Building and Orchestrating ETL Pipelines by Using Athena and Step Functions

Lab overview and objectives

In this lab, you will use AWS Step Functions to build an extract, transform, and load (ETL) pipeline that uses Amazon Simple Storage Service (Amazon S3), an AWS Glue Data Catalog, and Amazon Athena to process a large dataset.

Step Functions can help you automate business processes by creating *workflows*, also referred to as *state machines*. In this lab, you will use Step Functions to build a workflow that invokes Athena to take a series of actions. An example of an action is running a query to discover if AWS Glue tables exist.

The AWS Glue Data Catalog provides a persistent metadata store, including table definitions, schemas, and other control information. This information will help you to create the ETL pipeline.

Athena is a serverless interactive query service that simplifies analyzing data in Amazon S3 by using standard SQL.

You will design the workflow so that *if AWS Glue tables don't exist*, the workflow will invoke additional Athena queries to create them. *If the tables do exist*, the workflow will run an additional AWS Glue query to create a view in Athena that combines data from two tables. You can then query that view to make interesting time-based and location-based discoveries in the large dataset.

After completing this lab, you should be able to do the following:

- Create and test a Step Functions workflow by using Step Functions Studio.
- Create an AWS Glue database and tables.
- Store data on Amazon S3 in Parquet format to use less storage space and to promote faster data reads.
- Partition data that is stored on Amazon S3 and use Snappy compression to optimize performance.
- Create an Athena view.
- Add an Athena view to a Step Functions workflow.
- Construct an ETL pipeline by using Step Functions, Amazon S3, Athena, and AWS Glue.

Duration

This lab will require approximately **120 minutes** to complete.

AWS service restrictions

In this lab environment, access to AWS services and service actions might be restricted to the ones that are needed to complete the lab instructions. You might encounter errors if you attempt to access other services or perform actions beyond the ones that are described in this lab.

Scenario

Previously, you created a proof of concept (POC) to demonstrate how to use AWS Glue to infer a data schema and manually adjust column names. Then, you used Athena to query the data. Although Mary likes this approach, each time that she starts a new project she must complete many manual steps. She has asked you to create a reusable data pipeline that will help her to quickly start building new data processing projects.

One of Mary's projects is to study New York City taxi data. She knows the column names for the table data and has already created views and ingestion SQL commands for you. She wants to study taxi usage patterns in New York City in the early part of 2020.

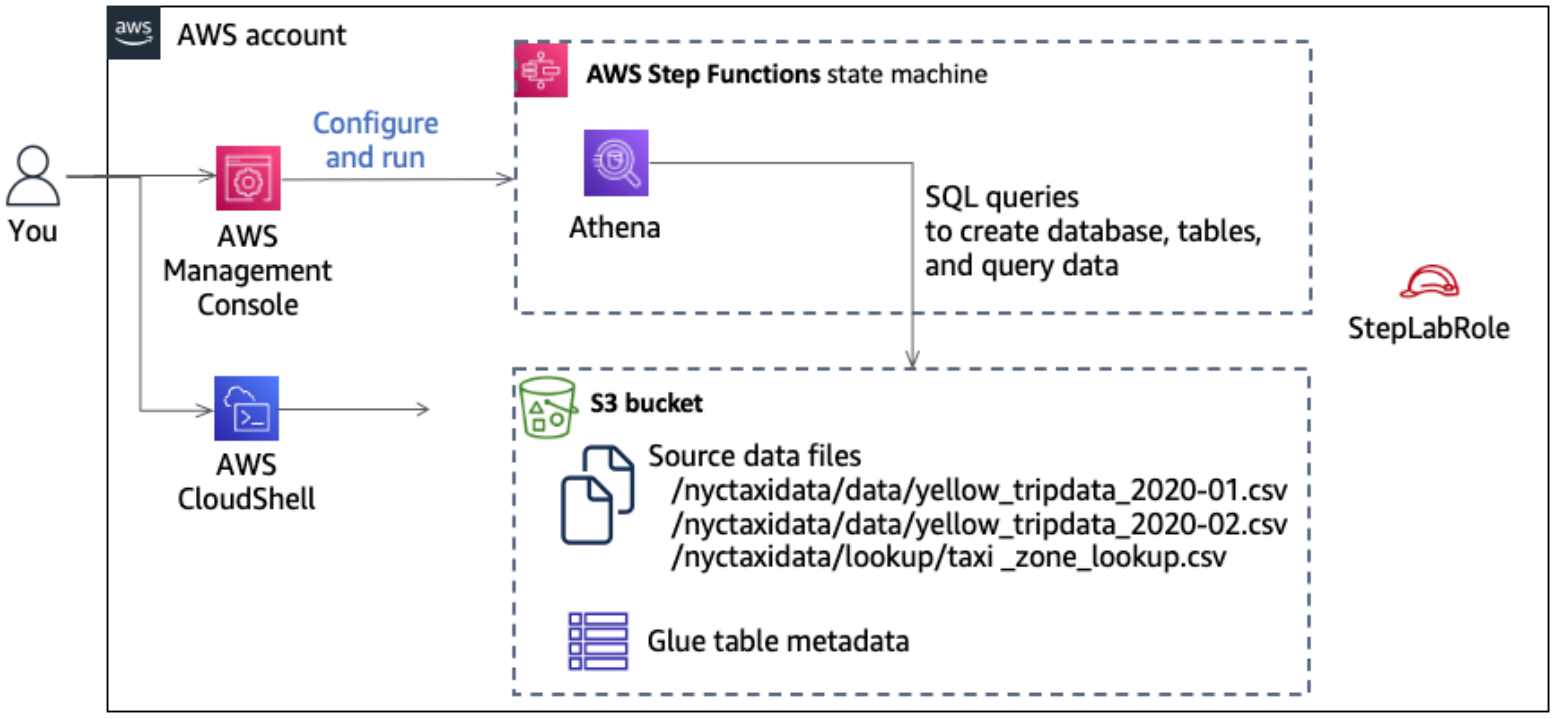
Mary has requested that you store the table data partition by month in Parquet format with Snappy compression. This will promote efficiency and cost. Because it is a POC, Mary is OK with you using hard-coded values for column names, partitions, views, and S3 bucket information.

Mary has provided the following:

- Links to access the taxi data
- The partitions that she would like to create (*pickup_year* and *pickup_month*)
- SQL ingestion scripts
- A script that will create a view in SQL that she wants to use for this particular project

When you start the lab, the environment will contain the resources that are shown in the following diagram.

By the end of the lab, you will have created the architecture that is shown in the following diagram.



After doing some research, you decided to take advantage of the flexibility of Step Functions to create the ETL pipeline logic. With Step Functions, you can handle initial runs where the table data and SQL view don't exist, in addition to subsequent runs where the tables and view do exist.

OK, let's get started!

Accessing the AWS Management Console

1. At the top of these instructions, choose ▸ **Start Lab**.
   - The lab session starts.
   - A timer displays at the top of the page and shows the time remaining in the session.

     Tip: To refresh the session length at any time, choose ▸ **Start Lab** again before the timer reaches 0:00.
   - Before you continue, wait until the circle icon to the right of the AWS 🟢 link in the upper-left corner turns green. When the lab environment is ready, the AWS Details panel will also display.

2. To connect to the AWS Management Console, choose the **AWS** link in the upper-left corner.
   - A new browser tab opens and connects you to the console.

     Tip: If a new browser tab does not open, a banner or icon is usually at the top of your browser with the message that your browser is preventing the site from opening pop-up windows. Choose the banner or icon, and then choose **Allow pop-ups**.

Task 1: Analyzing existing resources and loading the source data

In this first task, you will analyze an AWS Identity and Access Management (IAM) role and an S3 bucket that were created for you. Then, you will copy the source taxi data from a public S3 bucket into your bucket. You will use this data later in the lab when you create a Step Functions workflow.

3. Open all the AWS service consoles that you will use during this lab.

   Tip: Since you will use the consoles for many AWS services throughout this lab, it will be easier to have each console open in a separate browser tab.
   - In the search box to the right of **Services**, search for `Step Functions`
   - Open the context menu (right-click) on the **Step Functions** entry which appears in the search results and choose the option to **open the link in a new tab**.
   - Repeat this same process to open the AWS service consoles for each of these additional services:
     - S3
     - AWS Glue
     - Athena
     - Cloud9
     - IAM
   - Confirm that you now have each of the six AWS services consoles open in different browser tabs.

4. Analyze the existing IAM role that is named *StepLabRole*.
   - In the **IAM** console and in the navigation pane, choose **Roles**.
   - Search for `StepLabRole` and choose the link for the role when it appears.
   - On the **Permissions** tab, expand and view the **Policy-For-Step** IAM policy that is attached to the role.

     Analysis: When you create the Step Functions workflow, you will associate this role with the workflow. This policy will allow the workflow to make calls to the Athena, Amazon S3, AWS Glue, and AWS Lake Formation services.

5. Analyze the existing S3 bucket.

   - In the **S3** console, in the list of buckets, choose the link for the bucket that has **gluelab** in its name.

     Notice that it doesn't currently hold any objects. Later in this lab, you will reference this bucket in the Step Functions workflow that you configure.

   - Copy the bucket name to a text file.

     You will use this name multiple times later in this lab.

6. Connect to the AWS Cloud9 IDE.

   - In the **Cloud9** console, in the *Your environments* page, under **Cloud9 Instance**, choose **Open IDE**.

7. Load data into your bucket from the source dataset.

   - Run the following commands in the Cloud9 bash terminal. Replace *<FMI_1>* with your actual bucket name (the one with **gluelab** in the name).

     Important: Be sure to keep the quotes around the bucket name.

     ```
     mybucket="<FMI_1>"
     echo $mybucket
     ```

     Tip: You might be prompted about safely pasting multiline text. To disable this prompt for the future, clear **Ask before pasting multiline code**. Choose **Paste**.

     Analysis: With these commands, you assigned your bucket name to a shell variable. You then echoed the value of that variable to the terminal. Saving the bucket name as a variable will be useful when you run the next few commands.

   - Copy the yellow taxi data for *January* into a prefix (folder) in your bucket called *nyctaxidata/data*.

     ```
     wget -qO- https://aws-tc-largeobjects.s3.us-west-2.amazonaws.com/CUR-TF-200-ACDENG-1/step-lab/yellow_tripdata_2020-01.csv | aws s3 cp - "s3://$mybucket/nyctaxidata/data/yellow_tripdata_2020-01.csv"
     ```

     Note: The command takes about 20 seconds to complete. The file that you are copying is approximately 500 MB in size. Wait for the terminal prompt to display again before continuing.

   - Copy the yellow taxi data for *February* into a prefix in your bucket called *nyctaxidata/data*.

     ```
     wget -qO- https://aws-tc-largeobjects.s3.us-west-2.amazonaws.com/CUR-TF-200-ACDENG-1/step-lab/yellow_tripdata_2020-02.csv | aws s3 cp - "s3://$mybucket/nyctaxidata/data/yellow_tripdata_2020-02.csv"
     ```

     Tip: Much more taxi data is available, and in a production solution, you would likely want to include many years of data. However, for POC purposes, using 2 months of data will suffice.

   - Copy the location information (lookup table) into a prefix in your bucket called *nyctaxidata/lookup*.

     Important: The space in the **taxi _zone_lookup.csv** file name is intentional.

     ```
     wget -qO- https://aws-tc-largeobjects.s3.us-west-2.amazonaws.com/CUR-TF-200-ACDENG-1/step-lab/taxi+_zone_lookup.csv | aws s3 cp - "s3://$mybucket/nyctaxidata/lookup/taxi _zone_lookup.csv"
     ```

8. Analyze the structure of the data that you copied.

   The data in the *lookup table* has the following structure. The following are the first few lines of the file:

```
"LocationID","Borough","Zone","service_zone"
1,"EWR","Newark Airport","EWR"
2,"Queens","Jamaica Bay","Boro Zone"
3,"Bronx","Allerton/Pelham Gardens","Boro Zone"
4,"Manhattan","Alphabet City","Yellow Zone"
5,"Staten Island","Arden Heights","Boro Zone"
6,"Staten Island","Arrochar/Fort Wadsworth","Boro Zone"
7,"Queens","Astoria","Boro Zone"
8,"Queens","Astoria Park","Boro Zone"

  ...truncated
```

Analysis: The structure is defined by listing the column names on the first line. Mary is familiar with these column names; therefore, the SQL commands that she provided will work without modification later in the lab.

The *yellow taxi data* file structure for January and February is similar to the following:

```
VendorID,tpep_pickup_datetime,tpep_dropoff_datetime,passenger_count,trip_distance,RatecodeID,store_and_f
wd_flag,PULocationID,DOLocationID,payment_type,fare_amount,extra,mta_tax,tip_amount,tolls_amount,improve
ment_surcharge,total_amount,congestion_surcharge
1,2020-01-01 00:28:15,2020-01-01 00:33:03,1,1.20,1,N,238,239,1,6,3,0.5,1.47,0,0.3,11.27,2.5
1,2020-01-01 00:35:39,2020-01-01 00:43:04,1,1.20,1,N,239,238,1,7,3,0.5,1.5,0,0.3,12.3,2.5
1,2020-01-01 00:47:41,2020-01-01 00:53:52,1,.60,1,N,238,238,1,6,3,0.5,1,0,0.3,10.8,2.5

...truncated
```

As with the lookup table file, the first line in each file defines the column names.

Congratulations! In this task, you successfully loaded the source data. Now, you can start building.

Task 2: Automating creation of an AWS Glue database

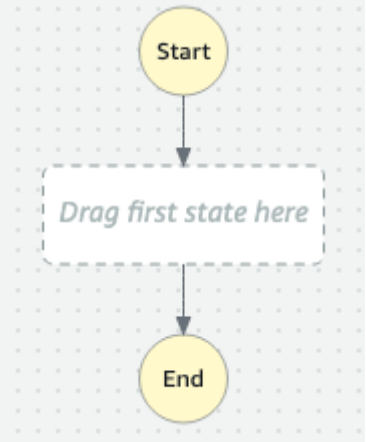
In this task, you will create a Step Functions workflow that will use Athena to check whether an AWS Glue database exists. If the database doesn't already exist, Athena will create it.

9. Begin to create a workflow.
   - In the **Step Functions** console, to open the navigation pane, choose the menu icon (☰), and then choose **State machines**.
   - Choose **Create state machine**.
   - Choose **Cancel** when presented with the template screen.
   - Choose **JSONPath** under **State machine query language**.

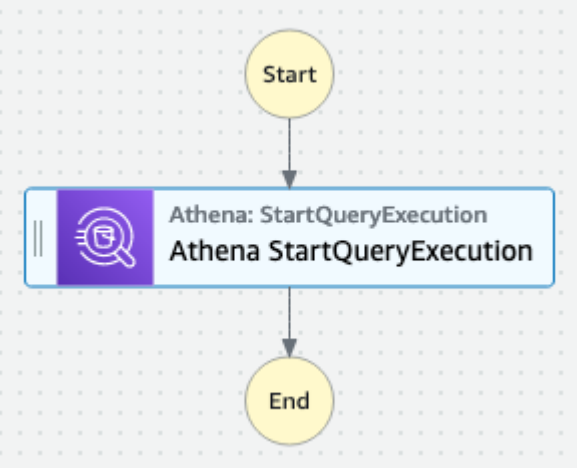
     The Step Functions Workflow Studio interface displays.

10. Design the workflow by using the Workflow Studio interface.
    - If a *Welcome to Workflow Studio* message appears, dismiss it by choosing the **X** icon.

      Notice that a starter workflow, with *Start* and *End* tasks, is already defined, as shown in the following image.



- In the **Actions** panel on the left, search for `Athena`
- Drag the **StartQueryExecution** task to the canvas between the *Start* and *End* tasks, as shown in the following image.



Analysis: Athena uses the AWS Glue Data Catalog to store and retrieve table metadata for data that is stored in Amazon S3. The table metadata indicates to the Athena query engine how to find, read, and process the data that you want to query.

- In the **Inspector** panel on the right:
  - Change **State name** to `Create Glue DB`
  - Keep the **Integration type** as **Optimized**.
  - For **API Parameters**, replace the default JSON code with the following. Replace *<FMI_1>* with your actual bucket name (the one with **gluelab** in the name).

```
{
    "QueryString": "CREATE DATABASE if not exists nyctaxidb",
    "WorkGroup": "primary",
    "ResultConfiguration": {
      "OutputLocation": "s3://<FMI_1>/athena/"
    }
}
```

  - Select ☐ **Wait for task to complete - optional**.

    Note: This ensures that the workflow will wait until the task is complete before continuing to any additional downstream tasks. This particular task is complete when Athena verifies that the database exists or creates it.

- Keep **Next state** as **Go to end**.
- At the top of the page, choose **Create**.

11. Review the settings and finish creating the workflow.

Analysis: In the JSON code, notice how Step Functions will invoke Athena to run a query. The query will check if a database named *nyctaxidb* already exists. If it doesn't, the query will create the database. The database will be stored in the *gluelab* S3 bucket in a folder named *athena*.

- Choose **View role configuration**.
- For **State machine name**, enter `WorkflowPOC`
- For **Execution role** select **StepLabRole**.
- Keep the other default settings, and choose **Create**.

12. Test the workflow.

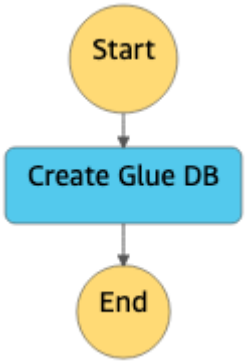
    Now that you have created a workflow, run it and see what happens on this first run.

    - Choose **Start execution**.
    - For **Name**, enter `TaskTwoTest` and then choose **Start execution**.

      Important: Be sure to name your Start execution tests exactly as documented in these lab instructions, otherwise you may not receive full credit for your work later when you submit the lab for a score.

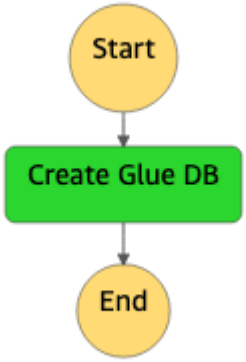
      On the **Details** tab at the top of the page, the status first shows as *Running*.

      The initial **Graph inspector** view shows the *Create Glue DB* step in blue, as shown in the following image.



    - Wait a minute or two while the workflow runs.

      When the *Create Glue DB* step turns green, as shown in the following image, the step succeeded.



13. Verify that a result file was created in the S3 bucket.

    - In the **S3** console, choose the link for the **gluelab** bucket, or if you are already on that page, use the refresh icon to refresh the page.

      You should see a new *athena* prefix (folder) in the bucket.

    - Choose the **athena** link to view the contents.

      The folder contains a text file. Notice that the size of the file is 0 B, which indicates that the file is *empty*.

14. Verify that the AWS Glue database was created.

- In the **AWS Glue** console, in the navigation pane, under **Data Catalog**, choose **Databases**.
- Select the ☐ **nyctaxidb** database.

  Notice that the database currently doesn't have any tables. This is expected. You will add steps to the workflow later to create tables. However, this is great progress for now!

In this task, you successfully created an AWS Glue database by using a Step Functions workflow.

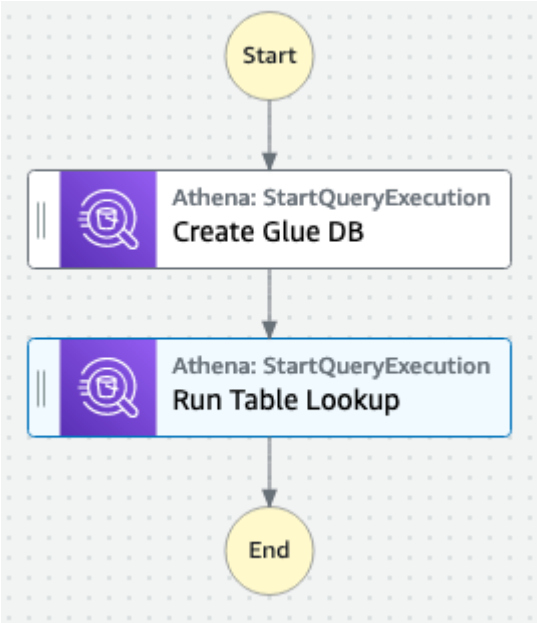
Task 3: Creating the task to check whether tables exist in the AWS Glue database

In this task, you will update the workflow so that it will check whether tables exist in the AWS Glue database that you just created.

15. Add another task to your workflow.
    - In the **Step Functions** console, choose the **WorkflowPOC** state machine, and then choose **Edit**.
    - In the **Actions** panel, search for `Athena`
    - Drag another **StartQueryExecution** task to the canvas between the *Create Glue DB* task and the *End* task.

16. Configure the task and save the change.
    - With the new *StartQueryExecution* task selected, in the **Inspector** panel, change **State name** to `Run Table Lookup`

      After you rename the state, the workflow displays as shown in the following image.



    - For **API Parameters**, replace the default JSON code with the following. Replace *<FMI_1>* with your actual bucket name (the one with **gluelab** in the name).

```
{
  "QueryString": "show tables in nyctaxidb",
  "WorkGroup": "primary",
  "ResultConfiguration": {
    "OutputLocation": "s3://<FMI_1>/athena/"
  }
}
```

    - Select ☐ **Wait for task to complete - optional**.

- Keep **Next state** as **Go to end**.
- At the top of the page, choose **Save**.

  Confirm the definition by selection **{} Code**. It should look similar to the following JSON code.

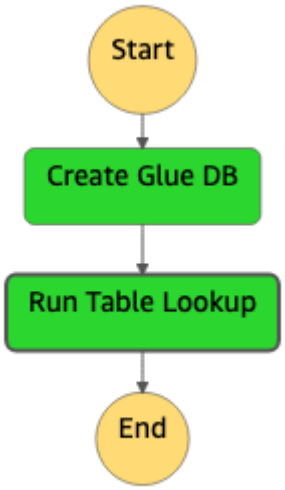
```
{
  "Comment": "A description of my state machine",
  "StartAt": "Create Glue DB",
  "States": {
    "Create Glue DB": {
      "Type": "Task",
      "Resource": "arn:aws:states:::athena:startQueryExecution.sync",
      "Parameters": {
        "QueryString": "CREATE DATABASE if not exists nyctaxidb",
        "WorkGroup": "primary",
        "ResultConfiguration": {
          "OutputLocation": "s3://<your-gluelab-bucket-name>/athena/"
        }
      },
      "Next": "Run Table Lookup"
    },
    "Run Table Lookup": {
      "Type": "Task",
      "Resource": "arn:aws:states:::athena:startQueryExecution.sync",
      "Parameters": {
        "QueryString": "show tables in nyctaxidb",
        "WorkGroup": "primary",
        "ResultConfiguration": {
          "OutputLocation": "s3://<your-gluelab-bucket-name>/athena/"
        }
      },
      "End": true
    }
  }
}
```

- When prompted about how the IAM role might need new permissions, choose **Save anyway**.

  Note: Recall that you previously reviewed the permissions that are granted to this IAM role. The permissions are sufficient to complete all the tasks in this lab.

17. Test the updated workflow.
    - Choose **Execute**.
    - For **Name**, enter `TaskThreeTest` and then choose **Start execution**.

      Watch as the workflow runs each task and the tasks change from white to blue to green in the **Graph view** section. The following image shows the graph after the workflow succeeds.



In the **Events** history section, notice that the status of each task is provided in addition to the time that each took to run.

The workflow takes about 1 minute to run, and it will *not* find any tables.

- After the workflow completes, in the **Graph view** section, choose the **Run Table Lookup** task.
- In the **Details** panel to the right, choose the **Output** tab.

  Notice that the task generated a *QueryExecutionId*. You will use this in the next task.
- In the **Amazon S3** console, choose the link for the **gluelab** bucket, and then choose the **athena** link.

  Notice that the folder (prefix) has more files now.

  Tip: You may need to refresh the browser tab to see them.

  The .txt files are blank, but a metadata file now exists and contains some data. AWS Glue will use the metadata file internally.

Congratulations! In this task, you updated the workflow by adding a task that checks whether tables exist in the AWS Glue database.

Task 4: Adding routing logic to the workflow based on whether AWS Glue tables exist

In this task, you will reference the execution ID that the *Run Table Lookup* task returns to check for existing tables in the AWS Glue database. You will also use a choice state to determine the logical route to follow based on the result of the previous task.

18. Update the workflow to look up query results.
    - In the **Step Functions** console, choose the **WorkflowPOC** state machine, and then choose **Edit**.
    - In the **Actions** panel, search for `Athena`
    - Drag a **GetQueryResults** task to the canvas between the *Run Table Lookup* task and the *End* task.

      ⚠ Do not use a GetQueryExecution task.
    - With the *GetQueryResults* task selected, change **State name** to `Get lookup query results`
    - For **API Parameters**, replace the existing contents with what is in the code block below.

```
{
     "QueryExecutionId.$": "$.QueryExecution.QueryExecutionId"
}
```

Analysis: This task will use the query execution ID that the prior task made available as an output value. By passing the value along, the next task (which you haven't added yet) can use the value to evaluate whether tables were found.

Note: You don't need to internally poll for this task to complete, so you don't need to select **Wait for task to complete**.

- Choose **{} Code**.

  Confirm the definition. It should look similar to the following JSON code where the `<FMI_1>` placeholders contain your actual gluelab bucket name.

```
{
  "Comment": "A description of my state machine",
"StartAt": "Create Glue DB",
  "States": {
    "Create Glue DB": {
      "Type": "Task",
      "Resource": "arn:aws:states:::athena:startQueryExecution.sync",
      "Parameters": {
        "QueryString": "CREATE DATABASE if not exists nyctaxidb",
        "WorkGroup": "primary",
        "ResultConfiguration": {
          "OutputLocation": "s3://<FMI_1>/athena/"
        }
      },
      "Next": "Run Table Lookup"
    },
    "Run Table Lookup": {
      "Type": "Task",
      "Resource": "arn:aws:states:::athena:startQueryExecution.sync",
      "Parameters": {
        "QueryString": "show tables in nyctaxidb",
        "WorkGroup": "primary",
        "ResultConfiguration": {
          "OutputLocation": "s3://<FMI_1>/athena/"
        }
      },
      "Next": "Get lookup query results"
    },
    "Get lookup query results": {
      "Type": "Task",
      "Resource": "arn:aws:states:::athena:getQueryResults",
      "Parameters": {
        "QueryExecutionId.$": "$.QueryExecution.QueryExecutionId"
      },
      "End": true
    }
  }
}
```

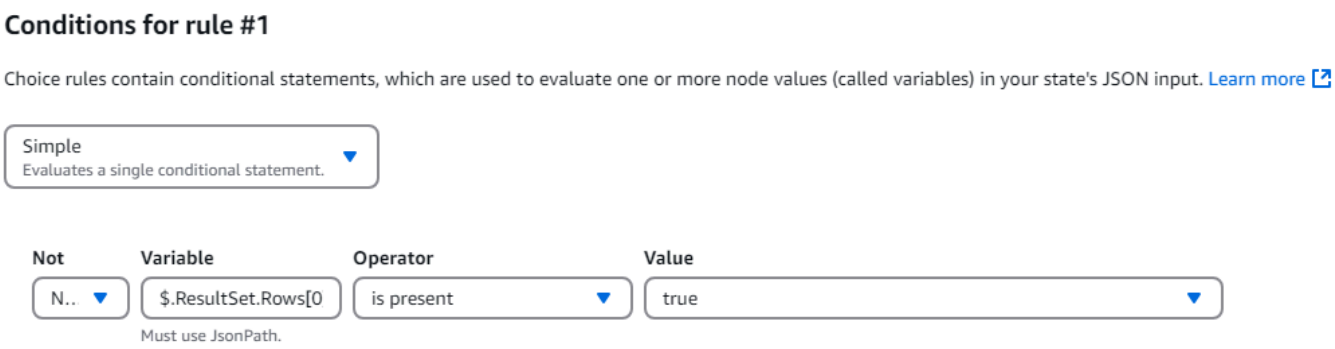
- Choose **Save**.

19. Add a choice state to the workflow.
    - Choose **Design** towards the top.
    - In the **Actions** panel, choose the **Flow** tab.
    - Drag a **Choice** state to the canvas between the *Get lookup query results* task and the *End* task.

- With the *Choice* state selected, change **State name** to `ChoiceStateFirstRun`
- In the **Choice Rules** section, for **Rule #1**, choose the edit icon and configure the following:
  - Choose **Add conditions**.
  - Keep the default **Simple** condition.
  - For **Not**, choose **NOT**.
  - For **Variable**, enter the following:

    ```
    $.ResultSet.Rows[0].Data[0].VarCharValue
    ```

  - For **Operator**, choose **is present**.
  - For **Value**, choose **true**.
  - Ensure that your settings match the following image.

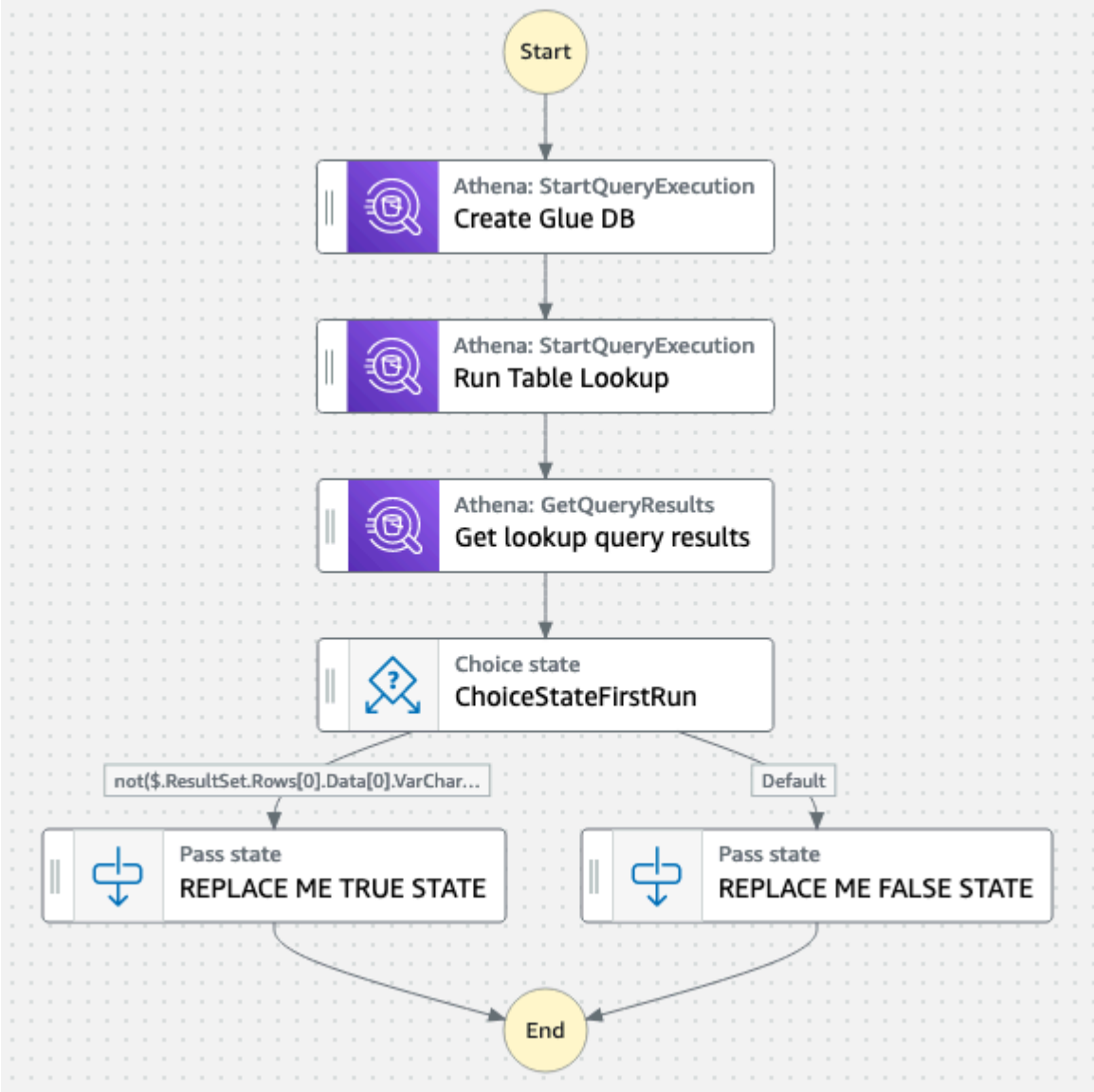
    

  - Choose **Save conditions**.

20. Add two pass states to the workflow.
    - Drag a **Pass** state to the canvas after the *ChoiceStateFirstRun* state, on the left side under the arrow that is labeled *not...*.
    - With the *Pass* state selected, change **State name** to `REPLACE ME TRUE STATE`

      Note: This is a temporary name, which you will update later.
    - Drag another **Pass** state to the canvas after the *ChoiceStateFirstRun* state, on the right side under the arrow that is labeled *Default*.
    - With the *Pass* state selected, change **State name** to `REPLACE ME FALSE STATE`

      Your workflow canvas should now look like the following image:



- Choose **Save**.

  Analysis: When you run the workflow and the *Get lookup query results* task is complete, the choice state will evaluate the results of the last query.

  If tables aren't found (the *$.ResultSet.Rows[0].Data[0].VarCharValue* logic evaluates this), the workflow will go the *REPLACE ME TRUE STATE* route. In the next task, you will replace this state with a process to create tables.

  Otherwise, if tables are found, the workflow will go the *Default* route (the *REPLACE ME FALSE STATE* route). Later in this lab, you will replace this state with a process to check for any new data (for example, February taxi data) and then insert it into an existing table.

Congratulations! In this task, you successfully added a choice state to support evaluating the results of the *Get lookup query results* task.

Task 5: Creating the AWS Glue table for the yellow taxi data

In this task, you will define logic in the workflow that will create AWS Glue tables if they don't exist.

21. Add another Athena *StartQueryExecution* task to the workflow and configure it to create a table.
    - Choose the **Actions** tab, and search for `athena`
    - Drag a **StartQueryExecution** task to the canvas between the *ChoiceStateFirstRun* state and the *REPLACE ME TRUE STATE* state.
    - With the *StartQueryExecution* task selected, change **State name** to `Run Create data Table Query`
    - For **Integration type**, keep **Optimized** selected.

- For **API Parameters**, replace the default JSON code with the following. Replace *<FMI_1>* and *<FMI_2>* with your actual bucket name (the one with **gluelab** in the name).

```
{
        "QueryString": "CREATE EXTERNAL TABLE nyctaxidb.yellowtaxi_data_csv(  vendorid bigint,
tpep_pickup_datetime string,   tpep_dropoff_datetime string,   passenger_count bigint,
trip_distance double,   ratecodeid bigint,   store_and_fwd_flag string,   pulocationid bigint,
dolocationid bigint,   payment_type bigint,   fare_amount double,   extra double,   mta_tax double,
  tip_amount double,   tolls_amount double,   improvement_surcharge double,   total_amount double,
congestion_surcharge double) ROW FORMAT DELIMITED   FIELDS TERMINATED BY ',' STORED AS INPUTFORMAT
'org.apache.hadoop.mapred.TextInputFormat' OUTPUTFORMAT
'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat' LOCATION
's3://<FMI_1>/nyctaxidata/data/' TBLPROPERTIES (  'skip.header.line.count'='1')",
        "WorkGroup": "primary",
        "ResultConfiguration": {
          "OutputLocation": "s3://<FMI_2>/athena/"
        }
}
```

  Analysis: Recall that you reviewed the structure of the source data files that you copied into your *gluelab* bucket. The yellow_tripdata_2020-01.csv and yellow_tripdata_2020-02.csv source files are in comma-separated value (CSV) format.

  The first line in each file defines the columns of data that are contained in the file. The columns include **vendorid**, **tpep_pickup_datetime**, and the other columns that are defined in the CREATE EXTERNAL TABLE SQL statement that you just entered for the task.

  The CSV file doesn't define data types for each column of data, but your AWS Glue table does define them (for example, as *bigint* and *string*). Note that, by defining the table as EXTERNAL, you indicate that the table data will remain in Amazon S3, in the location defined by the LOCATION part of the command (*s3://<gluelab-bucket>/nyctaxidata/data/*).

  The QueryString that you are sending to Athena in this task uses the Create Table as Select (CTAS) feature of Athena. CTAS statements use standard SELECT queries to create new tables. By using this feature, you can extract, transform, and load data into Amazon S3 for processing. For more information, see "Using CTAS and INSERT INTO for ETL and Data Analysis" at https://docs.aws.amazon.com/athena/latest/ug/ctas-insert-into-etl.html.

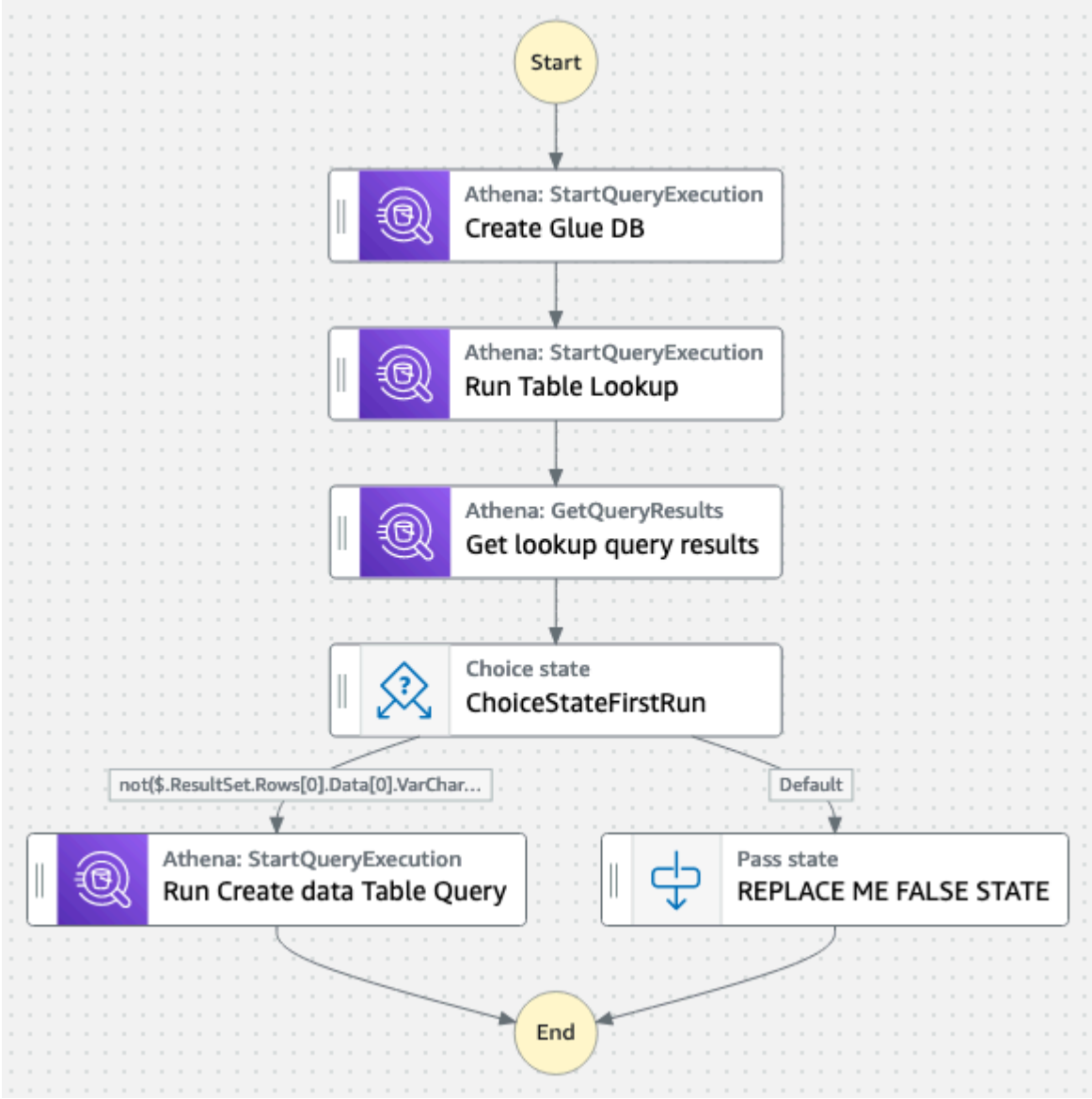
- Select ☐ **Wait for task to complete - optional**.

  Note: It is important for the table to be fully created before the workflow continues.

- For **Next state**, choose **Go to end**.
- On the canvas, select the *REPLACE ME TRUE STATE* state and delete it by pressing the Delete key.

  Important: Verify that the *REPLACE ME TRUE STATE* state is no longer on the canvas.

  Your workflow canvas should now look like the following image:

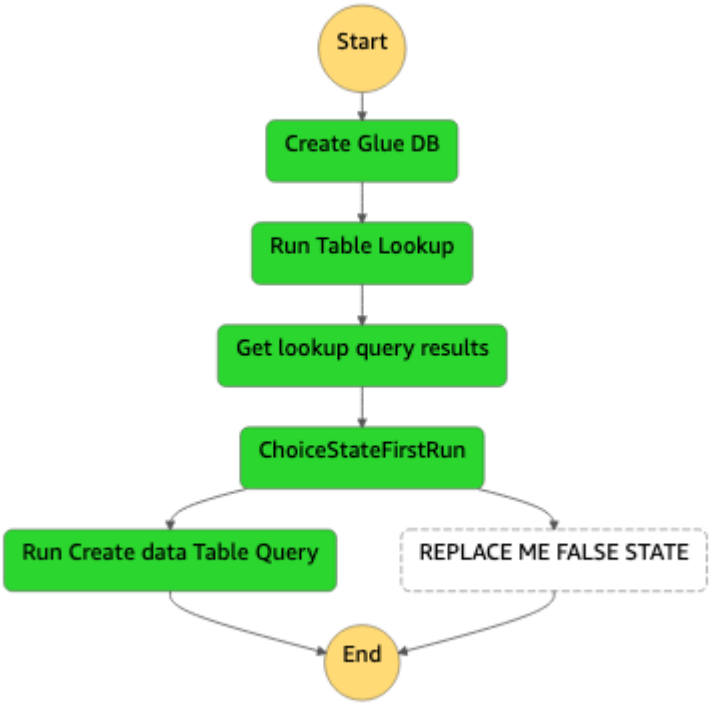


- Choose **Save**.

22. Test the workflow.
    - Choose **Execute**.
    - For **Name**, enter `TaskFiveTest` and then choose **Start execution**.

      It will take a few minutes for each step in the workflow to go from white, to blue, to green. Wait for the workflow to complete successfully.

      This run will not create a new database. However, because it won't find any tables in the database, it should take the route with the *Run Create data Table Query* task, as shown in the following image.



23. Verify that the updated workflow created a table in the AWS Glue database the first time that you ran it.
    - In the **Amazon S3** console, navigate to the contents of the *athena* folder in your *gluelab* bucket.

      Notice that the folder contains another metadata file and additional empty text files.

      Note: The empty text files are basic output files from Step Functions tasks. You can ignore them.
    - In the **AWS Glue** console, in the navigation pane, choose **Tables**.

      Notice that a *yellowtaxi_data_csv* table now exists. This is the AWS Glue table that Athena created when your Step Function workflow invoked the *Run Create data Table Query* task.
    - To view the schema details, choose the link for the **yellowtaxi_data_csv** table.

      The schema looks like the following image.

Schema

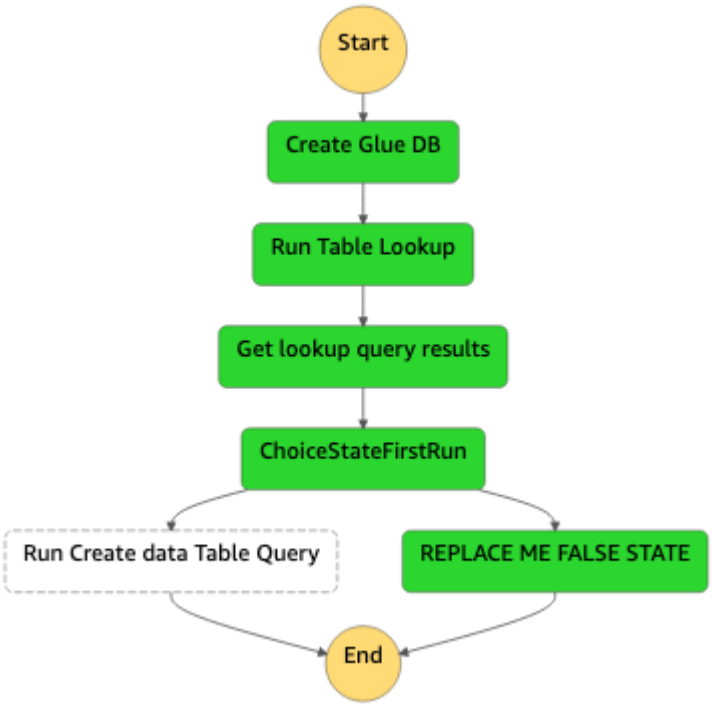
	Column name	Data type
1	vendorid	bigint
2	tpep_pickup_...	string
3	tpep_dropoff_...	string
4	passenger_co...	bigint
5	trip_distance	double
6	ratecodeid	bigint
7	store_and_fw...	string
8	pulocationid	bigint
9	dolocationid	bigint
10	payment_type	bigint
11	fare_amount	double
12	extra	double
13	mta_tax	double
14	tip_amount	double
15	tolls_amount	double
16	improvement_...	double
17	total_amount	double
18	congestion_s...	double

24. Run the workflow again to test the other choice route.
    - In the **Step Functions** console, choose the link for the **WorkflowPOC** state machine.

- Choose **Start execution**.
    - For **Name**, enter `NewTest` and then choose **Start execution** again.
    - Wait for the workflow to complete successfully.

      Analysis: You want to ensure that, if the workflow finds the new table (as it should this time), the workflow will take the other choice route and invoke the *REPLACE ME FALSE STATE* state.

      The following image shows the completed workflow.



This run didn't re-create the database or try to overwrite the table that was created during the previous run. Step Functions did generate some output files in Amazon S3 with updated AWS Glue metadata.

In this task, you successfully created an AWS Glue table that points to the yellow taxi data.

Task 6: Creating the AWS Glue table for location lookup data

In this task, you will create another AWS Glue table by updating and running the Step Functions workflow. The new table will reference the taxi _zone_lookup.csv source data file in Amazon S3. After you create this table, you will be able to join the yellow taxi data table with the lookup table in a later task. Joining the two tables will help you to make more sense of the data.

Recall that the lookup table holds taxi activity location information. The following text box shows the column names from the first line of the CSV-formatted source data file. The following also shows the first line of *data* in the file and provides an example of the data types that appear in each column.

```
"LocationID","Borough","Zone","service_zone"
1,"EWR","Newark Airport","EWR"
```

The query will again use CTAS to have Athena create an external table.

26. Update the workflow to create the lookup table.
    - Still in the **Step Functions** console, use the method that you used in previous steps to open the *WorkflowPOC* state machine in Workflow Studio.
    - In the **Actions** panel, search for `athena`
    - Drag a **StartQueryExecution** task between the *Run Create data Table Query* task and the *End* task.
    - With the *StartQueryExecution* task selected, change **State name** to `Run Create lookup Table Query`
    - For **API Parameters**, replace the default JSON code with the following. Replace *<FMI_1>* and *<FMI_2>* with your actual bucket name.

```
{
    "QueryString": "CREATE EXTERNAL TABLE nyctaxidb.nyctaxi_lookup_csv(  locationid bigint,
borough string,   zone string,   service_zone string,   latitude double,   longitude double)ROW
FORMAT DELIMITED   FIELDS TERMINATED BY ',' STORED AS INPUTFORMAT
'org.apache.hadoop.mapred.TextInputFormat' OUTPUTFORMAT
'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'LOCATION
's3://<FMI_1>/nyctaxidata/lookup/' TBLPROPERTIES (  'skip.header.line.count'='1')",
     "WorkGroup": "primary",
     "ResultConfiguration": {
          "OutputLocation": "s3://<FMI_2>/athena/"
     }
}
```

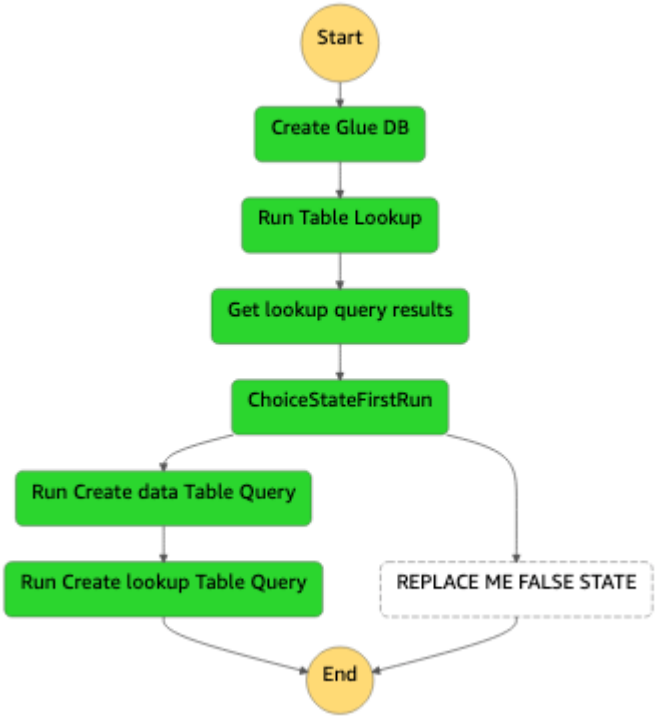
- Select ☐ **Wait for task to complete - optional**.
- Choose **Save**.

  Important: Don't run the workflow yet. First, you need to remove the table that the workflow created previously. If you don't remove that table, the workflow will take the default path from the choice state and not get to the task that you just added to the workflow.

27. Delete the existing AWS Glue table.
    - In the **AWS Glue** console, in the navigation pane, choose **Tables**.
    - Select the ☐ **yellow taxi_data_csv** table.
    - Choose **Delete**.
    - When prompted to proceed, choose **Delete**.

28. Run the latest workflow.
    - In the **Step Functions** console, use the method that you used in previous steps to run the *WorkflowPOC* state machine. Name the test `TaskSixTest`
    - Wait for the workflow to complete successfully.

      The following image shows the completed workflow.



- In the **AWS Glue** console, in the navigation pane, choose **Tables**.

The AWS Glue database now has two tables. The latest run of the workflow re-created the *yellowtaxi_data_csv* table and created the *nyctaxi_lookup_csv* table.

Note: It might take a minute or two for the tables to appear.

Observe the schema for the lookup table, which looks like the following image.

Schema

	Column name	Data type
1	locationid	bigint
2	borough	string
3	zone	string
4	service_zone	string
5	latitude	double
6	longitude	double

Congratulations! In this task, you successfully used a Step Functions workflow to create both tables in the AWS Glue database.

Task 7: Optimizing the data format and using compression

In this task, you will optimize the tables so that they will be more efficient for stakeholders to work with. Specifically, you will modify the data storage to use the Parquet format and Snappy compression. These updates will help users to work with the data more quickly and cost-effectively.

The taxi data goes back several years and is updated over time, so it makes sense to compartmentalize the data by time series.

You will create the table by using the *nyctaxi_lookup_csv* table as the source. You decide to build a Parquet version of the table that has same column names as the csv version of the table. You also decide to declare Snappy as the compression type.

To accomplish this, you will create a task in Step Functions to run the following command to create a Parquet file from the source CSV data.

```
CREATE table if not exists nyctaxidb.nyctaxi_lookup_parquet WITH
(format='PARQUET',parquet_compression='SNAPPY', external_location = 's3://<FMI_1>/nyctaxidata/optimized-data-lookup/') AS SELECT locationid, borough, zone , service_zone , latitude ,longitude  FROM nyctaxidb.nyctaxi_lookup_csv
```

29. Update the *WorkflowPOC* state machine to create a Parquet table with Snappy compression.
    - In the **Step Functions** console, use the method that you used in previous steps to open the *WorkflowPOC* state machine in Workflow Studio.
    - In the **Actions** panel, search for `athena`
    - Drag a **StartQueryExecution** task to the canvas between the *Run Create lookup Table Query* task and the *End* task.
    - With the *StartQueryExecution* task selected, change **State name** to `Run Create Parquet lookup Table Query`
    - For **API Parameters**, replace the default JSON code with the following. Replace <*FMI_1*> and <*FMI_2*> with your actual bucket name.

```
{
        "QueryString": "CREATE table if not exists nyctaxidb.nyctaxi_lookup_parquet WITH
(format='PARQUET',parquet_compression='SNAPPY', external_location =
's3://<FMI_1>/nyctaxidata/optimized-data-lookup/') AS SELECT locationid, borough, zone ,
service_zone , latitude ,longitude  FROM nyctaxidb.nyctaxi_lookup_csv",
        "WorkGroup": "primary",
        "ResultConfiguration": {
          "OutputLocation": "s3://<FMI_2>/athena/"
        }
}
```

- Select ☐ **Wait for task to complete - optional**.
- For **Next state**, keep **Go to end** selected.
- Choose **Save**.

30. Test by removing the existing tables from AWS Glue, running the workflow, and verifying the results.
    - In the **AWS Glue** console, in the navigation pane, choose **Tables**.
    - Delete both of the tables in the AWS Glue database.

      This will ensure that the correct path is taken in the workflow when you run it next.
    - In the **Step Functions** console, use the method that you used in previous steps to run the *WorkflowPOC* state machine. Name the test `TaskSevenTest`
    - Wait for the workflow to complete successfully.

      The following image shows the completed workflow.

- Check the **AWS Glue** console to see that a new *nyctaxi_lookup_parquet* table was created.

  The following image shows the schema for the table.

Input format	org.apache.hadoop.hive.ql.io.parquet.MapredParquetInputFormat
Output format	org.apache.hadoop.hive.ql.io.parquet.MapredParquetOutputFormat
Serde name	nyctaxi_lookup_parquet
Serde serialization lib	org.apache.hadoop.hive.ql.io.parquet.serde.ParquetHiveSerDe
Serde parameters	-
Table properties	presto_query_id **20220708_211003_00034_e8m75** EXTERNAL **TRUE** has_encrypted_data **false** parquet.compression **SNAPPY**

Schema

Showing: 1 - 6 of 6

	Column name	Data type	Partition key	Comment
1	locationid	bigint		
2	borough	string		
3	zone	string		
4	service_zone	string		
5	latitude	double		
6	longitude	double		

Wonderful! In this task, you successfully created the lookup table in Parquet format with Snappy compression. You will create another Parquet table, and then you will be able to combine the information from both tables.

Task 8: Optimizing with partitions

In this task, you will create a *yellowtaxi_data_parquet* table that uses the Parquet format and Snappy compression, similar to what you did with the lookup table.

However, you will also make another change. Because the data in the taxi data table is *time specific*, it makes sense to *partition* the data. You will create a prefix in Amazon S3 named *optimized-data* so that you can partition through the pickup year and pickup month.

With *partitions*, you can restrict the amount of data that each query scans, which improves performance and reduces costs. Partitioning divides a table into parts and keeps related data together based on column values.

By using partitions, as new data is added, it will be compartmentalized. Queries that include a pickup date will be much more efficient to run. With the Parquet format and Snappy compression in place, the data storage will be fully optimized.

31. Update the workflow with a new step that creates the *yellow taxi_data_parquet* table.
    - In the **Step Functions** console, use the method that you used in previous steps to open the *WorkflowPOC* state machine in Workflow Studio.
    - In the **Actions** panel, search for `athena`
    - Drag a **StartQueryExecution** task between the *Run Create Parquet lookup Table Query* task and the *End* task.

- With the *StartQueryExecution* task selected, change **State name** to `Run Create Parquet data Table Query`
- For **API Parameters**, replace the default JSON code with the following. Replace <*FMI_1*> and <*FMI_2*> with your actual bucket name.

```
{
        "QueryString": "CREATE table if not exists nyctaxidb.yellowtaxi_data_parquet WITH
(format='PARQUET',parquet_compression='SNAPPY',partitioned_by=array['pickup_year','pickup_month'],ex
ternal_location = 's3://<FMI_1>/nyctaxidata/optimized-data/') AS SELECT
vendorid,tpep_pickup_datetime,tpep_dropoff_datetime,passenger_count,trip_distance,ratecodeid,store_a
nd_fwd_flag,pulocationid,dolocationid,fare_amount,extra,mta_tax,tip_amount,tolls_amount,improvement_
surcharge,total_amount,congestion_surcharge,payment_type,substr(\"tpep_pickup_datetime\",1,4)
pickup_year, substr(\"tpep_pickup_datetime\",6,2) AS pickup_month FROM nyctaxidb.yellowtaxi_data_csv
where substr(\"tpep_pickup_datetime\",1,4) = '2020' and substr(\"tpep_pickup_datetime\",6,2) =
'01'",
        "WorkGroup": "primary",
        "ResultConfiguration": {
          "OutputLocation": "s3://<FMI_2>/athena/"
        }
}
```

- Select ☐ **Wait for task to complete - optional**.
- Choose **Save**.

32. Test by removing the existing tables in AWS Glue, running the workflow, and then verifying the results.
    - In the **AWS Glue** console, delete all three of the existing tables.

      This will ensure that the workflow takes the correct path when you run it next.
    - In the **S3** console, navigate to the contents of the *nyctaxidata* folder in your *gluelab* bucket.
    - Select the ☐ **optimized-data-lookup** prefix, and choose **Delete**.
    - On the **Delete objects** page, enter `permanently delete` in the field at the bottom of the page, and then choose **Delete objects**.
    - Choose **Close**.

      Explanation: The permissions that were granted to Athena don't allow Athena to delete table information that is stored in Amazon S3. Therefore, you need to manually remove the *optimized-data-lookup* prefix in your S3 bucket before running the workflow. If you don't, the workflow will fail during the *Create Parquet lookup Table Query* task. This wasn't a problem with the other tables because they were defined as *external* tables; however, the Parquet tables are defined as *internal* tables.
    - In the **Step Functions** console, use the method that you used in previous steps to run the *WorkflowPOC* state machine. Name the test `TaskEightTest`

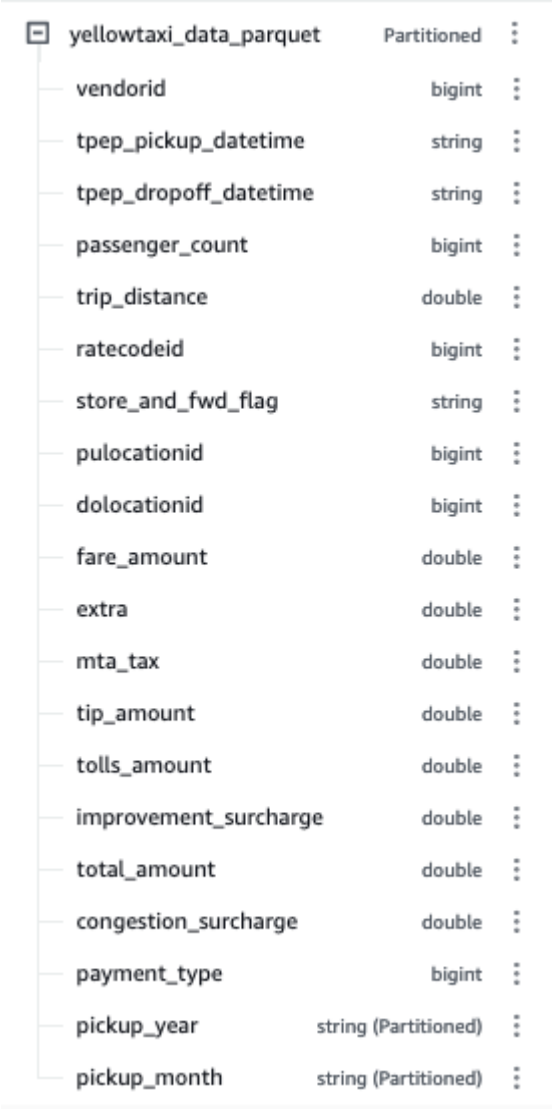
      The following image shows the completed workflow.

33. Verify that the new table was created.
    - In the **Athena** console, in the navigation pane, choose **Query editor**.

      Tip: If the navigation pane is collapsed, open it by choosing the menu icon (☰).

      Note: Because this is your first time using Athena, a message at the top of the page indicates that you need to set up a query result location in Amazon S3.
    - Choose the **Settings** tab.
    - Choose **Manage** and configure the following:
        - Choose **Browse S3**.
        - Choose the link for your **gluelab** bucket.
        - Choose the option for the **athena** prefix.
        - Select **Choose**.
        - Choose **Save**.
    - Choose the **Editor** tab.
    - In the **Data** panel, for **Database**, choose **nyctaxidb**.
    - Expand the **yellowtaxi_data_parquet** table.

      The following image shows the expanded view.



Notice the *Partitioned* label for the table.

Tip: You might need to scroll down to see the last two columns of the database, which will store data as partitioned strings.

Excellent! In this task, you successfully re-created the two AWS Glue tables in the Parquet format and with Snappy compression. Furthermore, you configured the *yellowtaxi_data_parquet* table to be partitioned, and you confirmed that you can load the table in the Athena query editor.

Task 9: Creating an Athena view

In this task, you will create a view of the data in the Athena query editor. The view will combine data from both tables that are stored in the Parquet format.

34. Create a new view of the data by using the Athena query editor.
    - In the **Data** panel, in the **Tables and views** section, choose **Create** > **CREATE VIEW**.

      The following SQL commands populate in a query tab to help you get started.

      ```
      -- View Example
      CREATE OR REPLACE VIEW view_name AS
      SELECT column1, column2
      FROM table_name
      WHERE condition;
      ```

    - Replace the default commands with the following code.

```
create or replace view nyctaxidb.yellowtaxi_data_vw as select a.*,lkup.* from (select
datatab.pulocationid pickup_location ,pickup_month, pickup_year, sum(cast(datatab.total_amount AS
decimal(10, 2))) AS sum_fare , sum(cast(datatab.trip_distance AS decimal(10, 2))) AS
sum_trip_distance , count(*) AS countrec   FROM nyctaxidb.yellowtaxi_data_parquet datatab WHERE
datatab.pulocationid is NOT null  GROUP BY  datatab.pulocationid, pickup_month, pickup_year) a ,
nyctaxidb.nyctaxi_lookup_parquet lkup where lkup.locationid = a.pickup_location
```

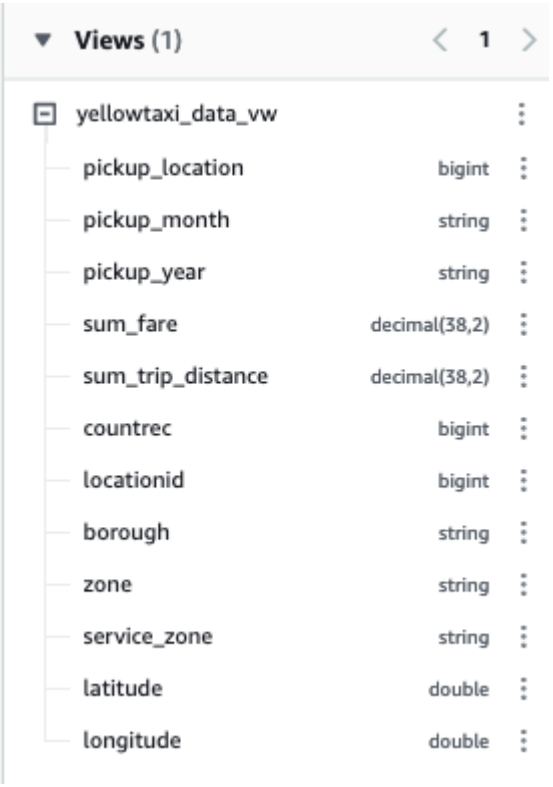
Note: In this scenario, Mary provided these SQL commands.

- Choose **Run**.

  The query completes successfully. In the **Data** panel, in the **Views** section, a **yellowtaxi_data_vw** view is now listed.

- Expand the details of the new view.

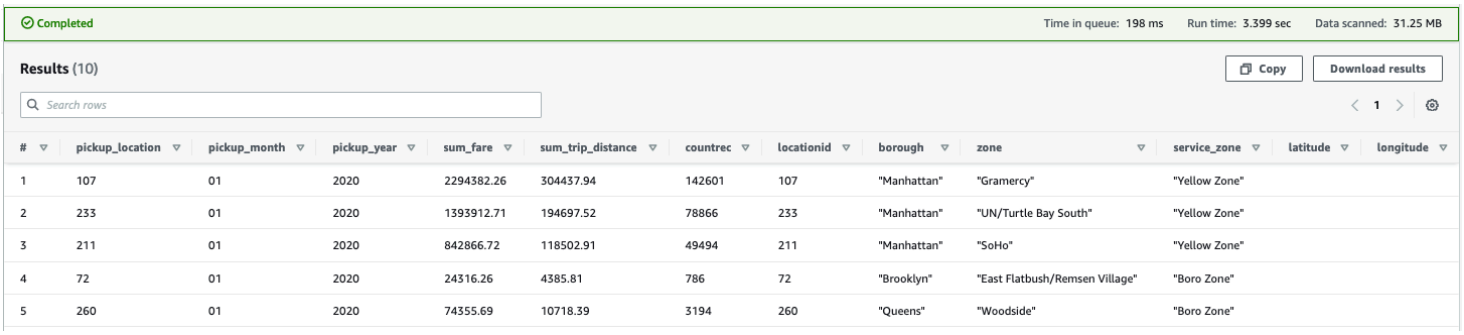
  The following image shows the expanded view.



  Notice how the view contains **sum_fare** and **sum_trip_distance** columns.

- To the right of the view name, choose the three-dot icon () and then choose **Preview View**.

  The results display and are similar to the following image.



  This view looks like it could be quite useful for the team. You are getting close to completing the POC!

Great progress! In this task, you successfully created a view of the data that was obtained by querying both of the Parquet tables.

Task 10: Adding the view to the Step Functions workflow

You know how to create the view manually by using the Athena query editor. The next step is to add a task to the workflow so that the ETL pipeline will create the view when it doesn't already exist. You will add this new task to run *after* the tables are created so that you don't need to re-create the view each time that you add new data.

35. Remove the view that you created manually.

    Note: These instructions assume that you don't need the complete step-by-step instructions because you have completed similar actions earlier in the lab.

    - In the **Amazon S3** console, then navigate to the contents of the *nyctaxidata* folder in your *gluelab* bucket.
    - Delete both of the prefixes that contain **optimized** in their names.
    - In the **AWS Glue** console, and delete all five tables.

36. Add a step to the Step Functions workflow to create the view.

    - In the **Step Function** console, use the method that you used in previous steps to open the *WorkflowPOC* state machine in Workflow Studio.
    - In the **Actions** panel, search for `athena`
    - Drag a **StartQueryExecution** task between the *Run Create Parquet data Table Query* task and the *End* task.
    - With the *StartQueryExecution* task selected, change **State name** to `Run Create View`
    - For **API Parameters**, replace the default JSON code with the following. Replace *<FMI_1>* with your actual bucket name.

      ```
      {
              "QueryString": "create or replace view nyctaxidb.yellowtaxi_data_vw as select a.*,lkup.*
      from (select  datatab.pulocationid pickup_location ,pickup_month, pickup_year,
      sum(cast(datatab.total_amount AS decimal(10, 2))) AS sum_fare , sum(cast(datatab.trip_distance AS
      decimal(10, 2))) AS sum_trip_distance , count(*) AS countrec   FROM
      nyctaxidb.yellowtaxi_data_parquet datatab WHERE datatab.pulocationid is NOT null  GROUP BY
      datatab.pulocationid, pickup_month, pickup_year) a , nyctaxidb.nyctaxi_lookup_parquet lkup where
      lkup.locationid = a.pickup_location",
              "WorkGroup": "primary",
              "ResultConfiguration": {
                "OutputLocation": "s3://<FMI_1>/athena/"
              }
      }
      ```

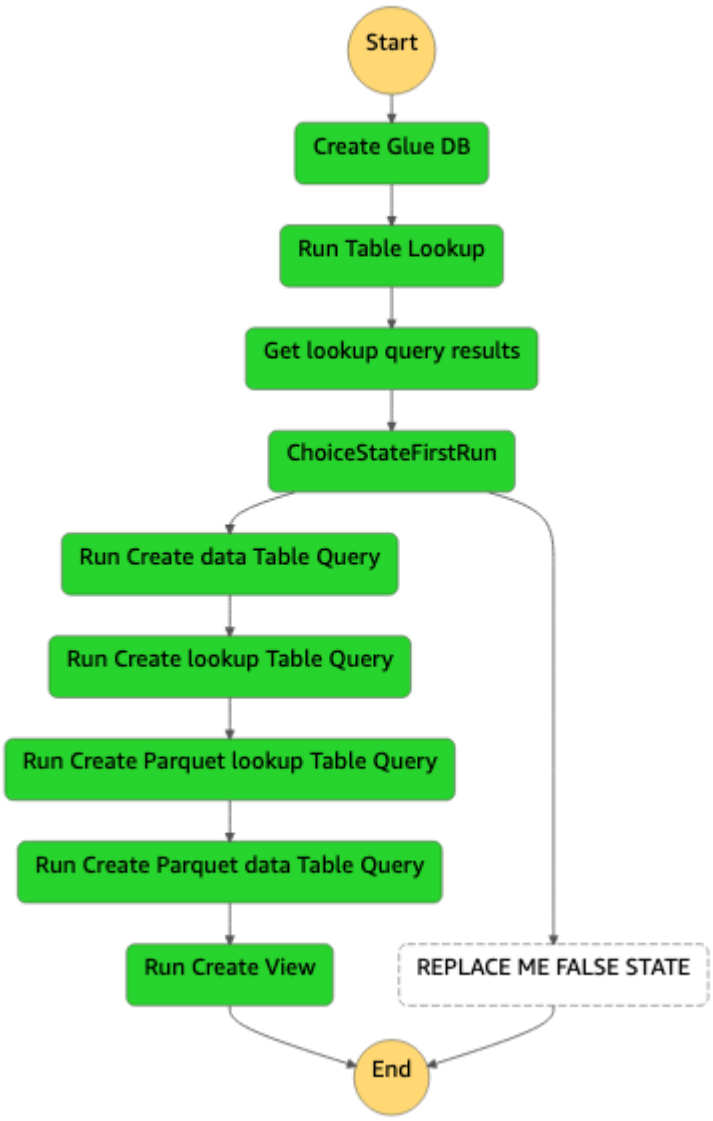
      Notice that the QueryString contains the same query that you ran to create the view by using the Athena query editor in the previous task.

    - Select ☐ **Wait for task to complete - optional**.
    - Choose **Save**.

37. Test the workflow.

    - Use the method that you used in previous steps to run the *WorkflowPOC* state machine. Name the test `TaskTenTest`

      The following image shows the completed workflow.



Excellent! You now have an entire ETL pipeline as a POC. The POC is constructed to be easy to use for a new project. To use the workflow, someone would only need to swap in the new bucket locations and update queries for the format of the data and how they want to partition it and condition it.

The only remaining issue that this implementation doesn't yet handle is when someone wants to process *new* time-sequence data (for example, February data). That is what you will work to handle next.

Task 11: Adding the new workflow for data injection

In this task, you will add the February data to the workflow.

The following command, which Mary provided, will insert the data for February (02).

```
INSERT INTO nyctaxidb.yellowtaxi_data_parquet select
vendorid,tpep_pickup_datetime,tpep_dropoff_datetime,passenger_count,trip_distance,ratecodeid,store_and_fwd_f
lag,pulocationid,dolocationid,fare_amount,extra,mta_tax,tip_amount,tolls_amount,improvement_surcharge,total_
amount,congestion_surcharge,payment_type,substr(\"tpep_pickup_datetime\",1,4) pickup_year,
substr(\"tpep_pickup_datetime\",6,2) AS pickup_month FROM nyctaxidb.yellowtaxi_data_csv where
substr(\"tpep_pickup_datetime\",1,4) = '2020' and substr(\"tpep_pickup_datetime\",6,2) = '02'"
```

You could run this command for each file; however, that would result in two CSV files and two Parquet files. You want to add data to only the Parquet table for the yellow taxi data.

You decide that an effective approach is to use a Step Functions *map* flow step, because this type of step can iterate over all five of the AWS Glue tables and pass over (skip) the tables that you don't want to update. In this way, you can run the statement on only the yellow taxi data Parquet file.

38. Add a map state to the workflow.
    - Use the method that you used in previous steps to open the *WorkflowPOC* state machine in Workflow Studio.
    - In the **Actions** panel, choose the **Flow** tab.
    - Drag a **Map** state to the canvas between the *REPLACE ME FALSE STATE* task and the *End* task.
    - Delete the *REPLACE ME FALSE STATE* task from the workflow.
    - With the **Map** state selected, change **State name** to `Check All Tables`
    - Choose **Provide a path to items array - optional**, enter `$.Rows`
    - Choose the **Input/Output** tab.
    - Select **Filter input with InputPath - optional**, and for the InputPath, enter `$.ResultSet`

      Analysis: The InputPath defines what data will be analyzed during each iteration.
    - Make sure that **Transform array item with Parameters** isn't selected.
    - Choose the **Configuration** tab.
    - For **Next state**, keep **Go to end** selected.

      Important: Don't apply the changes yet. You will add more to the workflow in the next step.

39. Add a choice state to the workflow.
    - From the **Flow** panel, drag a **Choice** state to the canvas where "Drop state here" appears after the *Check All Tables* state.
    - With the **Choice** state selected, change **State name** to `CheckTable`
    - In the **Choice Rules** section, for **Rule #1**, choose the edit icon and configure the following:
      - Choose **Add conditions**.
      - Keep the default **Simple** condition.
      - Keep **Not** blank. (Don't select an option.)
      - For **Variable**, enter `$.Data[0].VarCharValue`
      - For **Operator**, choose **matches string**.
      - For **Value**, enter `*data_parquet`

        Analysis: Each iteration through the AWS Glue table names will check whether the name matches the pattern that ends in *data_parquet*. If you look at the table names in the AWS Glue console, you will find that this pattern matches only one table, which is the desired logic.
    - Choose **Save conditions**.

      Important: Don't apply the changes yet. You will add more to the workflow in the next step.

40. Add a pass state to the workflow and configure the default choice logic.
    - From the **Flow** panel, drag a **Pass** state to the canvas after the *CheckTable* state, on the right side under the arrow that is labeled *Default*.
    - With the **Pass** state selected, change **State name** to `Ignore File`
    - On the canvas, choose the **Default** label on the arrow under the *CheckTable* state.
    - In the **Inspector** panel, in the **Choice Rules** section, open the **Default rule** details.

- For **Default state**, verify that **Ignore File** is selected.

  Important: Don't apply the changes yet. You will add more to the workflow in the next step.

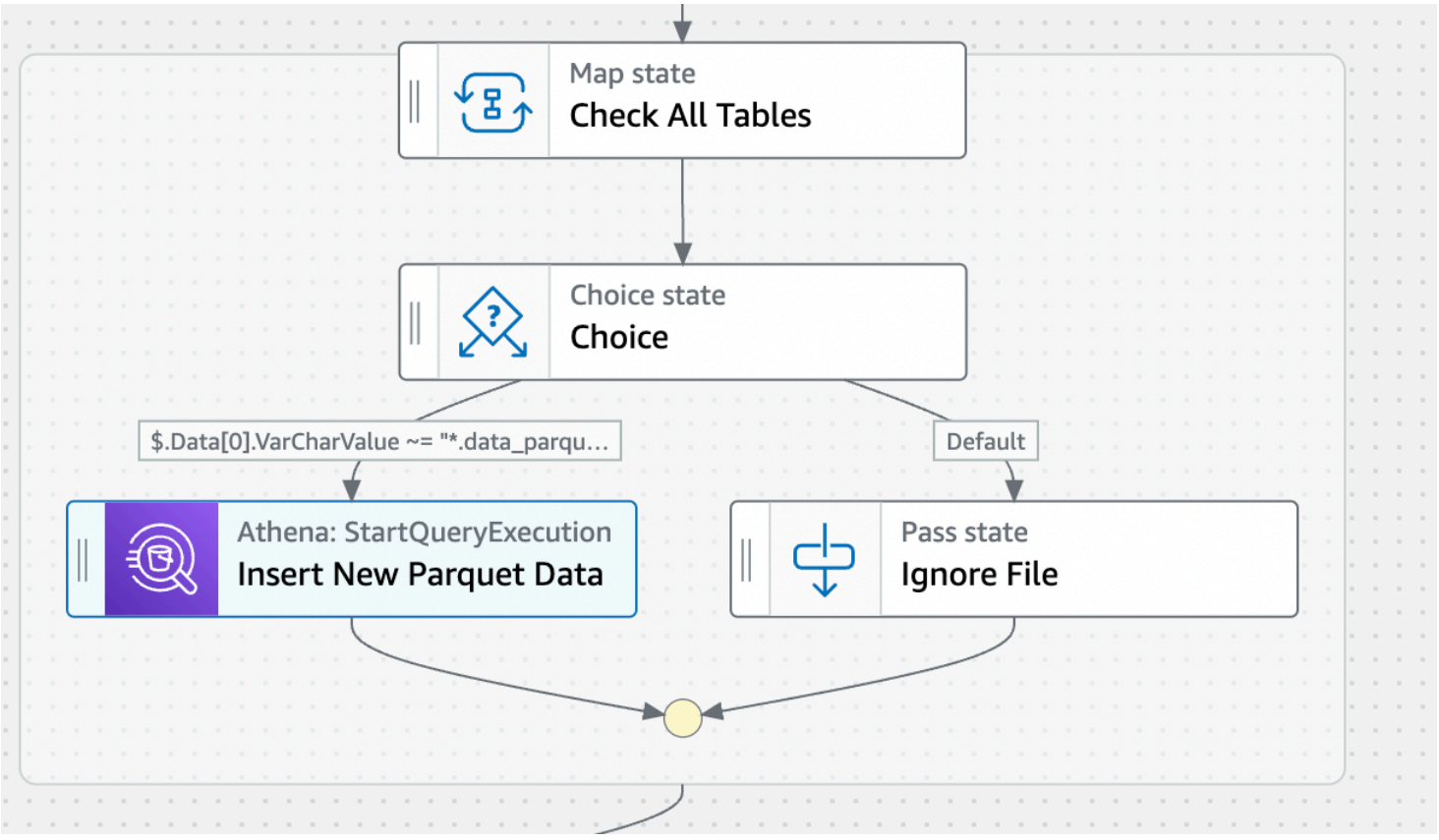
  Analysis: The default rule will be invoked for any AWS Glue table that isn't the one that you want to modify (which is all of the tables except the *yellowtaxi_data_parquet* table).

41. Add a StartQueryExecution task to the workflow to update the taxi Parquet table.
    - In the **Flow** panel, choose the **Actions** tab, and search for `athena`
    - Drag a **StartQueryExecution** task to the canvas after the *CheckTable* state, on the left side.
    - With the *StartQueryExecution* task selected, change **State name** to `Insert New Parquet Data`
    - For **API Parameters**, replace the default JSON code with the following. Replace *<FMI_1>* with your actual bucket name.

      Note: Mary provided this SQL statement to insert the February data. Notice the `02` at the end of the QueryString.

```
{
   "QueryString": "INSERT INTO nyctaxidb.yellowtaxi_data_parquet select
vendorid,tpep_pickup_datetime,tpep_dropoff_datetime,passenger_count,trip_distance,ratecodeid,store_a
nd_fwd_flag,pulocationid,dolocationid,fare_amount,extra,mta_tax,tip_amount,tolls_amount,improvement_
surcharge,total_amount,congestion_surcharge,payment_type,substr(\"tpep_pickup_datetime\",1,4)
pickup_year, substr(\"tpep_pickup_datetime\",6,2) AS pickup_month FROM nyctaxidb.yellowtaxi_data_csv
where substr(\"tpep_pickup_datetime\",1,4) = '2020' and substr(\"tpep_pickup_datetime\",6,2) =
'02'",
   "WorkGroup": "primary",
   "ResultConfiguration": {
     "OutputLocation": "s3://<FMI_1>/athena/"
   }
 }
```

    - Select ☐ **Wait for task to complete - optional**.
    - For **Next state**, keep **Go to end** selected.
    - Confirm that the new logic that you added to the workflow looks like the following image:



    - Choose **Save**.

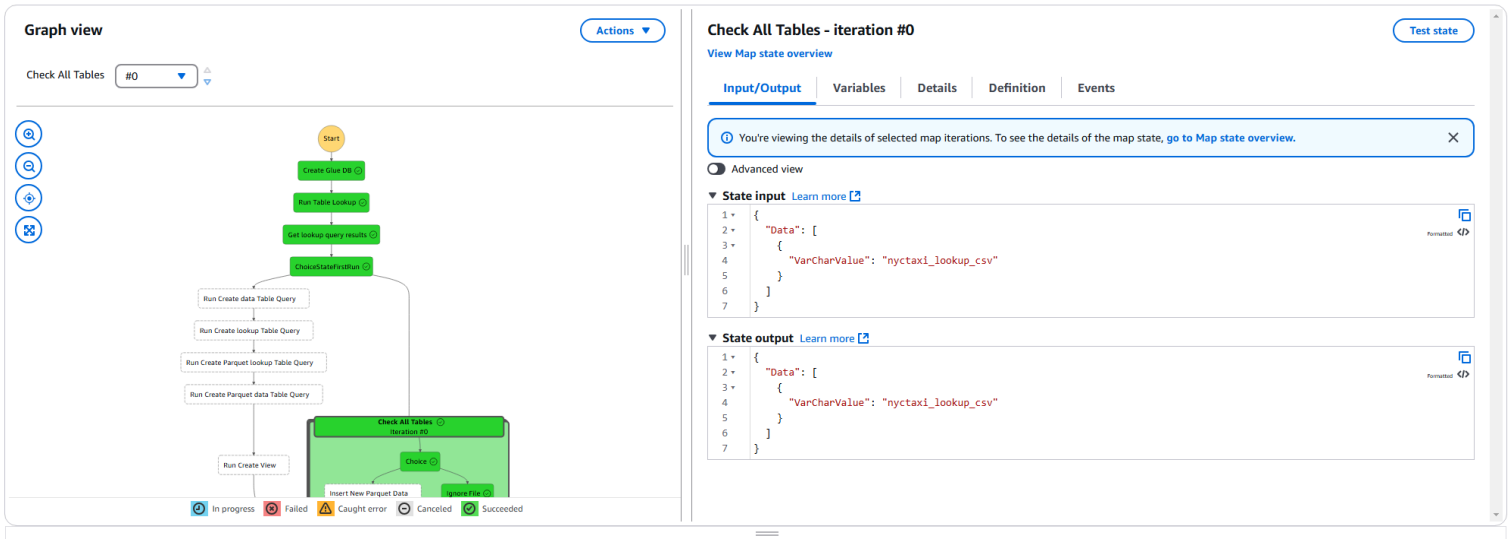
Excellent! You successfully added the final bit of logic to the workflow. This logic will process the additional month of taxi data.

Task 12: Testing the complete solution

In this last task, you will test the completed POC solution.

42. Choose **Execute**. For **Name**, enter `TaskTwelveTest` and then choose **Start execution**.
43. Verify that the iterator is working as expected.
    - In the **Graph Inspector** section, choose the **Check All Tables** step.

      At the top of the section, two dropdown menus appear for **Iteration status** and **Index**. By default, the first iteration with an index value of **0** is selected.
    - In the **Details** panel to the right, verify that the first iteration succeeded.
    - Change **Index** to **1**, and verify that the iteration succeeded.
    - Repeat these steps for iterations **2**, **3**, and **4**. They should all have succeeded.
    - Change **Index** back to **0**.
    - Choose the **Step input** tab, and verify that the JSON code looks like the following image. VarCharValue should be set to *nyctaxi_lookup_csv*.



    - While you stay on the **Step input** tab, change **Index** until VarCharValue in the JSON code is equal to *yellowtaxi_data_parquet*.
    - In the graph, choose the **Insert New Parquet Data** step.
    - Choose the **Step output** tab.

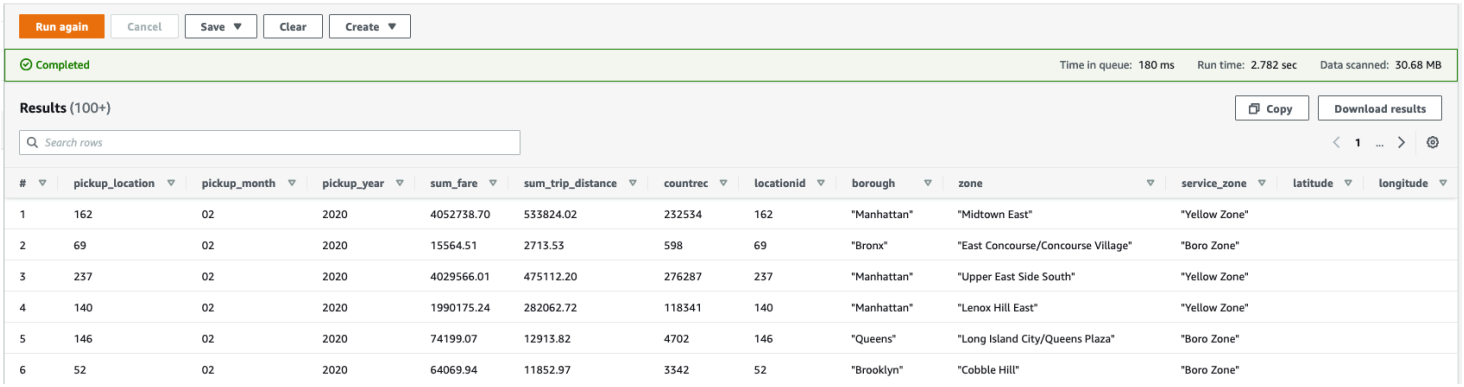
      Here you see the query that created the view in addition to other step run details.

44. Test in the Athena console.
    - In the **Athena** console, open the query editor, and ensure that **nyctaxidb** is selected for **Database**.
    - In the **Views** section, choose the three-dot icon () for the listed view, and then choose **Preview View**.

      The first 10 records from the results display. Notice that the view is now scanning data that includes the month *02* (February).
    - To verify that the February taxi data is also in the dataset, run the following query in the query editor:

```
SELECT * FROM "nyctaxidb"."yellowtaxi_data_vw" WHERE pickup_month = '02'
```

The first 100 results display as shown in the following image.


Run again | Cancel | Save | Clear | Create

Completed — Time in queue: 180 ms — Run time: 2.782 sec — Data scanned: 30.68 MB

Results (100+) — Copy — Download results

Search rows — 1 ...

#	pickup_location	pickup_month	pickup_year	sum_fare	sum_trip_distance	countrec	locationid	borough	zone	service_zone	latitude	longitude
1	162	02	2020	4052738.70	533824.02	232534	162	"Manhattan"	"Midtown East"	"Yellow Zone"		
2	69	02	2020	15564.51	2713.53	598	69	"Bronx"	"East Concourse/Concourse Village"	"Boro Zone"		
3	237	02	2020	4029566.01	475112.20	276287	237	"Manhattan"	"Upper East Side South"	"Yellow Zone"		
4	140	02	2020	1990175.24	282062.72	118341	140	"Manhattan"	"Lenox Hill East"	"Yellow Zone"		
5	146	02	2020	74199.07	12913.82	4702	146	"Queens"	"Long Island City/Queens Plaza"	"Boro Zone"		
6	52	02	2020	64069.94	11852.97	3342	52	"Brooklyn"	"Cobble Hill"	"Boro Zone"		

Excellent! The ETL pipeline can now also handle the additional data and integrate it into the view so that the data can be queried from Athena.

Update from the team

After building the complete POC, you provided a quick demonstration to Mary. She was quite impressed!

Mary said that she is confident that she can duplicate this POC and adjust the hardcoded values in it as needed for each project. She can't wait to start using the ETL pipeline that you created to accelerate her data processing across her many projects.

Submitting your work

45. To record your progress, choose **Submit** at the top of these instructions.

46. When prompted, choose **Yes**.

    After a couple of minutes, the grades panel appears and shows you how many points you earned for each task. If the results don't display after a couple of minutes, choose **Grades** at the top of these instructions.

    Tip: You can submit your work multiple times. After you change your work, choose **Submit** again. Your last submission is recorded for this lab.

47. To find detailed feedback about your work, choose **Submission Report**.

Lab complete

Congratulations! You have completed the lab.

48. At the top of this page, choose **End Lab**, and then choose **Yes** to confirm that you want to end the lab.

    A message panel indicates that the lab is terminating.

49. To close the panel, choose **Close** in the upper-right corner.