This lab covers how to create Apache Iceberg™ tables that use Snowflake as the catalog and support read and write operations. Iceberg tables for Snowflake combine the performance and query semantics of regular Snowflake tables with external cloud storage that you manage.

Complete this tutorial using a worksheet in Snowsight or using a Snowflake client such as SnowSQL. You can copy and paste the code examples, and then run them.

## What you'll learn

In this tutorial, you'll learn how to do the following:

- Create and configure an external volume for Snowflake-managed Iceberg tables. For demonstration purposes, the tutorial creates an external volume for Amazon S3.
- Create two Iceberg tables that use Snowflake as the Iceberg catalog (Snowflake-managed tables).
- Insert data into the Iceberg tables.
- Query the Iceberg tables.
- Delete rows from an Iceberg table.

## Prerequisites

Before you start, you should be familiar with the following:

- Snowflake object identifiers and their requirements.
- Apache Iceberg and Iceberg tables in Snowflake. For more information, see Apache Iceberg™ tables.
- Cloud object storage.
- If using S3, you should be familiar with AWS Identity and Access Management (IAM) and IAM policy elements.

You need:

- A Snowflake user with a role that has the privileges to perform the following actions:
    - CREATE WAREHOUSE
    - CREATE DATABASE

    - CREATE EXTERNAL VOLUME
    - CREATE ICEBERG TABLE
- If using a 30-day trial account, you can log in as the user that was created for the account. This user has the role with the privileges needed to create the objects.
  If you don't have a user with the necessary permissions, ask someone who does to create one for you. Users with the ACCOUNTADMIN role can create new users and grant them the required privileges.
- Administrator access for your cloud storage provider in order to configure an external volume.
- A storage bucket (or container) with the same cloud provider, in the same region that hosts your Snowflake account.
- Access to the SNOWFLAKE_SAMPLE_DATA database in your account. Snowflake creates the sample database in new accounts by default. If the database has not been created in your account, see Using the Sample Database.

To begin, set up your environment by creating a warehouse and database for this lab.

```
CREATE WAREHOUSE iceberg_tutorial_wh
  WAREHOUSE_TYPE = STANDARD
  WAREHOUSE_SIZE = XSMALL;

USE WAREHOUSE iceberg_tutorial_wh;

CREATE OR REPLACE DATABASE iceberg_tutorial_db;
USE DATABASE iceberg_tutorial_db;
```

Before you can create an Apache Iceberg™ table for Snowflake, you must have an external volume. An external volume is an account-level Snowflake object that stores an identity and access management (IAM) entity for your external cloud storage.

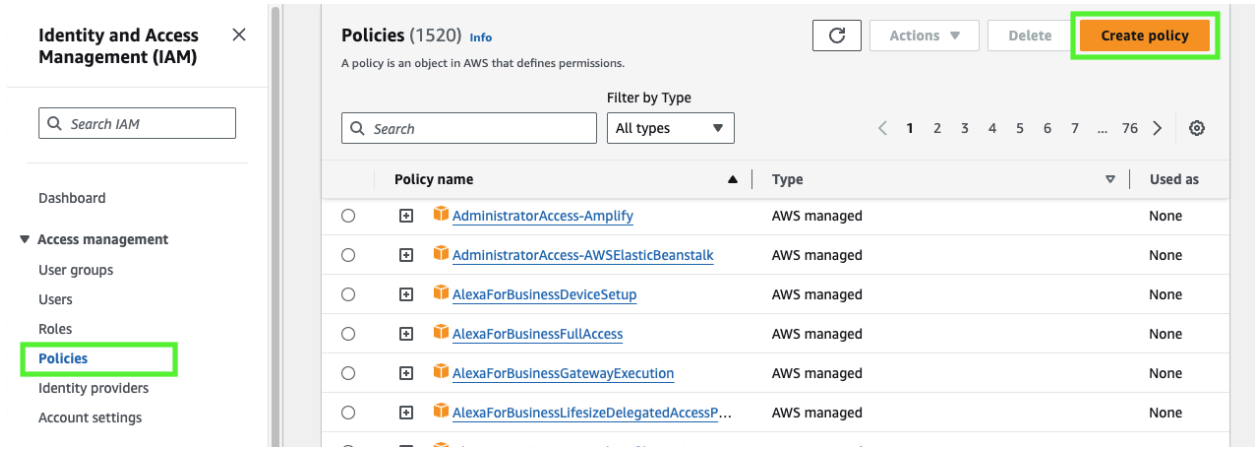
Snowflake uses the external volume to securely connect to your cloud storage to access table data and metadata.

For demonstration purposes, this step covers how to create an external volume for Amazon S3. To create an external volume for a different cloud storage service, see the following topics:

- Configure an external volume for Google Cloud Storage
- Configure an external volume for Azure

## Create an IAM policy that grants access to your S3 location

To configure access permissions for Snowflake in the AWS Management Console, do the following:

1. Log in to the AWS Management Console.
2. From the home dashboard, search for and select **IAM**.
3. From the left-hand navigation pane, select **Account settings**.
4. Under **Security Token Service (STS)** in the **Endpoints** list, find the Snowflake region where your account is located. If the **STS status** is inactive, move the toggle to **Active**.
5. From the left-hand navigation pane, select **Policies**.
6. Select **Create Policy**.
7. 

8. For **Policy editor**, select **JSON**.
9. Add a policy to provide Snowflake with the required permissions to read and write data to your S3 location.

   The following example policy grants access to all locations in the specified bucket.

   **Note**

   - Replace *my_bucket* with your actual bucket name. You can also specify a path in the bucket; for example, *my_bucket/path*.
   - Setting the `"s3:prefix":` condition to `["*"]` grants access to all prefixes in the specified bucket; setting it to `["path/*"]` grants access to a specified path in the bucket.

- For buckets in government regions, the bucket ARNs use the `arn:aws-us-gov:s3:::` prefix.

For the purpose of the lab, we created a file called “S3_Policy.json” that you can use.

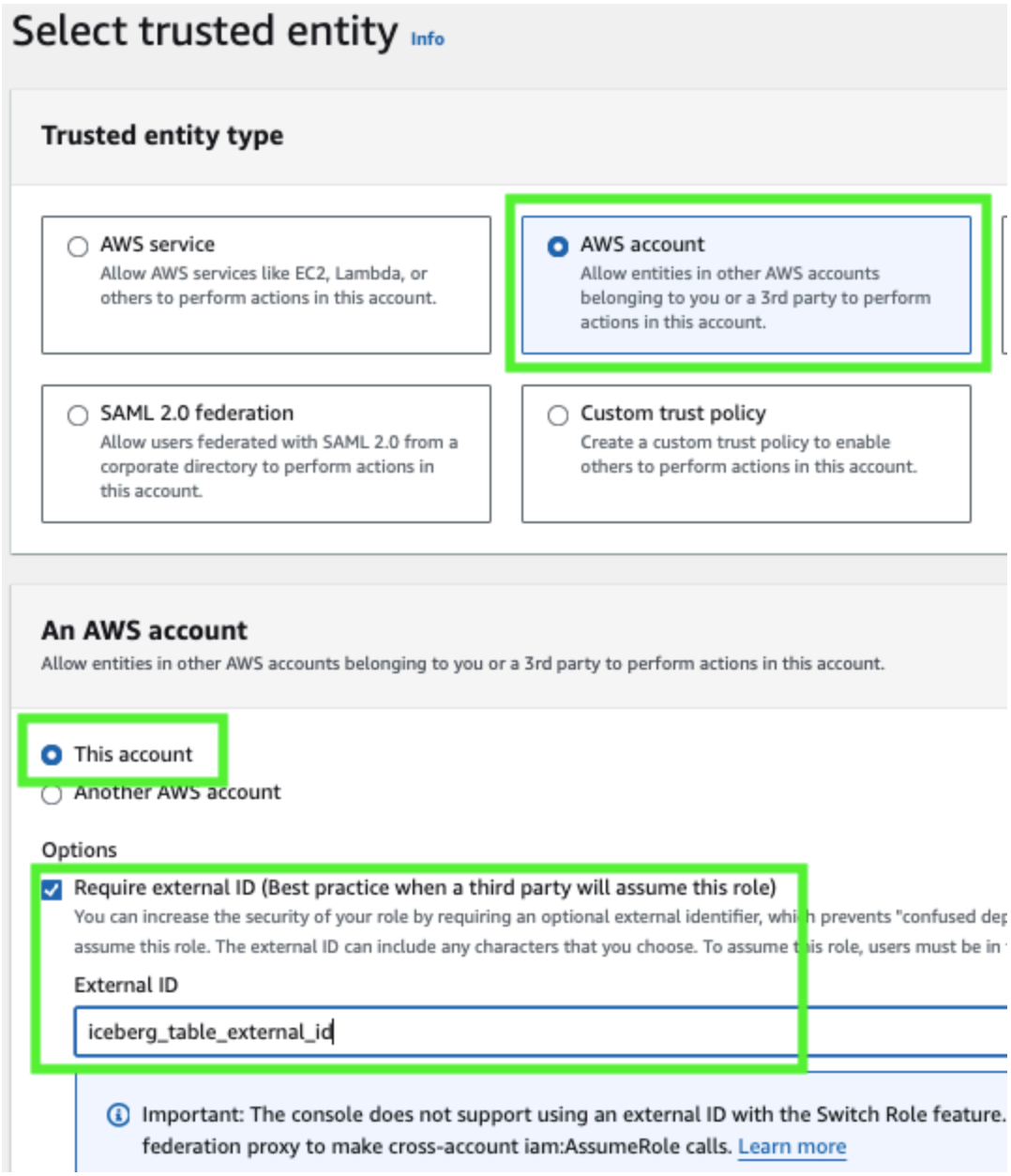
1. Select **Next**.
2. Enter a **Policy name** (for example, `snowflake_access`) and an optional **Description**.
3. Select **Create policy**.

## Create an IAM role

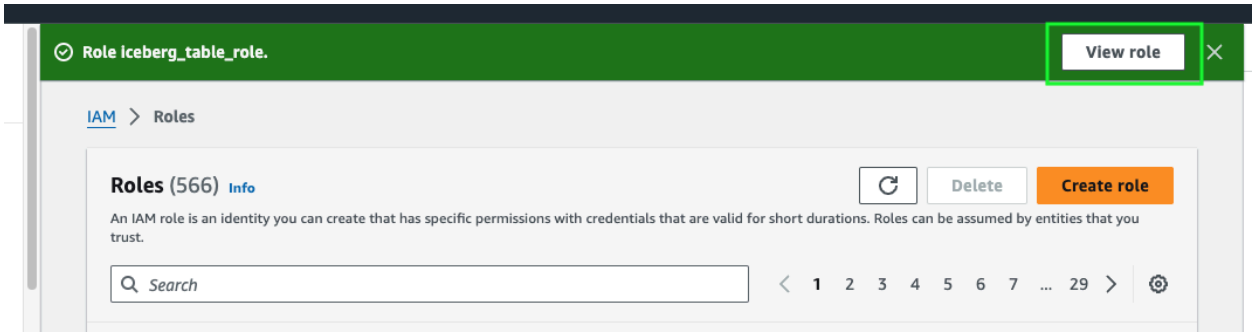
Create an AWS IAM role to grant privileges on the S3 bucket containing your data files.

1. From the left-hand navigation pane in the Identity and Access Management (IAM) Dashboard, select **Roles**.
2. Select **Create role**.
3. For the trusted entity type, select **AWS account**.
4. Under **An AWS account**, select **This account**. In a later step, you modify the trust relationship and grant access to Snowflake.
5. Select the **Require external ID** option. Enter an external ID of your choice. For example, `iceberg_table_external_id`.

   An external ID is used to grant access to your AWS resources (such as S3 buckets) to a third party like Snowflake.

6. 

7. Select **Next**.
8. Select the policy that you created for the external volume, then select **Next**.
9. Enter a **Role name** and description for the role, then select **Create role**.
   You have now created an IAM policy for an S3 location, created an IAM role, and attached the policy to the role.
10. Select **View role** to view the role summary page. Locate and record the **ARN** (Amazon Resource Name) value for the role.

11. 


## Create an external volume in Snowflake

Create an external volume using the CREATE EXTERNAL VOLUME command. The following example creates an external volume named `iceberg_external_volume` that defines a single Amazon S3 storage location with encryption.

```
CREATE OR REPLACE EXTERNAL VOLUME iceberg_external_volume
   STORAGE_LOCATIONS =
      (
         (
            NAME = 'my-s3-us-west-2'
            STORAGE_PROVIDER = 'S3'
            STORAGE_BASE_URL = 's3://<my_bucket>/'
            STORAGE_AWS_ROLE_ARN = '<arn:aws:iam::123456789012:role/myrole>'
            STORAGE_AWS_EXTERNAL_ID = 'iceberg_table_external_id'
         )
      );
```

The example specifies the external ID (`iceberg_table_external_id`) associated with the IAM role that you created for the external volume. Specifying an external ID lets you use the same IAM role (and external ID) across multiple external volumes.

**Note**

Specify ARNs exactly as provided by AWS. ARNs are case-sensitive.

## Retrieve the AWS IAM user for your Snowflake account

Retrieve the ARN for the AWS IAM user that was created automatically for your Snowflake account using the DESCRIBE EXTERNAL VOLUME command. Specify the name of your external volume.

The following example describes an external volume named `iceberg_external_volume`.

```
DESC EXTERNAL VOLUME iceberg_external_volume;
```

1. Record the value for the `STORAGE_AWS_IAM_USER_ARN` property, which is the AWS IAM user created for your Snowflake account; for example, `arn:aws:iam::123456789001:user/abc1-b-self1234`.
   Snowflake provisions a single IAM user for your entire Snowflake account. All S3 external volumes in your account use that IAM user.
   **Note**
   If you didn't specify an external ID (`STORAGE_AWS_EXTERNAL_ID`) when you created an external volume, Snowflake generates an ID for you to use. Record the value so that you can update your IAM role trust policy with the generated external ID.

## Grant the IAM user permissions to access bucket objects

In this step, you configure permissions that allow the IAM user for your Snowflake account to access objects in your S3 bucket.

1. Log in to the AWS Management Console.
2. From the home dashboard, search for and select **IAM**.
3. From the left-hand navigation pane, select **Roles**.
4. Select the IAM role that you created for your external volume.
5. Select the **Trust relationships** tab.
6. Select **Edit trust policy**.
7. Modify the policy document with the DESC EXTERNAL VOLUME output values that you recorded.

8. 

9. **Policy document for IAM role**
10. 
```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "",
      "Effect": "Allow",
      "Principal": {
        "AWS": "<snowflake_user_arn>"
      },
      "Action": "sts:AssumeRole",
      "Condition": {
        "StringEquals": {
          "sts:ExternalId": "<iceberg_table_external_id>"
        }
      }
    }
  ]
}
```
11. Where:
    a. *`snowflake_user_arn`* is the STORAGE_AWS_IAM_USER_ARN value you recorded.
    b. *`iceberg_table_external_id`* is your external ID. If you *already* specified an external ID when you created the role, and used the same ID to create your

external volume, leave the value as-is. Otherwise, update `sts:ExternalId` with the value that you recorded.

12. Note

    You must update this policy document if you create a new external volume (or recreate an existing external volume using the CREATE OR REPLACE EXTERNAL VOLUME syntax) and don't provide your own external ID. For security reasons, a new or recreated external volume has a different external ID and cannot resolve the trust relationship unless you update this trust policy.
13. Select Update policy to save your changes.

# Create a table

In this step, you'll create two Apache Iceberg™ tables: one with the standard CREATE ICEBERG TABLE syntax, and another with the CREATE ICEBERG TABLE … AS SELECT variant. Both tables use the external volume configured in the previous step.

You'll also learn how to set the Iceberg catalog and external volume at the database level.

## Create a table using the standard syntax

First, create an Iceberg table using the standard CREATE ICEBERG TABLE syntax.

Specify `CATALOG = 'SNOWFLAKE'` so that the table uses Snowflake as the Iceberg catalog.

To tell Snowflake where to write table data and metadata, specify a value for the `BASE_LOCATION` parameter. The example sets the table name (`customer_iceberg`) as the `BASE_LOCATION`. This way, Snowflake writes data and metadata under a directory with the same name as the table in your external volume location.

```
CREATE OR REPLACE ICEBERG TABLE customer_iceberg (
    c_custkey INTEGER,
    c_name STRING,
    c_address STRING,
    c_nationkey INTEGER,
    c_phone STRING,
    c_acctbal INTEGER,
    c_mktsegment STRING,
    c_comment STRING
)
    CATALOG = 'SNOWFLAKE'
    EXTERNAL_VOLUME = 'iceberg_external_volume'
    BASE_LOCATION = 'customer_iceberg';
```

Later in the tutorial, you load data into this table from the `snowflake_sample_data.tpch_sf1.customer` table in the SNOWFLAKE_SAMPLE_DATA database. The column definitions in the CREATE ICEBERG TABLE statement match the sample table.

**Note**

If you check your cloud storage location, you should now see a directory named `metadata/` that Snowflake wrote during table creation under your `BASE_LOCATION`. The directory stores the metadata files for your table.

## Set the catalog integration and external volume for the database

Next, set the `CATALOG` and `EXTERNAL_VOLUME` parameters for the `iceberg_tutorial_db` that you created in this tutorial. Setting the parameters tells Snowflake to use the specific catalog and external volume that you choose for *all* Iceberg tables created after the change.

To verify, check the parameters for the current database (`iceberg_tutorial_db`):

```
ALTER DATABASE iceberg_tutorial_db SET CATALOG = 'SNOWFLAKE';
ALTER DATABASE iceberg_tutorial_db SET EXTERNAL_VOLUME = 'iceberg_external_volume';

SHOW PARAMETERS IN DATABASE ;
```

### Create a table using CTAS

Finally, create a second Iceberg table called `nation_iceberg` using the CREATE ICEBERG TABLE … AS SELECT syntax. We'll base the new table on the `snowflake_sample_data.tpch_sf1.nation` table in the Snowflake sample database.

**Note**

Since you just set the `CATALOG` and `EXTERNAL_VOLUME` parameters for the `iceberg_tutorial_db` database, you can omit both parameters from the CREATE ICEBERG TABLE statement. The `nation_iceberg` table will inherit the values from the database.

```
CREATE OR REPLACE ICEBERG TABLE nation_iceberg (
  n_nationkey INTEGER,
  n_name STRING
)
  BASE_LOCATION = 'nation_iceberg'
  AS SELECT
    N_NATIONKEY,
    N_NAME
  FROM snowflake_sample_data.tpch_sf1.nation;
```

## Load data and query the tables

In this step, you start by loading data from the Snowflake sample database into the `customer_iceberg` table using `INSERT INTO <table>`:

```
INSERT INTO customer_iceberg
  SELECT * FROM snowflake_sample_data.tpch_sf1.customer;
```

**Note**

If you check your cloud storage location, you should now see a directory that contains your table data files at the following path: *`STORAGE_BASE_URL`*`/`*`BASE_LOCATION`*`/customer_iceberg/data/`.

Now that there's data in the table, you can query the table. The following query joins the `customer_iceberg` table with the `nation_iceberg` table (which already contains data).

```
SELECT
    c.c_name AS customer_name,
    c.c_mktsegment AS market_segment,
    n.n_name AS nation
  FROM customer_iceberg c
  INNER JOIN nation_iceberg n
    ON c.c_nationkey = n.n_nationkey
  LIMIT 15;
```

Output:

```
+--------------------+----------------+----------------+
| CUSTOMER_NAME      | MARKET_SEGMENT | NATION         |
|--------------------+----------------+----------------|
| Customer#000015001 | HOUSEHOLD      | MOROCCO        |
| Customer#000015002 | BUILDING       | VIETNAM        |
| Customer#000015003 | BUILDING       | INDONESIA      |
| Customer#000015004 | FURNITURE      | SAUDI ARABIA   |
| Customer#000015005 | HOUSEHOLD      | KENYA          |
| Customer#000015006 | BUILDING       | UNITED KINGDOM |
| Customer#000015007 | MACHINERY      | FRANCE         |
| Customer#000015008 | HOUSEHOLD      | INDIA          |
| Customer#000015009 | FURNITURE      | EGYPT          |
| Customer#000015010 | HOUSEHOLD      | ETHIOPIA       |
| Customer#000015011 | FURNITURE      | UNITED KINGDOM |
| Customer#000015012 | BUILDING       | FRANCE         |
| Customer#000015013 | FURNITURE      | SAUDI ARABIA   |
| Customer#000015014 | HOUSEHOLD      | KENYA          |
| Customer#000015015 | MACHINERY      | ROMANIA        |
+--------------------+----------------+----------------+
```

In this step, you use a DELETE statement to remove specific rows from the `customer_iceberg` table.

Start by querying the first 10 rows of the table and notice that four rows belong to the `AUTOMOBILE` market segment:

```
SELECT
  c_name AS customer_name,
  c_mktsegment AS market_segment
FROM customer_iceberg
LIMIT 10;
```

Output:

```
+--------------------+----------------+
| CUSTOMER_NAME      | MARKET_SEGMENT |
|--------------------+----------------|
| Customer#000000001 | BUILDING       |
| Customer#000000002 | AUTOMOBILE     |
| Customer#000000003 | AUTOMOBILE     |
| Customer#000000004 | MACHINERY      |
| Customer#000000005 | HOUSEHOLD      |
| Customer#000000006 | AUTOMOBILE     |
| Customer#000000007 | AUTOMOBILE     |
| Customer#000000008 | BUILDING       |
| Customer#000000009 | FURNITURE      |
| Customer#000000010 | HOUSEHOLD      |
+--------------------+----------------+
```

Next, let's use a DELETE statement to remove all of the rows from the table where the market segment is `AUTOMOBILE`:

```
DELETE FROM customer_iceberg WHERE c_mktsegment = 'AUTOMOBILE';
```

Output:

```
+-------------------------+
| number of rows deleted |
|-------------------------|
|                   29752 |
+-------------------------+
```

```
SELECT
  c_name AS customer_name,
  c_mktsegment AS market_segment
FROM customer_iceberg
WHERE c_mktsegment = 'AUTOMOBILE'
```

Output:

```
+---------------+----------------+
| CUSTOMER_NAME | MARKET_SEGMENT |
|---------------+----------------|
+---------------+----------------+
0 Row(s) produced. Time Elapsed: 1.426s
```

Congratulations!

You've just written to, read from, and modified your first Snowflake-managed Iceberg tables. You've also learned how to configure an external volume for Iceberg table storage and set the Iceberg catalog and external volume for all Iceberg tables in a database.