity-based policy to the
entity. However, if a resource-based policy grants access to a principal in the same account, no additional identity-based policy is required. For more information, see How IAM roles differ from resource-based policies in the IAM User Guide.

**Policy actions for EMR Serverless**

<table>
<thead>
<tr>
<th>Supports policy actions</th>
<th>Yes</th>
</tr>
</thead>
</table>

Administrators can use AWS JSON policies to specify who has access to what. That is, which principal can perform actions on what resources, and under what conditions.

The Action element of a JSON policy describes the actions that you can use to allow or deny access in a policy. Policy actions usually have the same name as the associated AWS API operation. There are some exceptions, such as permission-only actions that don't have a matching API operation. There are also some operations that require multiple actions in a policy. These additional actions are called dependent actions.

Include actions in a policy to grant permissions to perform the associated operation.

To see a list of EMR Serverless actions, see 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 view examples of Amazon EMR Serverless identity-based policies, see Identity-based policy examples for EMR Serverless (p. 138).

**Policy resources for EMR Serverless**

<table>
<thead>
<tr>
<th>Supports policy resources</th>
<th>Yes</th>
</tr>
</thead>
</table>

Administrators can use AWS JSON policies to specify who has access to what. That is, which principal can perform actions on what resources, and under what conditions.

The Resource JSON policy element specifies the object or objects to which the action applies. Statements must include either a Resource or a NotResource element. As a best practice, specify a resource using its Amazon Resource Name (ARN). You can do this for actions that support a specific resource type, known as resource-level permissions.

For actions that don't support resource-level permissions, such as listing operations, use a wildcard (*) to indicate that the statement applies to all resources.

```
"Resource": "***"
```
To see 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 you can specify the ARN of each resource, see Actions, resources, and condition keys for Amazon EMR Serverless.

To view examples of Amazon EMR Serverless identity-based policies, see Identity-based policy examples for EMR Serverless (p. 138).

Policy condition keys for EMR Serverless

<table>
<thead>
<tr>
<th>Supports service-specific policy condition keys</th>
<th>No</th>
</tr>
</thead>
</table>

Administrators can use AWS JSON policies to specify who has access to what. That is, which principal can perform actions on what resources, and under what conditions.

The Condition element (or Condition block) lets you specify conditions in which a statement is in effect. The Condition element is optional. You can create conditional expressions that use condition operators, such as equals or less than, to match the condition in the policy with values in the request.

If you specify multiple Condition elements in a statement, or multiple keys in a single Condition element, AWS evaluates them using a logical AND operation. If you specify multiple values for a single condition key, AWS evaluates the condition using a logical OR operation. All of the conditions must be met before the statement's permissions are granted.

You can also use placeholder variables when you specify conditions. For example, you can grant an IAM user permission to access a resource only if it is tagged with their IAM user name. For more information, see IAM policy elements: variables and tags in the IAM User Guide.

AWS supports global condition keys and service-specific condition keys. To see all AWS global condition keys, see AWS global condition context keys in the IAM User Guide.

To see a list of Amazon EMR Serverless condition keys and to learn which actions and resources you can use a condition key, see 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, see Example: Restricting access to a specific region.

Access control lists (ACLs) in EMR Serverless

<table>
<thead>
<tr>
<th>Supports ACLs</th>
<th>No</th>
</tr>
</thead>
</table>

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

<table>
<thead>
<tr>
<th>Supports ABAC (tags in policies)</th>
<th>Yes</th>
</tr>
</thead>
</table>

Attribute-based access control (ABAC) is an authorization strategy that defines permissions based on attributes. In AWS, these attributes are called tags. You can attach tags to IAM entities (users or roles) and to many AWS resources. Tagging entities and resources is the first step of ABAC. Then you design
ABAC policies to allow operations when the principal's tag matches the tag on the resource that they are trying to access.

ABAC is helpful in environments that are growing rapidly and helps with situations where policy management becomes cumbersome.

To control access based on tags, you provide tag information in the condition element of a policy using the `aws:ResourceTag/key-name`, `aws:RequestTag/key-name`, or `aws:TagKeys` condition keys.

If a service supports all three condition keys for every resource type, then the value is Yes for the service. If a service supports all three condition keys for only some resource types, then the value is Partial.

For more information about ABAC, see What is ABAC? in the IAM User Guide. To view a tutorial with steps for setting up ABAC, see Use attribute-based access control (ABAC) in the IAM User Guide.

**Using Temporary credentials with EMR Serverless**

<table>
<thead>
<tr>
<th>Supports temporary credentials</th>
<th>Yes</th>
</tr>
</thead>
</table>

Some AWS services don't work when you sign in using temporary credentials. For additional information, including which AWS services work with temporary credentials, see AWS services that work with IAM in the IAM User Guide.

You are using temporary credentials if you sign in to the AWS Management Console using any method except a user name and password. For example, when you access AWS using your company's single sign-on (SSO) link, that process automatically creates temporary credentials. You also automatically create temporary credentials when you sign in to the console as a user and then switch roles. For more information about switching roles, see Switching to a role (console) in the IAM User Guide.

You can manually create temporary credentials using the AWS CLI or AWS API. You can then use those temporary credentials to access AWS. AWS recommends that you dynamically generate temporary credentials instead of using long-term access keys. For more information, see Temporary security credentials in IAM.

**Cross-service principal permissions for EMR Serverless**

<table>
<thead>
<tr>
<th>Supports principal permissions</th>
<th>Yes</th>
</tr>
</thead>
</table>

When you use an IAM user or role to perform actions in AWS, you are considered a principal. Policies grant permissions to a principal. When you use some services, you might perform an action that then triggers another action in a different service. In this case, you must have permissions to perform both actions. To see whether an action requires additional dependent actions in a policy, see Actions, resources, and condition keys for Amazon EMR Serverless in the Service Authorization Reference.

**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, see AWS services that work with IAM. Find a service in the table that includes a Yes in the Service-linked role column. Choose the Yes link to view the service-linked role documentation for that service.

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, see AWS Services That Work with IAM and look for the services that have Yes in the Service-linked roles column. Choose a Yes with a link to view 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
{
```
Using service-linked roles

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",
      "Principal": { "Service": [ "ops.emr-serverless.amazonaws.com" ] },
      "Action": [ "sts:AssumeRole" ]
   }]
}
```

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, see 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.

```json
{
    "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, you can 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, see [Creating a service-linked role](#) in the IAM User Guide. If you delete this service-linked role, you can 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.

```json
{
    "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, see [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 recommend that you delete that role. This is so you don't have an unused entity that is not actively monitored or maintained. However, you must delete all EMR Serverless applications in all Regions before you can 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 EMR Serverless 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.

```json
{
   "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, see 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, see 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, see Create a job runtime role (p. 9).

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": [
```
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, see [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.

```json
{
  "Effect": "Allow",
  "Action": "iam:PassRole",
  "Resource": "arn:aws:iam::1234567890:role/JobRuntimeRoleForEMRServerless",
  "Condition": {
    "StringLike": {
      "iam:PassedToService": "emr-serverless.amazonaws.com"
    }
  }
}
```
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 right permissions for your users. This section focuses only on EMR Serverless policies. For samples of EMR Studio user policies, see Configure EMR Studio user permissions. For information about how to attach policies to IAM users (principals), see 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": "*"
    }
  ]
}
```
User access policies

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.

```
```

**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, see [Using service-linked roles for EMR Serverless](p. 129).

The following IAM policy permits you to create a EMR Serverless service-linked role for your account.

```
```

**Data engineer policy**

This following is a sample policy that allows users read-only permissions on EMR Serverless applications, as well as the 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.

```
```
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, see 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, see Deny access to add and remove tags (p. 138).
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": {
                    "emr-serverless:ResourceTag/department": "dev"
                }
            }
        }
    ]
}
```

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`, you could replace the condition block in the earlier example with the following.

```json
"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": {
                    "emr-serverless:RequestTag/department": "dev"
                }
            }
        }
    ]
}
```
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": {
            "Null": {
               "emr-serverless:RequestTag/department": "false"
            }
         }
      }
   ]
}
```

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": {
               "emr-serverless:ResourceTag/department": "dev"
            }
         }
      }
   ]
}
```

Identity-based policy examples for EMR Serverless

By default, users and roles don't have permission to create or modify Amazon EMR Serverless resources. They also can't perform tasks by using the AWS Management Console, AWS Command Line Interface (AWS CLI), or AWS API. To grant users permission to perform actions on the resources that they need, an IAM administrator can create IAM policies. The administrator can then add the IAM policies to roles, and users can assume the roles.

To learn how to create an IAM identity-based policy by using these example JSON policy documents, see Creating IAM policies in the IAM User Guide.

For details about actions and resource types defined by 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.
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:

- **Policy best practices**
  - 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 AWS 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 IAM Access Analyzer policy validation in the IAM User Guide.
  - Require multi-factor authentication (MFA) – If you have a scenario that requires IAM users or a root user in your AWS account, turn on MFA for additional security. To require MFA when API operations are called, add MFA conditions to your policies. For more information, see Configuring MFA-protected API access in the IAM User Guide.

For more information about best practices in IAM, see Security best practices in IAM in the IAM User Guide.

### Allow users to view their own permissions

This example shows how you might create a policy that allows IAM users to view the inline and managed policies that are attached to their user identity. This policy includes permissions to complete this action on the console or programmatically using the AWS CLI or AWS API.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "ViewOwnUserInfo",
            "Effect": "Allow",
```
Amazon EMR Serverless updates to AWS managed policies

View 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.

<table>
<thead>
<tr>
<th>Change</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>AmazonEMRServerlessServiceRolePolicy – Update to an existing policy</td>
<td>Amazon EMR Serverless added new permissions to allow Amazon EMR Serverless to publish aggregated account metrics for vCPU usage in the “AWS/Usage” namespace.</td>
<td>April 20, 2023</td>
</tr>
<tr>
<td>Amazon EMR Serverless started tracking changes</td>
<td>Amazon EMR Serverless started tracking changes for its AWS managed policies.</td>
<td>April 20, 2023</td>
</tr>
</tbody>
</table>

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 (p. 141)
- I am not authorized to perform iam:PassRole (p. 141)
- I want to allow people outside of my AWS account to access my Amazon EMR Serverless resources (p. 141)

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 you must 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 view 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:
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 recommend 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 applications.

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, you can 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 view the most recent events in the CloudTrail console in **Event history**. Using the information collected by CloudTrail, you can determine the request that was made to 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 about CloudTrail, see 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 view, search, and download recent events in your AWS account. For more information, see Viewing events with CloudTrail Event history.

For an ongoing record of events in your AWS account, including events for 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, you can configure other AWS services to further analyze and act upon the event data collected in CloudTrail logs. For more information, see the following:

- 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, see 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 don't appear in any specific order.

The following example shows a CloudTrail log entry that demonstrates the CreateApplication action.

```json
{
    "eventVersion": "1.08",
    "userIdentity": {
        "type": "AssumedRole",
        "principalId": "AIDACKCEVSQ6C2EXAMPLE:admin",
        "arn": "arn:aws:sts::012345678910:assumed-role/Admin/admin",
        "accountId": "012345678910",
        "accessKeyId": "AKIAIOSFODNN7EXAMPLE",
        "sessionContext": {
```
Secrets Manager for data protection with EMR Serverless

AWS Secrets Manager is a secret storage service that you can use to protect database credentials, API keys, and other secret information. Then in your code, you can 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, see the [AWS Secrets Manager User Guide](https://docs.aws.amazon.com/secretsmanager/latest/userguide/).

Secrets Manager encrypts secrets using AWS Key Management Service keys. For more information, see [Secret encryption and decryption](https://docs.aws.amazon.com/secretsmanager/latest/userguide/). In the [AWS Secrets Manager User Guide](https://docs.aws.amazon.com/secretsmanager/latest/userguide/).

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, see [Rotate AWS Secrets Manager secrets](https://docs.aws.amazon.com/secretsmanager/latest/userguide/) in the [AWS Secrets Manager User Guide](https://docs.aws.amazon.com/secretsmanager/latest/userguide/).

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 show how to provide a secret in a configuration classification at `StartJobRun`. If you want to configure classifications for Secrets Manager at the application level, see Default application configuration for EMR Serverless (p. 27).

In the examples, replace `SecretName` with the name of the secret to retrieve. Include the hyphen, followed by the six characters that Secrets Manager adds to the end of the secret ARN. For more information, see How to create a secret (p. 145).

In this section

- Specify secret references - Spark (p. 145)
- Specify secret references - Hive (p. 146)

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://DOC-EXAMPLE-BUCKET/scripts/spark-jdbc.py",
      "sparkSubmitParameters": "--jars s3://DOC-EXAMPLE-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 '{
```
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://DOC-EXAMPLE-BUCKET/emr-serverless-hive/query/hive-query.ql",
      "parameters": "--hiveconf hive.exec.scratchdir=s3://DOC-EXAMPLE-BUCKET/emr-serverless-hive/hive/scratch
                    --hiveconf hive.metastore.warehouse.dir=s3://DOC-EXAMPLE-BUCKET/emr-serverless-hive/hive/warehouse
                    --hiveconf java.io.option.ConnectionUser=EMR.secret@SecretName
                    --hiveconf java.io.option.ConnectionPassword=EMR.secret@SecretName
                    --hiveconf hive.metastore.client.factory.class=org.apache.hadoop.hive.ql.metadata.SessionHiveMetaStoreClientFactory
                    --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://EXAMPLE-LOG-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",
    "hive.metastore.warehouse.dir": s3://DOC-EXAMPLE-BUCKET/emr-serverless-hive/warehouse
  }
}
```
Grant access to the secret

"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, see 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.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "secretsmanager:GetSecretValue",
                "secretsmanager:DescribeSecret"
            ],
            "Principal": {
                "Service": ["emr-serverless.amazonaws.com"
            ]
        },
        "Resource": ["*"],
        "Condition": {
            "StringEquals": {
                "aws:SourceArn": "arn:aws:emr-serverless:AWS Region:aws_account_id:/applications/applicationId"
            }
        }
    ]
}
```

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"
    ]
}
```
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.

Compliance validation for Amazon EMR Serverless

Third-party auditors assess the security and compliance of Amazon EMR Serverless as part of multiple AWS compliance programs. These include SOC, PCI, FedRAMP, HIPAA, and others.

To learn whether an AWS service is within the scope of specific compliance programs, see AWS services in Scope by Compliance Program and choose the compliance program that you are interested in. For general information, see AWS Compliance Programs.

You can download third-party audit reports using AWS Artifact. For more information, see Downloading Reports in AWS Artifact.

Your compliance responsibility when using AWS services is determined by the sensitivity of your data, your company's compliance objectives, and applicable laws and regulations. AWS provides the following resources to help with compliance:

- Security and Compliance Quick Start Guides – These deployment guides discuss architectural considerations and provide steps for deploying baseline environments on AWS that are security and compliance focused.
- Architecting for HIPAA Security and Compliance on Amazon Web Services – This whitepaper describes how companies can use AWS to create HIPAA-eligible applications.

Note
Not all AWS services are HIPAA eligible. For more information, see the HIPAA Eligible Services Reference.

- AWS Compliance Resources – This collection of workbooks and guides might apply to your industry and location.
- Evaluating Resources with Rules in the AWS Config Developer Guide – The AWS Config service assesses how well your resource configurations comply with internal practices, industry guidelines, and regulations.
Resilience

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, you can 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, see 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 Serverless is protected by the AWS global network security procedures that are described in the Amazon Web Services: Overview of Security Processes whitepaper.

You use AWS published API calls to access Amazon EMR Serverless through the network. Clients must support Transport Layer Security (TLS) 1.0 or later. We recommend TLS 1.2 or later. Clients must also support cipher suites with perfect forward secrecy (PFS) such as Ephemeral Diffie-Hellman (DHE) or Elliptic Curve Ephemeral Diffie-Hellman (ECDHE). Most modern systems such as Java 7 and later support these modes.

Additionally, requests must be signed by using an access key ID and a secret access key that is associated with an IAM principal. Or you can use the AWS Security Token Service (AWS STS) to generate temporary security credentials to sign requests.

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, see the following resources:

- Compliance validation for Amazon EMR Serverless (p. 148)
- Shared Responsibility Model
- Amazon Web Services: Overview of Security Processes (whitepaper)
## 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, see [AWS service endpoints](https://docs.aws.amazon.com/general/latest/gr/service-quotas.html).

<table>
<thead>
<tr>
<th>Region name</th>
<th>Region</th>
<th>Endpoint</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia Pacific (Mumbai)</td>
<td>ap-south-1</td>
<td>emr-serverless.ap-south-1.amazonaws.com</td>
<td>HTTPS</td>
</tr>
<tr>
<td>Asia Pacific (Hong Kong)</td>
<td>ap-east-1</td>
<td>emr-serverless.ap-east-1.amazonaws.com</td>
<td>HTTPS</td>
</tr>
<tr>
<td>Asia Pacific (Seoul)</td>
<td>ap-northeast-2</td>
<td>emr-serverless.ap-northeast-2.amazonaws.com</td>
<td>HTTPS</td>
</tr>
<tr>
<td>Asia Pacific (Singapore)</td>
<td>ap-southeast-1</td>
<td>emr-serverless.ap-southeast-1.amazonaws.com</td>
<td>HTTPS</td>
</tr>
<tr>
<td>Asia Pacific (Sydney)</td>
<td>ap-southeast-2</td>
<td>emr-serverless.ap-southeast-2.amazonaws.com</td>
<td>HTTPS</td>
</tr>
<tr>
<td>Asia Pacific (Tokyo)</td>
<td>ap-northeast-1</td>
<td>emr-serverless.ap-northeast-1.amazonaws.com</td>
<td>HTTPS</td>
</tr>
<tr>
<td>Canada (Central)</td>
<td>ca-central-1 (limited to the following Availability Zones: cac1-az1 and cac1-az2)</td>
<td>emr-serverless.ca-central-1.amazonaws.com</td>
<td>HTTPS</td>
</tr>
<tr>
<td>Europe (Frankfurt)</td>
<td>eu-central-1</td>
<td>emr-serverless.eu-central-1.amazonaws.com</td>
<td>HTTPS</td>
</tr>
<tr>
<td>Europe (Ireland)</td>
<td>eu-west-1</td>
<td>emr-serverless.eu-west-1.amazonaws.com</td>
<td>HTTPS</td>
</tr>
<tr>
<td>Europe (London)</td>
<td>eu-west-2</td>
<td>emr-serverless.eu-west-2.amazonaws.com</td>
<td>HTTPS</td>
</tr>
<tr>
<td>Europe (Paris)</td>
<td>eu-west-3</td>
<td>emr-serverless.eu-west-3.amazonaws.com</td>
<td>HTTPS</td>
</tr>
<tr>
<td>Europe (Stockholm)</td>
<td>eu-north-1</td>
<td>emr-serverless.eu-north-1.amazonaws.com</td>
<td>HTTPS</td>
</tr>
</tbody>
</table>
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 might 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, see [AWS service quotas](#).

<table>
<thead>
<tr>
<th>Name</th>
<th>Default limit</th>
<th>Adjustable?</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max concurrent vCPUs per account</td>
<td>16</td>
<td>Yes</td>
<td>The maximum number of vCPUs that can concurrently run for the account in the current AWS Region.</td>
</tr>
</tbody>
</table>
Other considerations

The following list contains other considerations with EMR Serverless.

- EMR Serverless is available in the following AWS Regions: Asia Pacific (Mumbai), Asia Pacific (Seoul), Asia Pacific (Singapore), Asia Pacific (Sydney), Asia Pacific (Tokyo), Canada (Central), Europe (Frankfurt), Europe (Ireland), Europe (London), Europe (Paris), Europe (Stockholm), South America (São Paulo), US East (N. Virginia), US East (Ohio), US West (N. California), and US West (Oregon). For a list of endpoints associated with these Regions, see Service endpoints (p. 150).

- 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, you can 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, 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, you can create your application with a VPC.

- EMR Serverless doesn't support HDFS. The local disks on workers are temporal storage that EMR Serverless uses to shuffle and process data during job runs.

- EMR Serverless doesn't support the existing emr-dynamodb-connector.
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.

Starting with Amazon EMR version 6.6.0, you can deploy EMR Serverless. This deployment option isn’t available with earlier Amazon EMR release versions. When you submit your job, you must specify a supported release version.

Topics

- EMR Serverless 6.14.0 (p. 153)
- EMR Serverless 6.13.0 (p. 153)
- EMR Serverless 6.12.0 (p. 154)
- EMR Serverless 6.11.0 (p. 154)
- EMR Serverless 6.10.0 (p. 154)
- EMR Serverless 6.9.0 (p. 155)
- EMR Serverless 6.8.0 (p. 155)
- EMR Serverless 6.7.0 (p. 156)
- EMR Serverless 6.6.0 (p. 156)

EMR Serverless 6.14.0

The following table lists the application versions available with EMR Serverless 6.14.0.

<table>
<thead>
<tr>
<th>Application</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache Spark</td>
<td>3.4.1</td>
</tr>
<tr>
<td>Apache Hive</td>
<td>3.1.3</td>
</tr>
<tr>
<td>Apache Tez</td>
<td>0.10.2</td>
</tr>
</tbody>
</table>

EMR Serverless 6.13.0

The following table lists the application versions available with EMR Serverless 6.13.0.

<table>
<thead>
<tr>
<th>Application</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache Spark</td>
<td>3.4.1</td>
</tr>
</tbody>
</table>
### EMR Serverless 6.12.0

The following table lists the application versions available with EMR Serverless 6.12.0.

<table>
<thead>
<tr>
<th>Application</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache Spark</td>
<td>3.4.0</td>
</tr>
<tr>
<td>Apache Hive</td>
<td>3.1.3</td>
</tr>
<tr>
<td>Apache Tez</td>
<td>0.10.2</td>
</tr>
</tbody>
</table>

### EMR Serverless 6.11.0

The following table lists the application versions available with EMR Serverless 6.11.0.

<table>
<thead>
<tr>
<th>Application</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache Spark</td>
<td>3.3.2</td>
</tr>
<tr>
<td>Apache Hive</td>
<td>3.1.3</td>
</tr>
<tr>
<td>Apache Tez</td>
<td>0.10.2</td>
</tr>
</tbody>
</table>

**EMR Serverless 6.11.0 release notes**

- [Access S3 resources in other accounts (p. 70)](#) - 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.

<table>
<thead>
<tr>
<th>Application</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache Spark</td>
<td>3.3.1</td>
</tr>
<tr>
<td>Apache Hive</td>
<td>3.1.3</td>
</tr>
<tr>
<td>Apache Tez</td>
<td>0.10.2</td>
</tr>
</tbody>
</table>
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, see Spark job properties (p. 46).

EMR Serverless 6.9.0

The following table lists the application versions available with EMR Serverless 6.9.0.

<table>
<thead>
<tr>
<th>Application</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache Spark</td>
<td>3.3.0</td>
</tr>
<tr>
<td>Apache Hive</td>
<td>3.1.3</td>
</tr>
<tr>
<td>Apache Tez</td>
<td>0.10.2</td>
</tr>
</tbody>
</table>

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 (p. 105).
- 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, see Amazon EMR Serverless architecture options (p. 38).
- You can now export, import, query, and join Amazon DynamoDB tables directly from your EMR Serverless Spark and Hive applications. For more information, see Connecting to DynamoDB with Amazon EMR Serverless (p. 110).

Known issues

- If you use the 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.

<table>
<thead>
<tr>
<th>Application</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache Spark</td>
<td>3.3.0</td>
</tr>
<tr>
<td>Apache Hive</td>
<td>3.1.3</td>
</tr>
<tr>
<td>Apache Tez</td>
<td>0.9.2</td>
</tr>
</tbody>
</table>
EMR Serverless 6.7.0

The following table lists the application versions available with EMR Serverless 6.7.0.

<table>
<thead>
<tr>
<th>Application</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache Spark</td>
<td>3.2.1</td>
</tr>
<tr>
<td>Apache Hive</td>
<td>3.1.3</td>
</tr>
<tr>
<td>Apache Tez</td>
<td>0.9.2</td>
</tr>
</tbody>
</table>

Engine-specific changes, enhancements, and resolved issues

The following table lists a new engine-specific feature.

<table>
<thead>
<tr>
<th>Change</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feature</td>
<td>Tez scheduler now supports preemption of Tez task instead of preemption of container</td>
</tr>
</tbody>
</table>

EMR Serverless 6.6.0

The following table lists the application versions available with EMR Serverless 6.6.0.

<table>
<thead>
<tr>
<th>Application</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache Spark</td>
<td>3.2.0</td>
</tr>
<tr>
<td>Apache Hive</td>
<td>3.1.2</td>
</tr>
<tr>
<td>Apache Tez</td>
<td>0.9.2</td>
</tr>
</tbody>
</table>

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, see 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, see Configure applications.

Engine-specific changes, enhancements, and resolved issues

- The following table lists Hive and Tez backports.
## Hive and Tez changes

<table>
<thead>
<tr>
<th>Change</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backport</td>
<td><strong>TEZ-4430</strong>: Fixed issue with <code>tez.task.launch.cmd-opts</code> property</td>
</tr>
<tr>
<td>Backport</td>
<td><strong>HIVE-25971</strong>: Fixed Tez task shutdown delays due to open cached thread pool</td>
</tr>
</tbody>
</table>
## 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.

<table>
<thead>
<tr>
<th>Change</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>New feature (p. 158)</td>
<td>Configure multiple IAM roles to assume when you access Amazon S3 buckets in different accounts from EMR Serverless (p. 70) (6.11 and higher)</td>
<td>October 18, 2023</td>
</tr>
<tr>
<td>New release (p. 158)</td>
<td>EMR Serverless 6.14.0 (p. 153)</td>
<td>October 17, 2023</td>
</tr>
<tr>
<td>New feature (p. 158)</td>
<td>Default application configuration for EMR Serverless (p. 27)</td>
<td>September 25, 2023</td>
</tr>
<tr>
<td>Update to default Hive properties (p. 158)</td>
<td>Updated the default values for <code>hive.driver.disk</code>, <code>hive.tez.disk.size</code>, <code>hive.tez.auto.reducer.parallelism</code>, and <code>tez.grouping.min-size</code> Hive job properties.</td>
<td>September 12, 2023</td>
</tr>
<tr>
<td>New release (p. 158)</td>
<td>EMR Serverless 6.13.0 (p. 153)</td>
<td>September 11, 2023</td>
</tr>
<tr>
<td>New release (p. 158)</td>
<td>EMR Serverless 6.12.0 (p. 154)</td>
<td>July 21, 2023</td>
</tr>
<tr>
<td>New release (p. 158)</td>
<td>EMR Serverless 6.11.0 (p. 154)</td>
<td>June 8, 2023</td>
</tr>
<tr>
<td>Update to service-linked role policy (p. 158)</td>
<td>Updated the AmazonEMRServerlessServiceRolePolicy SLR role to publish account-level usage in &quot;AWS/Usage&quot; namespace.</td>
<td>April 20, 2023</td>
</tr>
<tr>
<td>EMR Serverless general availability (GA) (p. 158)</td>
<td>This is the first public release of EMR Serverless.</td>
<td>June 1, 2022</td>
</tr>
</tbody>
</table>