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Snowflake
The Definitive Guide

Architecting, Designing, and Deploying on the Snowflake Data Cloud

Early Release
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Joyce Kay Avila

Snowflake: The Definitive Guide

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With Early Release ebooks, you get books in their earliest form—the author's raw and unedited content as they write—so you can take advantage of these technologies long before the official release of these titles.

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by Joyce Kay Avila

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Chapter 1. Creating and Managing Snowflake Architecture

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This will be the 2nd chapter of the final book.

If you have comments about how we might improve the content and/or examples in this book, or if you notice missing material within this chapter, please reach out to the editor at *mcronin@oreilly.com*.

In the last decade, computer data storage and computer performance had to evolve. Teams, both large and small, near or far apart, often need access to the same data at the same time. Having access to that data and the ability to generate actionable insights quickly is now an absolutely must. Just from the sheer amount and complexity of today's data, data warehouses had to evolve into incredibly data-intensive applications. Yet, as we'll discover in the next section, simply making modifications to existing data warehouse architectures did not solve the scalability problem. Then, Snowflake burst onto the scene with a unique architecture.

The Snowflake Data Cloud is an evolutionary modern data warehouse that solved the scalability problem. Compared to traditional cloud data warehouse architectures, Snowflake enables data storage and processing that is significantly faster and easier to use and is much more affordable. Snowflake's Data Cloud provides users with a unique experience by combining a new SQL query engine with an innovative architecture that was designed and built from the ground up and specifically for the cloud.

Snowflake Architecture

In this section, we'll briefly review some traditional data warehouse architectures and approaches that were designed to improve scalability. Scalability is the ability of a system to handle an increasing amount of work. We'll also discuss the limitations of these data warehouse architectures. Then, we will discover what makes the Snowflake Data Cloud architecture so unique. Afterward, we will learn about each of the three different Snowflake architecture layers in detail: Cloud Services Layer, Query Processing (Virtual Warehouse) Compute Layer, and the Centralized (Hybrid-Columnar) Database Storage Layer.

Shared-Disk (Scalable) Data Warehouse Architecture

The shared-disk architecture was an early scaling approach designed to keep data stored in a central storage location, accessible from multiple database cluster nodes (Figure 1-1). The data accessed by each of the cluster nodes is consistently available because all data modifications are written to the shared disk. This architecture is a traditional database design and is known for the simplicity of its data management. While the approach is simple in theory, it requires complex on-disk locking mechanisms to ensure data consistency. Additionally, concurrency is a major problem and adding more compute nodes only compounds the problem. Therefore, the true scalability of this architecture is limited.

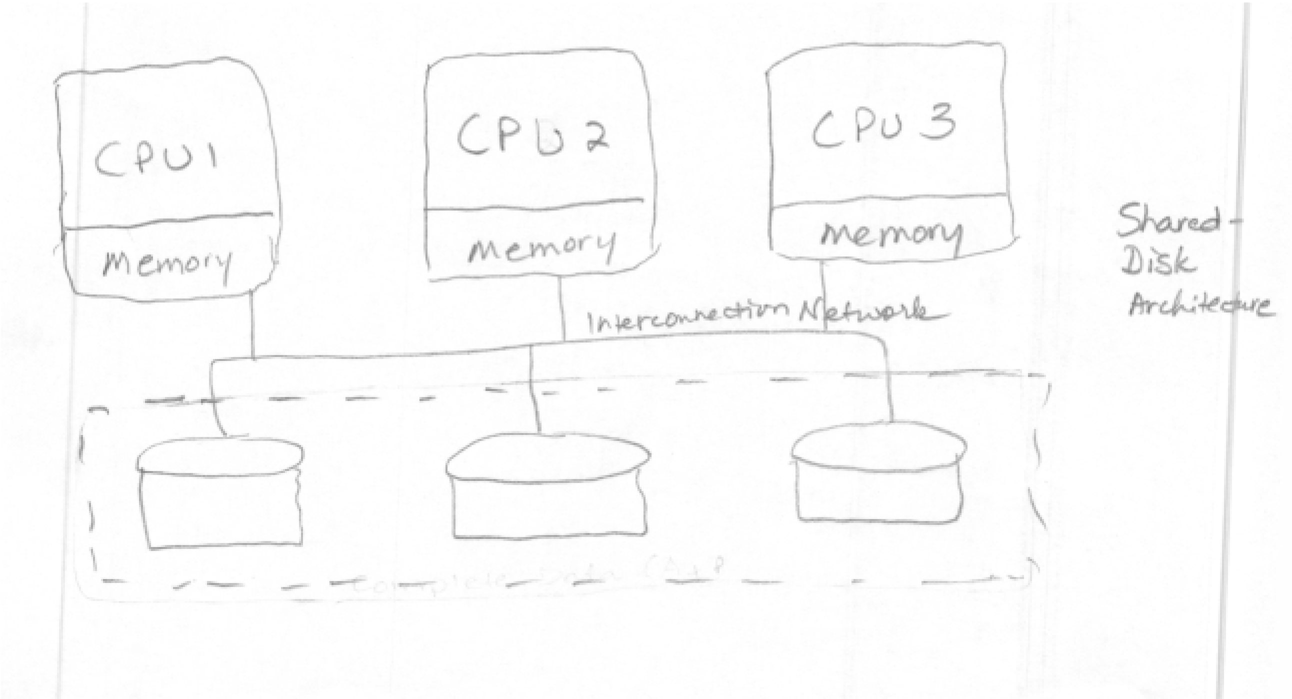


Figure 1-1. Shared-Disk Architecture

Shared-Nothing (Scalable) Data Warehouse Architecture

The shared-nothing architecture, in which processing and compute is scaled together (Figure 2-2), was designed in response to the bottleneck created by the shared-disk architecture. This evolution in architecture was made possible because storage had become relatively inexpensive. However, distributed cluster nodes along with the associated disk storage, CPU, and memory, requires data to be shuffled between nodes, which adds overhead. Depending on how the data is distributed across the nodes will determine the extent of the additional overhead. Striking the right balance between storage and compute is especially difficult. Even when it is possible to resize a cluster, it takes time to do so. Thus, organizations often overprovision shared-nothing resources, which results in unused, unneeded resources.

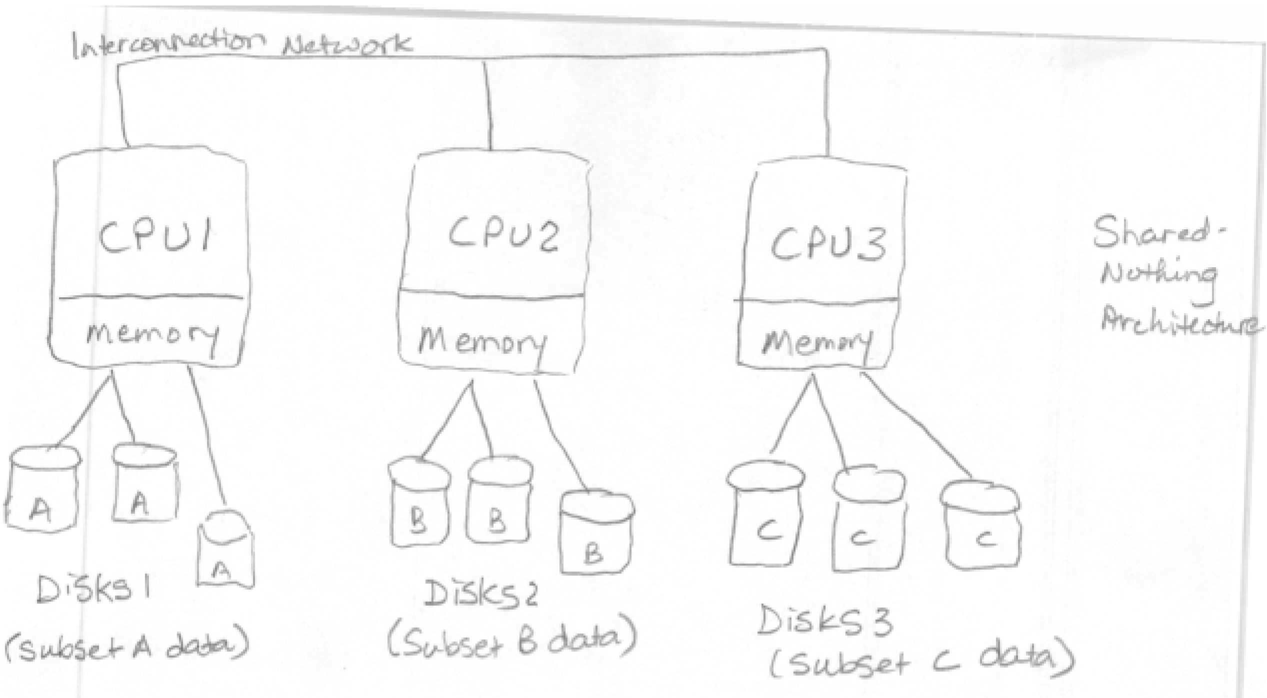


Figure 1-2. Shared-Nothing Architecture

NoSQL Alternatives

Most NOSQL solutions rely on shared-nothing architecture; thus, they have many of the same limitations. However, the benefit of NoSQL solutions is that they can store non-relational data without first requiring transformation of the data. Additionally, most NoSQL systems don't require schemas. NoSQL, a term that implies "Not Only SQL" rather than "NO to SQL", is a good choice for storing e-mail, web links, social media posts and tweets, road maps, and spatial data.

There are four types of NoSQL databases. Document-based NoSQL databases such as MongoDB store data in JSON objects where each document has key-value pair like structures. Key-value databases such as DynamoDB are especially useful for capturing customer behavior in a specific session. Cassandra is an example of a column-based database where large numbers of dynamic columns are logically grouped into column families. Graph-based databases, such as Neo4j and Amazon Neptune, work well for recommendation engines and social networks where they are able to help find patterns or relationships among data points.

The NoSQL solutions, however, are not database warehouse replacements. While NoSQL alternatives can be useful for data scientists, they do not perform well for analytics. Additionally, NoSQL alternative solutions require rare skillsets and aren't compatible with most SQL-based tools.

Snowflake's Hybrid Columnar Architecutre

Rather than trying to incrementally improve or transform existing software architecture, the Snowflake team's approach was to build an entirely new modern data warehouse that allows multiple users to concurrently share live data. The unique Snowflake design physically separates but logically integrates storage and compute along with providing services such as security and management. Snowflake's processing engine is native SQL and, as we will see in later chapters, Snowflake is also able to handle semi-structured and unstructured data.

The Snowflake hybrid-model architecture is comprised of three layers (Figure 2-3) known as the cloud services layer, the compute layer, and the data storage layer. Each of these layers, along with the three Snowflake caches, are discussed in more detail in the following sections.

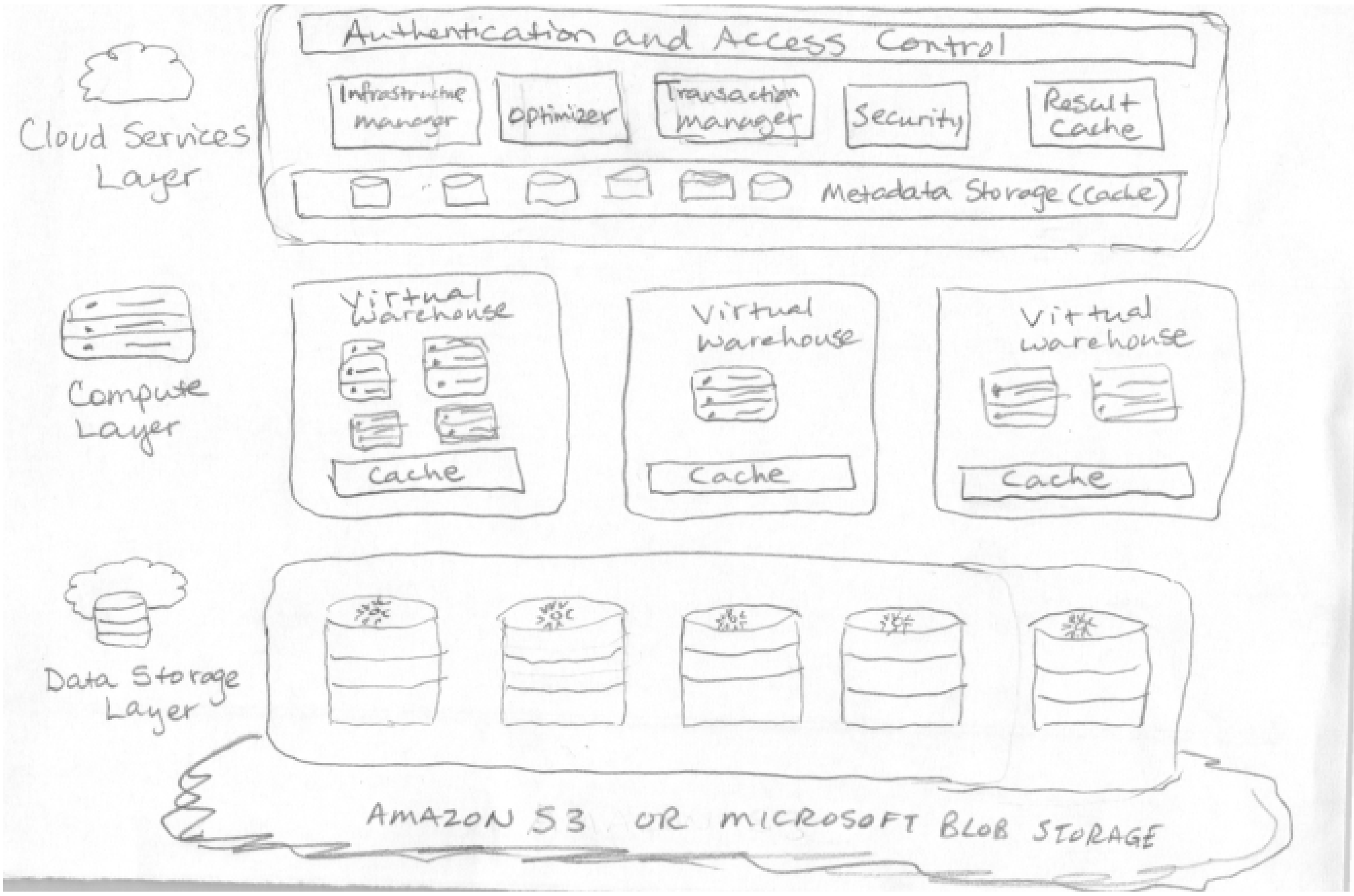


Figure 1-3. Snowflake's hybrid columnar architecture

Managing the Cloud Services Layer

All interactions with data in a Snowflake instance begin in the cloud services layer, also called the global services layer (Figure 1-4). The Snowflake cloud services layer is a collection of services that coordinate activities such as access control and encryption. It also includes management functions for handling infrastructure and metadata, as well as performing query parsing and optimization, among other features. This global services layer is sometimes referred to as the Snowflake "brain" because all the various service layer components work together to handle user requests that begin from the time a user requests to log in.

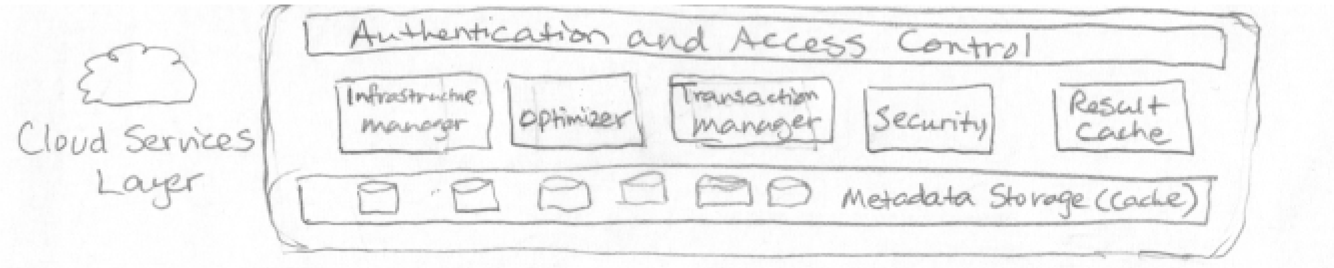


Figure 1-4. Snowflake Cloud Services Layer

Each time a user requests to log in, their request is handled by the services layer. When a user submits a Snowflake query, the SQL query will be sent to the cloud services layer optimizer before being sent to the compute layer for processing. The service layer is what enables the SQL client interface for Data Definition Language (DDL) and Data Manipulation Language (DML) operations on data.

The cloud services layer manages data security including the security for data sharing. The Snowflake cloud services layer runs across multiple availability zones and holds the result cache, a cached copy of the executed queries. The metadata required for query optimization or data filtering are also stored in the cloud services layer. Like the other Snowflake layers, the cloud services layer can be scaled independently.

Billing for the Cloud Services Layer

In February 2020, Snowflake began separately charging for cloud services consumption, across all warehouses, that exceeds 10% of the daily compute credit usage. The charge is calculated daily in the UTC time zone.

All queries use a small amount of cloud services resources. Data Definition Language operations are metadata operations. As such, they use only cloud services. Keeping both facts in mind, we should evaluate some situations where we know the cost will be higher for cloud services to consider whether the benefits will be worth the increased costs.

Using several simple queries, especially queries using the “Select Session” command, or large complex queries with many joins, will result in increased usage of the cloud services layer. Single row inserts, rather than bulk or batch loading, will also result in higher cloud services consumption. Finally, you’ll consume only cloud services resources if you use Information_Schema commands or certain metadata-only commands such as the “Show” command. If you are experiencing higher than expected costs for cloud services, you may want to investigate these situations. Be sure to also investigate any partner tools, including those using the JDBC driver, as there could be opportunities for improvement from these third-party tools.

Even though the cloud services cost for a particular use case is high, sometimes it makes sense either economically and/or strategically to incur those costs. For example, taking advantage of the result cache for queries, especially for large or complex queries, will mean zero compute cost for that query. Thoughtful choices about the right frequency and granularity for DDL commands, especially for use cases such as cloning, help to better balance the costs between cloud services consumption and warehouse costs to achieve an overall lower cost.

Query Processing (Virtual Warehouse) Compute Layer

A Snowflake virtual warehouse, most often referred to simply as a "warehouse," is a dynamic cluster of compute resources and database servers consisting of CPU memory and temporary storage. Creating virtual warehouses in Snowflake makes use of the compute clusters in EC2, which are provisioned behind the scenes. The Snowflake compute resources are created and deployed on-demand anytime to a Snowflake user, such as yourself, for whom the process is transparent.

A running virtual warehouse is required for most SQL queries and all DML operations, including loading and unloading data into tables, as well as updating rows in tables. No virtual warehouse has an impact on any other virtual warehouse because each Snowflake warehouse operates independently and does not share compute resources with other virtual warehouses. Snowflake warehouses perform multiple parallel processing (MPP). Thus, all these data-related tasks can be accomplished concurrently in Snowflake because two virtual warehouses can access the same data at the same time without causing contention issues.

> **NOTE**
>
> Unlike the Snowflake cloud services layer and the data storage layer, the Snowflake virtual warehouse layer (Figure 2-5) is NOT a multi-tenant architecture.

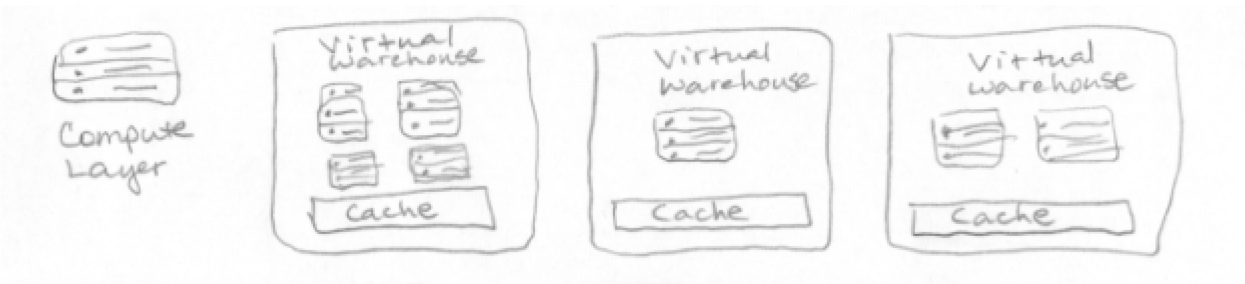


Figure 1-5. Snowflake Compute (Virtual Warehouse) Layer

A virtual warehouse is always consuming credits when it is running in a session. However, Snowflake virtual warehouses can be started and stopped at any time and they can be resized at any time, even while running. Snowflake supports two different ways to scale warehouses. Virtual warehouses can be scaled up by resizing a warehouse and can be scaled out by adding clusters to a warehouse. It is possible to use one or both scaling methods at a time.

Warehouse Size

A Snowflake warehouse cluster is defined by its size with size corresponding to the number of servers in the virtual warehouse cluster. For each warehouse size increase, the number of servers per cluster increases by a factor of 2.

(Figure 2-6)

> **NOTE**
>
> For cluster definitions, Snowflake users do not have compute choices. Instead, compute clusters are predefined by Azure and AWS.

Table 1-1. Snowflake Warehouse Sizes and associated number of servers per cluster

X-Small	Small	Medium	Large	X-Large	2X-Large	3X-Large	4X- L
1	2	4	8	16	32	64	128

Warehouse resizing to a larger size, also known as scaling up, is most often undertaken to improve query performance. This will be discussed in more detail in the next section.

> **TIP**
>
> Because Snowflake utilizes per second billing, it can often be cost effective to run larger warehouses because you are able to suspend warehouses when they aren't being used.

Scaling Up a Virtual Warehouse to Process Large Data Volumes and Complex Queries

When sizing a Snowflake virtual warehouse, the number of concurrent queries, the number of tables being queried, and the size and composition of the data should be considered. One potential solution to a queuing problem is to increase the size of the virtual warehouse to the next level which typically doubles the performance of subsequently executed queries (Figure 1-6).

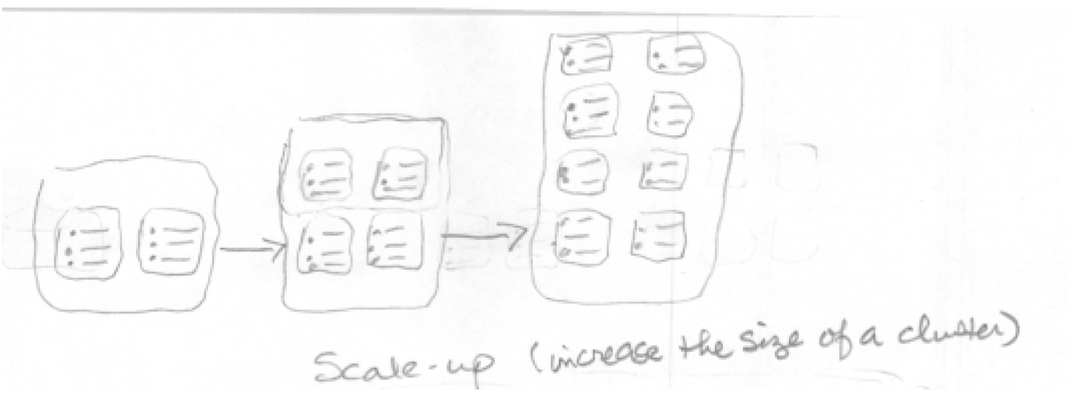


Figure 1-6. Scaling up a Snowflake warehouse increases the size of the cluster

Given that Snowflake utilizes per second billing, much of the time it is cost effective to run larger warehouses because you can suspend warehouses when they aren't being used. The exception is when you are running a lot of small or very basic queries on large warehouse sizes. There won't likely be any benefit from adding the additional resources regardless of the number of concurrent queries.

> **WARNING**
>
> Larger warehouses do not necessarily result in better performance for query processing or data loading.

Query processing, in terms of query complexity, is a consideration for choosing a warehouse size because the time it takes for a server to execute a complex query will likely be greater than running a simple query. Also, the amount of data to be loaded or unloaded can greatly affect performance.

> **TIP**
>
> It is recommended that you experiment with different types of queries and different warehouse sizes to determine the best way to manage your warehouses effectively and efficiently. The queries should be of a certain size and complexity that you would typically expect to complete within no more than 5 to 10 minutes.

Resizing a Snowflake virtual warehouse is a manual process and can be done even while queries are running because a virtual warehouse does not have to be stopped or suspended to be resized. However, when a Snowflake virtual warehouse is resized, only subsequent queries will make use of the new size. Any queries already running will finish running while any queued queries will run on the newly sized warehouse. Scaling a warehouse UP will increase the number of servers. An example would be from MEDIUM to LARGE. Scaling a warehouse DOWN will decrease the number of servers.

Scaling Out with Multi-Cluster Warehouses to Maximize Concurrency

A multi-cluster warehouse operates in much the same way as a single-cluster warehouse. The goal is to find the right balance where the Snowflake system will perform optimally in terms of size and number of clusters. From the previous section, we learned that when there was a queuing problem due to very long-running SQL queries or when there was a large data volume to be loaded or unloaded then scaling up could result in increased performance since the queries could run faster.

If a concurrency problem is due to many users, or connections, then scaling up will not adequately address the problem. Instead, we'll need to scale out by adding clusters (Figure 1-7), going from MIN to MAX for example. Multi-cluster warehouses can be set to automatically scale if the number of users and/or queries tend to fluctuate.

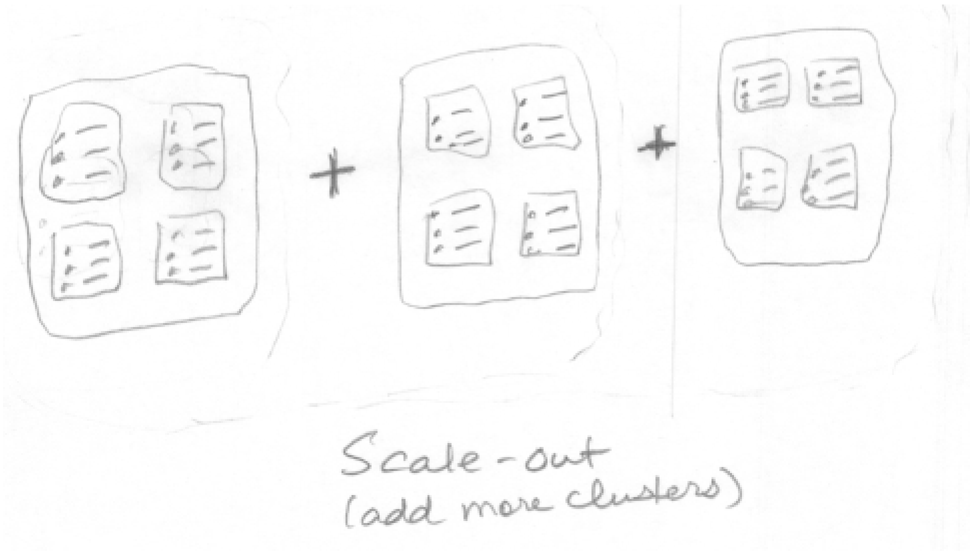


Figure 1-7. Scaling out increases the number of Snowflake warehouse clusters

Just like single cluster warehouses, multi-cluster warehouses can be created through the web interface or by using SQL for Snowflake instances. Unlike single cluster warehouses where sizing is a manual process, scaling in or out for multi-cluster warehouses is an automated process. *Elastic data warehousing* is provided only for the Enterprise Edition, Business Critical Edition, and Virtual Private Snowflake Edition.

The two different types of modes that can selected for a multi-cluster warehouse are *auto-scale* and *maximized*. The Snowflake scaling policy, designed to help control the usage credits in the auto-scale mode, can be set to *standard* or *economy*.

Whenever a multi-cluster warehouse is configured with the scaling policy set as standard, the first warehouse immediately starts when a query is queued, or the Snowflake system detects that there is one more query than the currently-running clusters can execute. Each successive warehouse starts 20 seconds after the prior warehouse has started.

If a multi-cluster warehouse is configured with the scaling policy set as economy, a warehouse starts only if the Snowflake system estimates the query load can keep the warehouse busy for at least six minutes. The goal of the economy scaling policy is to conserve credits by keeping warehouses fully loaded. As a result, queries may end up being queued and could take longer to complete.

When you are deciding on the MINIMUM number of clusters for a multi-cluster warehouse, you should consider whether high availability of the virtual warehouse is a concern. If you keep the MINIMUM number at the default of 1, then additional clusters are started as needed. If you set the MINIMUM number greater than 1, then your concern of high availability can be addressed since you can be assured of warehouse availability in the unlikely event one cluster fails.

It is recommended to set the MAXIMUM value as high as possible, while being aware of the associated costs. For example, if you set the MAXIMUM at 10, keep in mind you could experience a tenfold compute cost for the length of time all 10 clusters are running. A multi-cluster warehouse is “maximized” when the MINIMUM is greater than 1 and both the MINIMUM and MAXIMUM values are equal. We’ll see an example of that in the next section.

> **NOTE**
>
> Compute can be scaled up, down, in, or out. In all cases, there is no effect on storage used.

Creating and Using Virtual Warehouses

Commands for virtual warehouses can be executed in the Web UI or within a worksheet by using SQL. We’ll first take a look at creating and managing virtual warehouses with SQL. Next, we’ll take a look at the Web UI functionality for virtual warehouses.

Auto-suspend and auto-resume are two options available when creating a Snowflake virtual warehouse. Auto-suspend is the number of seconds that the virtual warehouse will wait if no queries need to be executed before going offline. Auto-resume will restart the virtual warehouse once there is an operation that requires compute resources.

The following SQL script will create a medium virtual warehouse, with four clusters, that will automatically suspend after 5 minutes. The warehouse will immediately resume when queries are executed.

```
USE ROLE SYSADMIN;
CREATE WAREHOUSE WH_CH2 WITH WAREHOUSE_SIZE = MEDIUM Auto_suspend = 300 Auto_resume = true
Initially_suspended = true;
```

Earlier, we discussed how we can scale virtual warehouses up or down and that doing so is a manual process. In order to scale up or down, i.e., change the size of a virtual warehouse, we will use the “Alter” command.

```
USE ROLE SYSADMIN;
ALTER WAREHOUSE WH_CH2
SET
    WAREHOUSE_SIZE = LARGE;
```

Any SQL statements executed in this workbook after creating this virtual warehouse will run on that virtual warehouse. If you prefer to use a certain warehouse to execute a script instead, then you can specify that warehouse in the worksheet.

```
USE WAREHOUSE WH_CH2;
```

Alternatively, you can update the warehouse field in the menu located above the worksheet. By selecting the virtual warehouse at the top right of the screen, the USE WAREHOUSE command is implied.

You'll notice that in the Web UI, you can also start / resume a warehouse or suspend it, and you can resize it (Figure 1-8).

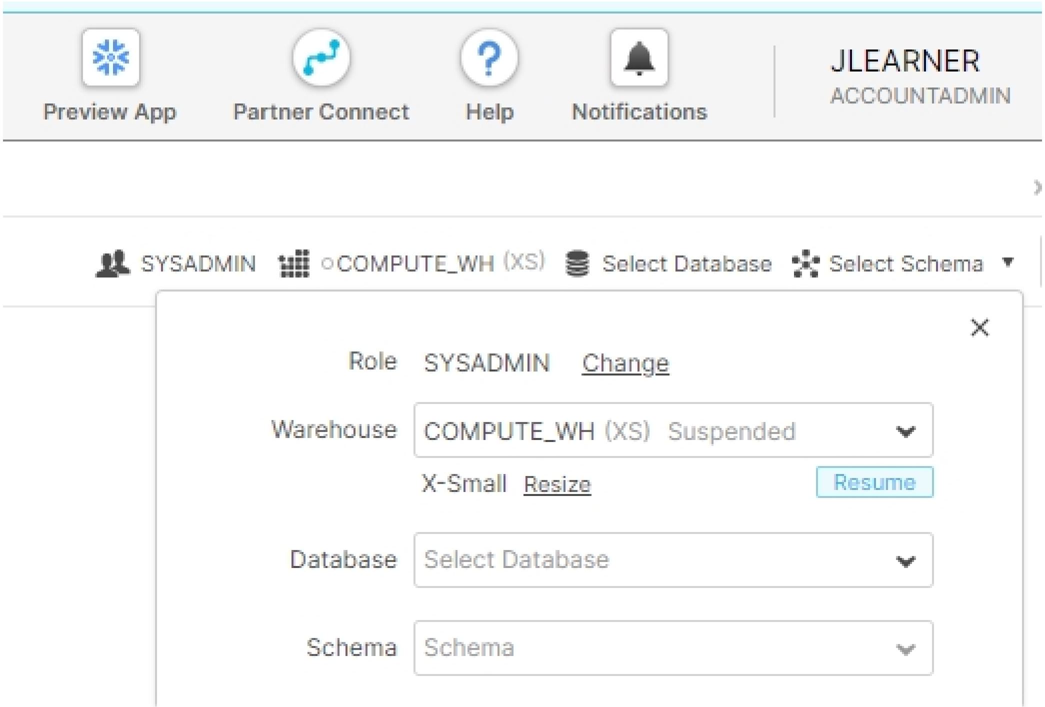


Figure 1-8. Snowflake Web UI

For Enterprise Edition, Business Critical Edition, and Virtual Private Snowflake Editions, elastic data warehousing is enabled. To create a Snowflake multi-cluster virtual warehouse, you'll need to specify the scaling policy as well as the minimum and maximum number of clusters. As stated previously, the scaling policy, which applies only if the warehouse is running in Auto-scale mode, can be either economy or standard.

A multi-cluster virtual warehouse can be easily created in the Web UI. Select Warehouses then the Create button (Figure 2-10). From there, you'll be prompted to fill out the details.

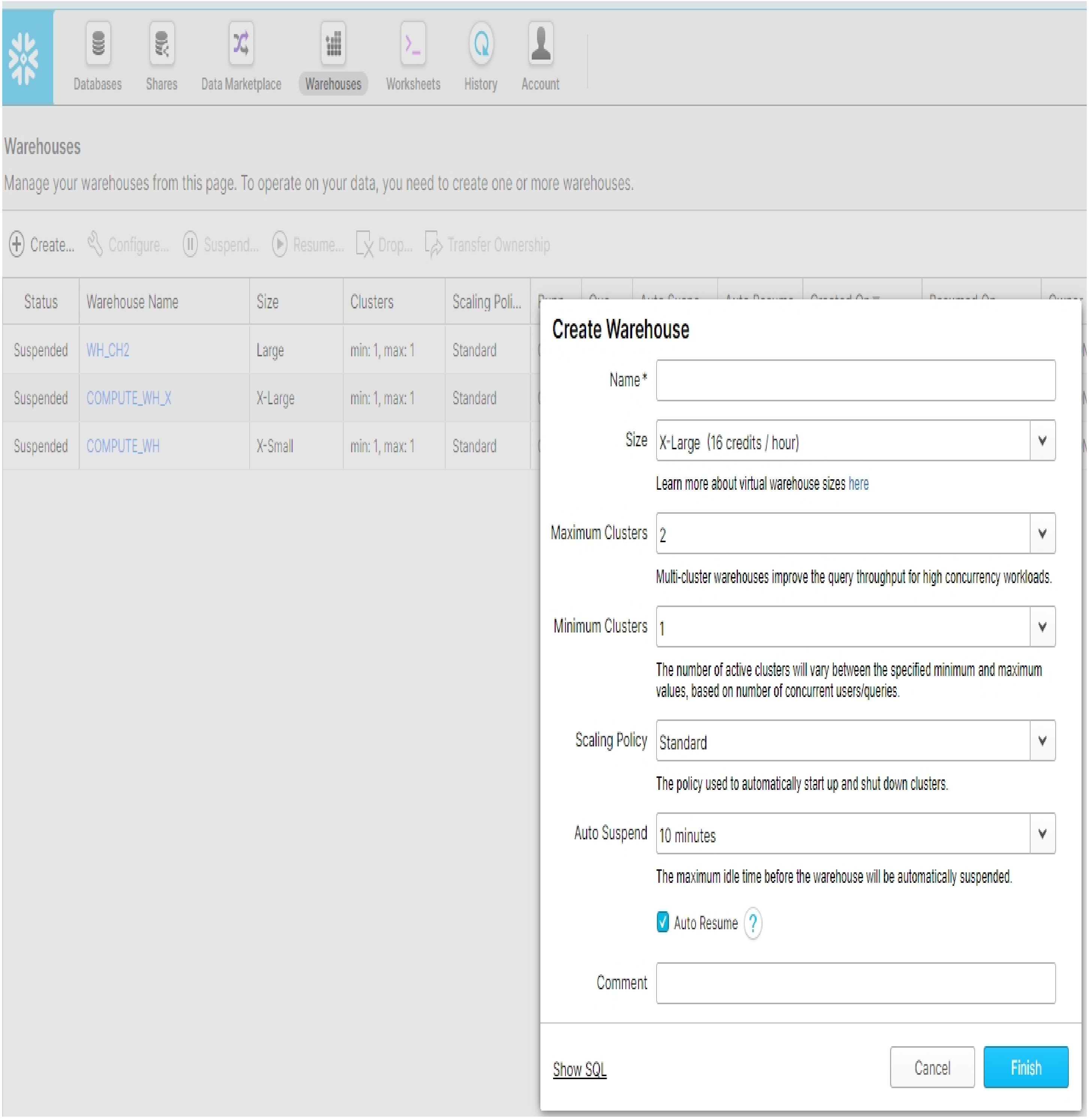


Figure 1-9. Creating a Snowflake multi-cluster virtual warehouse

NOTE

A multi-cluster virtual warehouse is said to be maximized when the minimum number of clusters and maximum number of clusters are the same. Additionally, value(s) must be more than one. An example of a maximized multi-cluster virtual warehouse is MIN_CLUSTER_COUNT = 3 MAX_CLUSTER_COUNT = 3.

Separation of Workloads and Workload Management

Query processing tends to slow down when the workload reaches full capacity on traditional database systems. In contrast, Snowflake estimates resources needed for each query and as the workload approaches 100%, each new query is suspended in a queue until there are sufficient resources to execute them. Handling the queues can be accomplished in multiple ways. One way is to separate the workloads by assigning different warehouses to different users or groups of users (Figure 1-10). Another way is to take advantage of multi-cluster warehouses and their ability to automatically scale in and out (Figure 1-11).

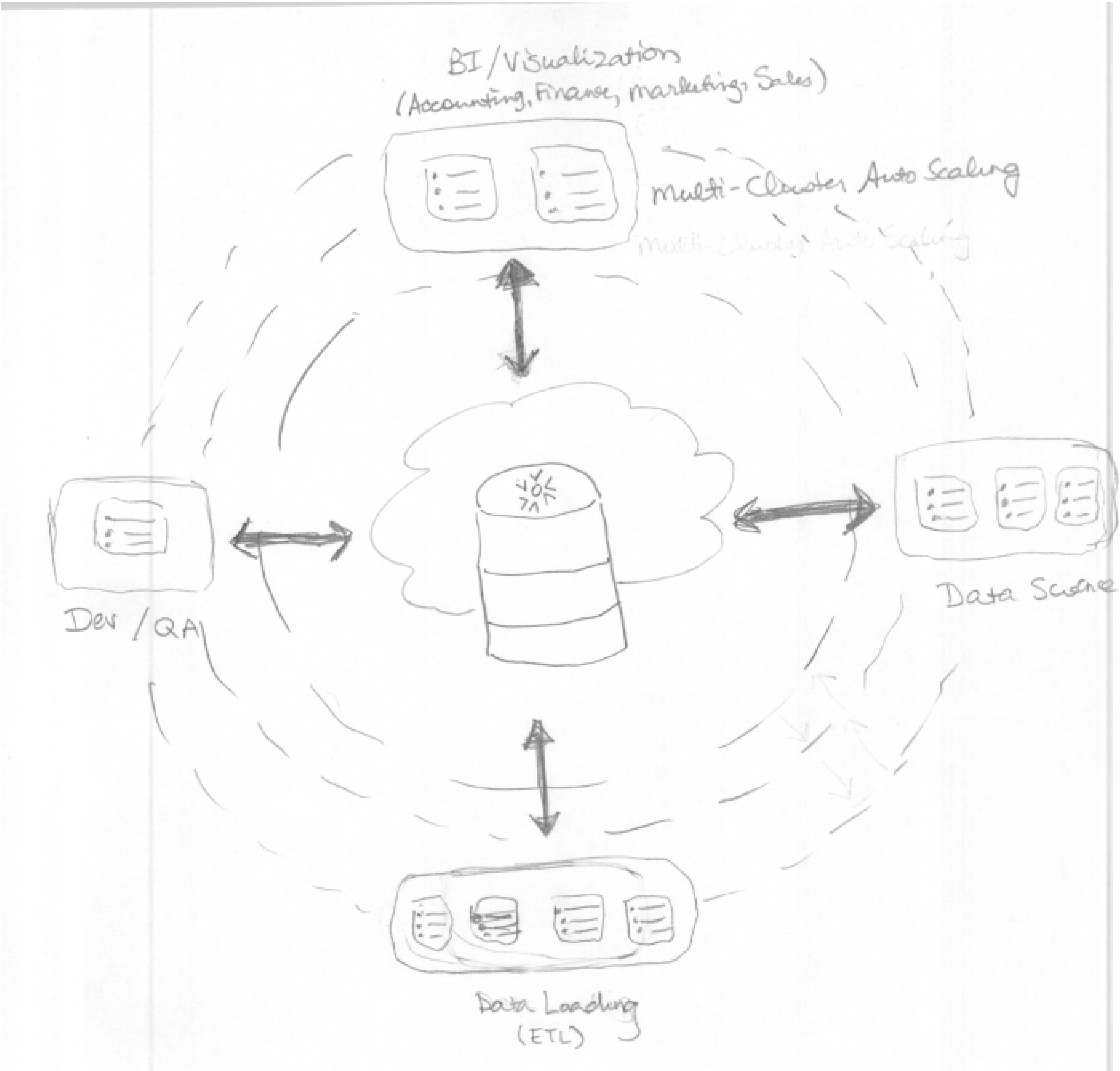


Figure 1-10. Separation of Snowflake workloads by assigning different warehouses to groups of users

Different groups of users can be assigned to different Snowflake virtual warehouses of varying sizes. Thus, users who are querying the data will experience an average query time that is consistent. Marketing and Sales can create and evaluate campaigns while also capturing sales activities. Accounting and Finance departments can access their reports and delve into the details of the underlying data. Data scientists can run large complex queries on vast amounts of data. And ETL processes can continuously load data.

We learned earlier in the chapter that multi-cluster warehouses can be set to automatically scale to avoid concurrency problems. For an automatically scaling multi-cluster warehouse, we will still need to define the warehouse size and the minimum and maximum number of clusters. Let's create a multi-cluster virtual warehouse for our Accounting and Finance, then take a look at an example of how auto-scaling for that warehouse might work.

```
CREATE WAREHOUSE ACCOUNTING WITH Warehouse_Size = MEDIUM MIN_CLUSTER_COUNT = 1
            MAX_CLUSTER_COUNT = 6 SCALING_POLICY = 'STANDARD';
```

The scaling process occurs automatically once the multi-cluster warehouse is configured. Figure 1-11 illustrates how auto-scaling works when the number of concurrent SQL statements increase. You can see that on an hourly basis, the workload is heavier between 8 am to 5 pm with a slightly lower workload around lunchtime hours and very late evening and early morning hours. We might also want to investigate to see whether daily the workload is heavier overall at the beginning of the month as the accounting department works to prepare and review the accounting statements for the prior month and other activities, such as monthly billing, is undertaken.

Figure 1-11. Management of Snowflake workloads by using multi-cluster warehouses to scale in and out

Unlike scaling up and down which is a manual process, scaling in and out is an automatic process. Clusters are added when needed and then suspended, after the predefined AUTO SUSPEND period, when no longer needed.

Billing for Virtual Warehouse Layer

Consumption charges for Snowflake virtual warehouses are calculated based on the warehouse size, as determined by the number of servers per cluster, the number of clusters if there are multi-cluster warehouses, and the amount of time each cluster server runs. Snowflake utilizes per-second billing with a 60-second minimum each time a warehouse starts or is resized. When a warehouse is scaled up, credits are billed for one minute of the additional resources that are provisioned. All billing, even though calculated in seconds, is reported in fractions of hours.

When using the ACCOUNTADMIN role, you can view the warehouse credit usage for your account by clicking on Account > Usage. You can also query the Account Usage view in the SNOWFLAKE shared database. It is recommended that you choose an XS (extra small) warehouse to do so.

Centralized (Hybrid-Columnar) Database Storage Layer

Snowflake's centralized database storage layer holds all data, including structured and semi-structured data. As data is loaded into Snowflake, it is optimally reorganized into a compressed, columnar format and stored and maintained in Snowflake databases. Each Snowflake database consists of one or more schemas, which is a logical grouping of database objects such as tables and views. Chapter 3 is entirely devoted to showing you how to create and manage databases and database objects. In Chapter 7, we will learn about Snowflake's physical data storage as we take a deep dive into micro partitions to better understand data clustering.

Data stored in Snowflake databases is always compressed and encrypted. Snowflake takes care of managing every aspect of how the data is stored. Snowflake automatically organizes stored data into micro-partitions, an optimized immutable compressed columnar format, which is encrypted using AES-256 encryption. Snowflake optimizes and compresses data to make metadata extraction and query processing easier and more efficient.

We learned earlier in the chapter that whenever a user submits a Snowflake query, that query will be sent to the cloud services optimizer before being sent to the compute layer for processing. The same is true for Snowflake data objects. Snowflake data objects, hidden to the user, are only accessible by SQL queries through the compute layer.

Snowflake's data storage layer is sometimes referred to as the Remote Disk layer. The underlying file system is implemented on Amazon S3 or Microsoft Blob storage (Figure 1-12). Snowflake doesn't place limits on the amount of data you can store or on the number of databases or database objects that you can create. Snowflake tables can easily store petabytes of data. There is no effect on virtual warehouse sizes as the storage increases or decreases in a Snowflake account. The two are scaled independently from each other and from the cloud services layer.

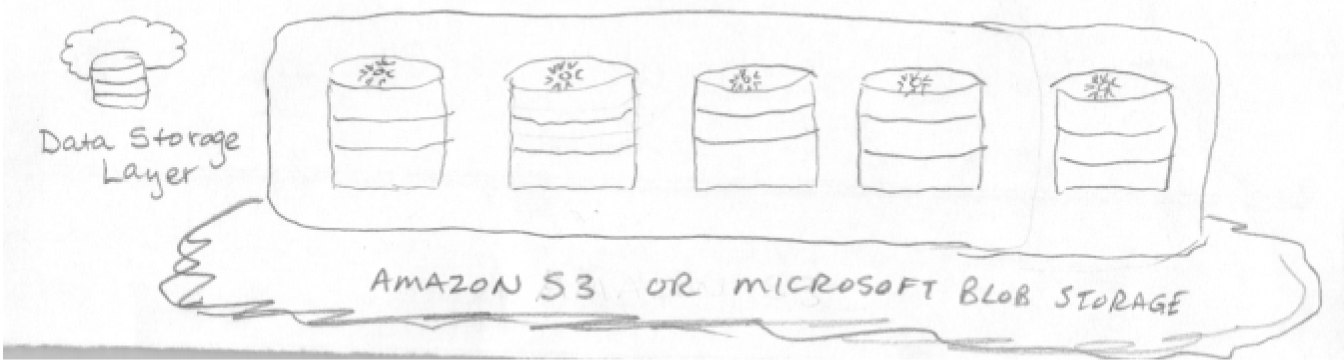


Figure 1-12. Snowflake Data Storage Layer

There are two unique features in the storage layer architecture – time travel and zero-copy cloning. Both very powerful Snowflake features will be introduced in this chapter and will be covered in more detail in later chapters. To prepare for those later chapters, you'll want to have a thorough understanding of these two features.

Introduction to Zero Copy Cloning

Zero-copy cloning offers the user a way to "snapshot" a Snowflake database, schema, or table along with its associated data. There is no additional storage charge until changes are made to the cloned object because zero-copy data cloning is a metadata-only operation. For example, if you clone a database and then add a new table or delete some rows from a cloned table, at that point then there would be storage charges assessed. There are many uses for zero-copy cloning other than creating a backup. Most often, zero-copy clones will be used to support development and test environments. We'll see examples of this in Chapter 7.

Introduction to Time Travel

Time travel allows you to restore a previous version of a database, table, or schema. This is an incredibly helpful feature that gives you an opportunity to fix previous edits incorrectly done or to restore items deleted in error. With time travel, you can also back up data from different points in the past by combining the time travel feature with the clone feature, or you can perform a simple query of a database object that no longer exists. How far back you can go into the past depends on a few different factors. Time travel will be discussed in detail in Chapter 8. For the purposes of this chapter, it is important to note that there will be data storage fees assessed for any data that has been deleted but is still available to restore.

Billing for Storage Layer

Snowflake data storage costs are calculated based on the daily average size of compressed rather than uncompressed, data. Storage costs include the cost of persistent data stored in permanent tables and files staged for bulk data loading and unloading. Both time travel and fail-safe data, data retained to enable data recovery, are also considered in the calculation of data storage costs. Clones of tables referencing data that has been deleted are similarly considered.

Snowflake Caching

When you submit a query, Snowflake checks to see if that query has been previously run and, if so, whether the results are still cached. Snowflake will use the cached result set if it is still available rather than executing the query you just submitted. In addition to retrieving the previous query results from a cache, Snowflake supports other caching techniques for optimizing query performance. These caching techniques not only give you faster results but also lower your compute costs because they are able to return results without using compute resources. There are three Snowflake caching types; query results cache, virtual warehouse cache, and metadata cache.

Query Results Cache

The fastest way to retrieve data from Snowflake is by using the query results cache. The results of a Snowflake query are cached, or persisted, for 24 hours and then purged. This contrasts with how the warehouse cache and metadata cache work. Neither of those caches are purged based on a timeline. Even though the results cache only persists for 24 hours, the clock is reset each time the query is re-executed up to a maximum of 31 days from the date and time when the query was first executed. After 31 days, or sooner if the underlying data changes, a new result is generated and cached when the query is submitted again.

The results cache is fully managed in the Snowflake global cloud services layer (Figure 2-14) and is available across all virtual warehouses since virtual warehouses have access to all data. Thus, the query results returned to one user are also available to any user who has the necessary access privileges and who executes the same query. Any user can run a query against the result cache with no running virtual warehouse needed, assuming the query is cached and the underlying data has not changed.

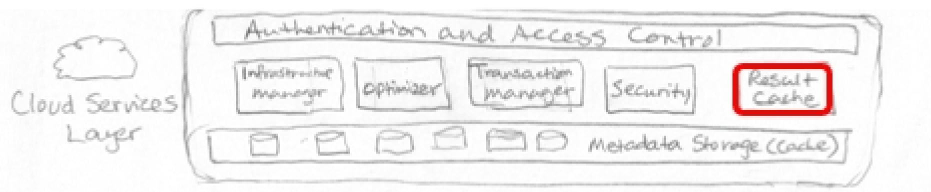


Figure 1-13. Result Cache in the Snowflake Cloud Services Layer

Metadata Cache

The metadata cache is fully managed in the global services layer (Figure 1-14) where the user does have some control over the metadata. Snowflake collects and manages metadata about tables, micro-partitions, and even clustering. For tables, Snowflake stores row count, table size in bytes, file references and table versions. Thus, a running warehouse will not be needed because the count statistics are kept in the metadata cache when running a SELECT COUNT(*) on a table.

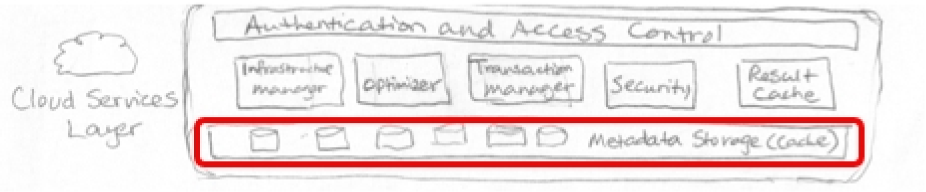


Figure 1-14. Metadata Storage Cache in the Snowflake Cloud Services Layer

The Snowflake metadata repository includes table definitions and references to the micro-partition files for that table. The range of values in terms of MIN and MAX, the NULL count, and the number of distinct values are captured from micro-partitions and stored in Snowflake. As a result, any queries which return the MIN or MAX value, for example, will not need a running warehouse. Snowflake stores the total number of micro-partitions and the depth of overlapping micro-partitions to provide information about clustering.

> **NOTE**
>
> All DML operations that require table maintenance make use of micro-partition data stored in the metadata cache.

Virtual Warehouse Local Disk Cache

Running virtual warehouses use SSD storage to store the micro-partitions that are pulled from the centralized database storage layer when a query is processed. The size of the warehouse's SSD cache is determined by the size of the virtual warehouse's compute resources (Figure 1-15). Whenever a virtual warehouse receives a query to execute, that warehouse will scan the SSD cache first before accessing the Snowflake remote disk storage. Reading from SSD is faster than from the database storage layer but still requires the use of a running virtual warehouse.

Figure 1-15. Virtual Warehouse Cache in the Snowflake Cloud Services Layer

Although the warehouse cache is implemented in the virtual warehouse layer where each virtual warehouse operates independently, the global services layer handles the overall system data freshness. It does so via the query optimizer which checks the freshness of each data segment of the assigned warehouse and then builds a query plan to update any segment by replacing it with data from the remote disk storage.

Note that the virtual warehouse cache is sometimes referred to as the "raw data cache", the "SSD cache", or the "data cache." This cache is dropped once the virtual warehouse is suspended, so you'll want to consider the trade-off between the credits that will be consumed by keeping a warehouse running versus the value from maintaining the cache of data from previous queries to improve performance. By default, Snowflake will automatically suspend a virtual warehouse after 10 minutes of idle time, but this can be changed.

> **TIP**
>
> Whenever possible, and where it makes sense, assign the same virtual warehouse to users who will be accessing the same data for their queries. This increases the likelihood that they will benefit from the virtual warehouse local disk cache.

Get Ready for Hands-On Learning

Hopefully these first two chapters have given you an understanding of the power of the Snowflake Data Cloud and its simplicity of use. In the upcoming chapters, we'll be demonstrating how Snowflake works by deep diving into hands-on learning examples throughout each of the chapters. If you haven't already done so, now is a good time to sign up for a Snowflake free trial account. Refer to Chapter 1 for more details on getting set up in a trial account.

Exercises to Test Your Knowledge

The following exercises are based on the coverage in this chapter.

1. Name the three Snowflake architecture layers.
2. Which of the three Snowflake layers are multi-tenant?
3. In which of the three Snowflake architecture layers will you find the warehouse cache? the result cache?
4. If you are experiencing higher than expected costs for Snowflake cloud services, what kinds of things might you want to investigate?
5. Explain the difference between scaling up and scaling out.
6. What effect does scaling up or scaling out have on storage used in Snowflake?
7. Shared-nothing architecture evolved from shared-disk architecture. NoSQL alternatives have also been created. What one main problem have they all been trying to solve?
8. In a Snowflake multi-cluster environment, what scaling policies can be selected?
9. What components do you need to configure specifically for multi-cluster warehouses?
10. What are two options to change the warehouse that will be used to run a SQL command within a specific worksheet?

Solutions to these exercises are available in Appendix A.

Chapter 2. Creating and Managing Snowflake Architecture Objects

A NOTE FOR EARLY RELEASE READERS

With Early Release ebooks, you get books in their earliest form—the author's raw and unedited content as they write—so you can take advantage of these technologies long before the official release of these titles.

This will be the 3rd chapter of the final book.

If you have comments about how we might improve the content and/or examples in this book, or if you notice missing material within this chapter, please reach out to the editor at *mcronin@oreilly.com*.

Within Snowflake, all data is stored in database tables logically structured in collections of rows and columns. This chapter focuses on the logical structure of databases and database objects, such as tables and views.

In this chapter, we will cover topics in specific order because the series of examples in each topic build upon each other. The code is provided for you here in the chapter as well as on Github. These are the topics we will work through together:

1. Databases
2. Schemas
3. Information Schema & Account Usage
4. Tables
5. Views
6. Stages, File Format Included
7. Stored Procedures, Task included
8. IDFs
9. Pipes, streams, and sequences

Code Cleanup & Test Your KnowledgeOur initial discussion of databases, tables, views, stages, pipes, and streams lay the foundation for following chapters where we do a deeper dive into these objects. We will conduct a deep dive for the User Defined Function (UDF) and Stored Procedure objects in this chapter. One advanced deep dive example includes using a file format object and another example uses a task object. Pipes, streams, and sequences are briefly introduced and covered in more detail in later chapters.

Creating and Managing Snowflake Databases

In the relational world, database objects such as tables, views, and more, are maintained within databases. In Snowflake, the database logically groups the data while the schema organizes it. Together, the database and schema comprise the *namespace*. In the examples throughout this chapter, whenever we work with database objects, we'll need to specify a namespace unless the schema and database we want to use are the active objects or unless we include the "USE" command. That way it is clear to Snowflake the location where objects are to be created or which specific object is being referenced in the commands.

There are two main types of databases we can create – permanent (persistent) and transient databases. At the time we create a database, the default will be a permanent database, if we don't specify which of the two types we want to create. Transient databases have a maximum one-day *time-travel* period and do not have a *fail-safe* period.

The Snowflake time travel period is the time during which databases and database objects can be cloned or "undropped", to allow historical data to be restored. The default time travel period is one day but can be up to 90 days for permanent databases or a user could set the time travel period to zero days, if no time travel period is desired.

Snowflake's fail-safe data recovery service provides a seven-day period during which data may be recoverable by Snowflake. The service is only available for databases and database objects that are permanent. It is important to note that data storage costs are incurred for those seven days. That is one consideration when deciding about the database type you want to create.

These are the basic SQL commands for Snowflake databases that we will be covering in this section:

- CREATE DATABASE
- ALTER DATABASE
- DROP DATABASE
- SHOW DATABASES

CREATE DATABASE is the command used to create a new database, clone an existing database, create a database from a share provided by another Snowflake account, or to create a replica of an existing primary database (i.e., a secondary database).

We can create databases from the User Interface (UI) or by using SQL code in the Snowflake worksheet. We created a database and database objects in Chapter 1 using the Web User Interface. We'll be using SQL commands in the Snowflake Worksheet for this chapter.

> **NOTE**
>
> For all exercises in this chapter, make sure you have your role set to SYSADMIN throughout the chapter unless otherwise directed.

Let’s go ahead and get started. We’ll create one permanent database and one transient database.

```
USE ROLE SYSADMIN;
CREATE
OR REPLACE DATABASE CHAPTER3_PDB1 Comment = "Permanent Database 1 used for Exercises in
Definitive Guide";
CREATE
OR REPLACE TRANSIENT DATABASE CHAPTER3_TDB1 Comment = "Transient Database 1 used for
Exercises in Definitive Guide";
```

Notice above that we used the word “OR REPLACE” optional keyword in the command. That way, an error would not be returned if the database already exists. Whenever you create a new database, that database is automatically set as the active database for the current session. It’s the equivalent of using the “USE DATABASE” command. If we needed or wanted to use a database, other than the one we just created, we’d have to include the “USE DATABASE” command in the worksheet to select the appropriate database.

If you navigate to the Databases UI, as shown in Figure 2-1, you will see that it shows the two databases we just created plus three out of the four databases that automatically come with the Snowflake account.

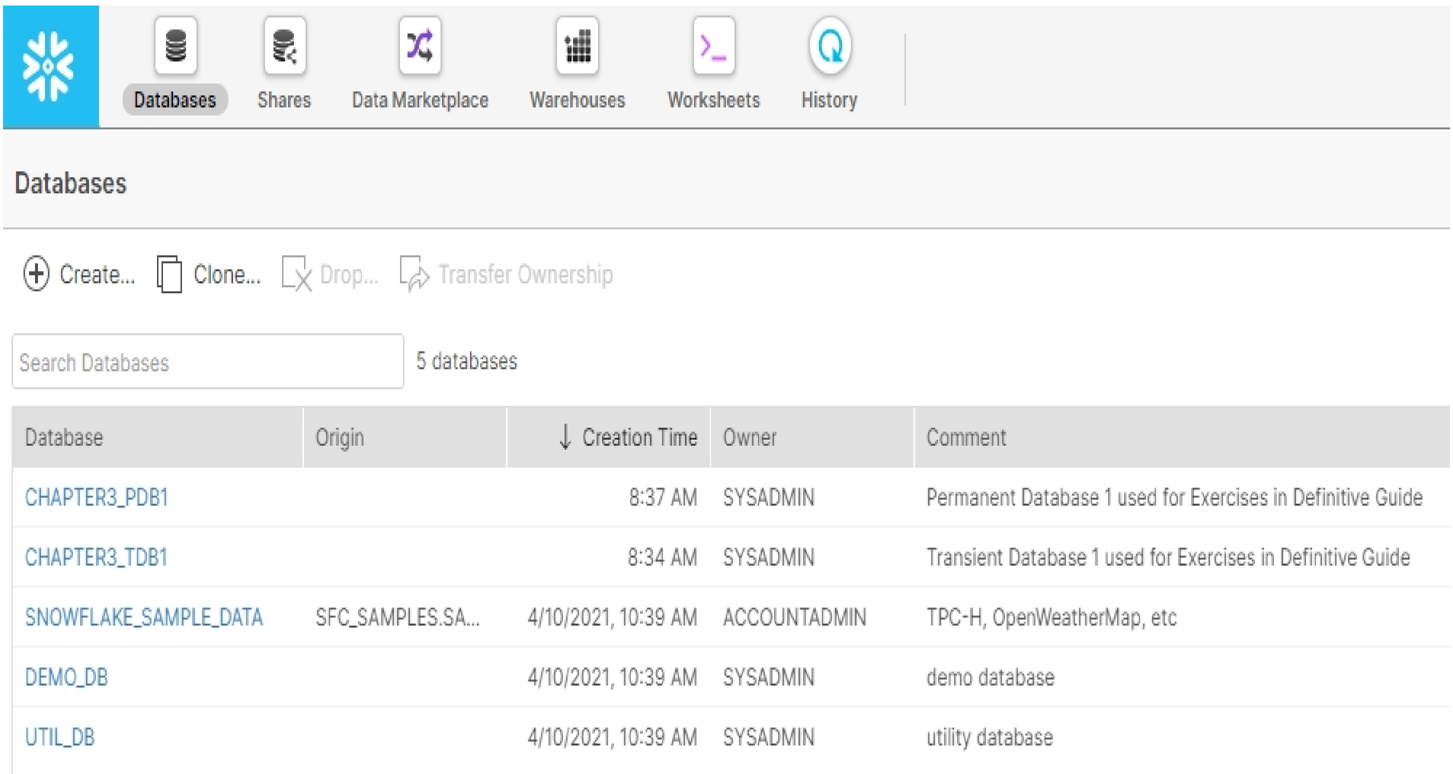


Figure 2-1. Web User Interface displaying a list of active Databases, based on the user’s SYSADMIN role

> **NOTE**
>
> The SNOWFLAKE database isn’t shown to those not using the ACCOUNTADMIN role.

Let’s switch back to the Worksheets and change our role to ACCOUNTADMIN and see if we can view the SNOWFLAKE database. Once in the worksheet:

```
USE ROLE ACCOUNTADMIN;
SHOW DATABASES;
```

Notice in Figure 3-2 that all databases, including the ones we just created, have a 1-day retention time. Data retention time (in days) is the same as the time travel number of days and specifies the number of days for which the “CLONE” and “UNDROP” commands can be performed on the database.

Row	created_on	name	is_default	is_current	origin	owner	comment	options	retention_time
1	2021-04-25 06:37:59.72...	CHAPTER3_PDB1	N	Y		SYSADMIN	Permanent Database 1 us...		1
2	2021-04-25 06:48:57.60...	CHAPTER3_TDB1	N	N		SYSADMIN	Transient Database 1 use...	TRANSIENT	1
3	2021-04-10 08:39:08.54...	DEMO_DB	N	N		SYSADMIN	demo database		1
4	2021-04-10 08:39:03.24...	SNOWFLAKE	N	N	SNOWFLAKE.ACCOUNT_...				1
5	2021-04-10 08:39:09.20...	SNOWFLAKE_SAMPLE_D...	N	N	SFC_SAMPLES.SAMPLE_...	ACCOUNTADMIN	TPC-H, OpenWeatherMa...		1
6	2021-04-10 08:39:05.33...	UTIL_DB	N	N		SYSADMIN	utility database		1

Figure 2-2. Worksheet displaying a list of active Databases, based on the user’s ACCOUNTADMIN role

We can change the data retention time for a permanent database but not for a transient one. We can change the retention time up to 90 days for permanent databases. We’ll go ahead and change the retention time for our permanent database to 10 days by using the “ALTER DATABASE” command. Be sure to change your role back to SYSADMIN before issuing the commands.

```
USE ROLE SYSADMIN;
ALTER DATABASE CHAPTER3_PDB1
SET
    DATA_RETENTION_TIME_IN_DAYS = 10;
```

If you attempt to change the data retention time for a transient database, you’ll receive an error telling you that the value “10” is an invalid value for the parameter. That is because a transient database can have a maximum 1-day data retention. You could change the retention time to 0 days but then you wouldn’t be able to “CLONE” or “UNDROP” that database if you do that.

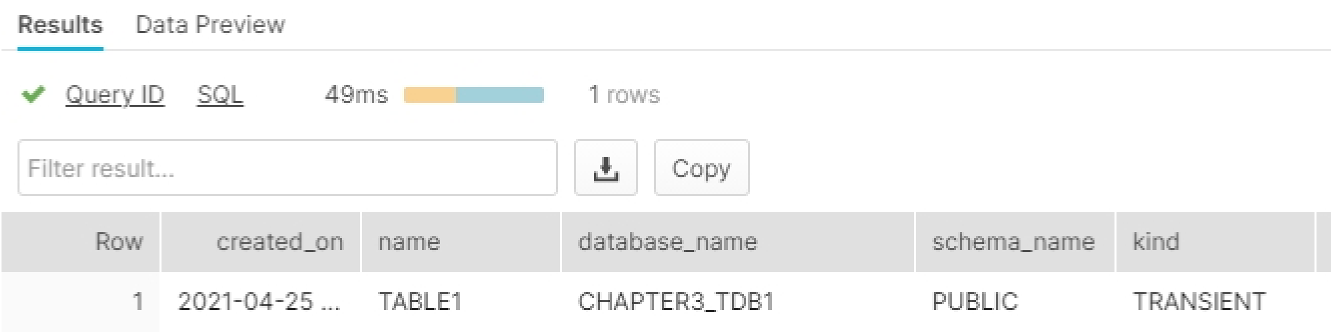
We’ll be covering tables in more detail in a later section, but for now, it is important to mention a few things about tables as they relate to permanent versus transient databases.

Snowflake uses a hybrid approach when it comes to permanent databases but not transient databases. A permanent database type is not limited to the different types of objects that can be stored within them. For example, you can store transient tables within a permanent database but not permanent tables within a transient database. Below is an example of creating a table in our transient database.

```
USE ROLE SYSADMIN;
CREATE
```

```
OR REPLACE TABLE "CHAPTER3_TDB1"."PUBLIC"."SUMMARY" (
    CASH_AMT number,
    RECEIVABLES_AMT number,
    CUSTOMER_AMT number
);
```

Notice we didn't specify the type of table as either permanent or transient. By default, Snowflake creates a permanent table unless you indicate otherwise when you are creating the table. The exception would be when you are creating a table within a transient database. In that case, the table would also have to be transient. By default, all tables created in a transient schema are transient. We can see that is the case by using the "SHOW TABLES" command which gives us the following result, shown in Figure 2-3, for the table we just created.



Row	created_on	name	database_name	schema_name	kind
1	2021-04-25 ...	TABLE1	CHAPTER3_TDB1	PUBLIC	TRANSIENT

Figure 2-3. Worksheet results of the "SHOW TABLES" command

NOTE

There is no limit to the number of database objects, schemas, and databases that can be created within a Snowflake account.

Each Snowflake account also comes with certain databases, schemas, and tables already included as shown in Figure 3-4 below. As shown, there are four databases that initially come with a Snowflake account:

- SNOWFLAKE database
- UTIL_DB database
- DEMO_DB database
- SNOWFLAKE_SAMPLE_DATA database

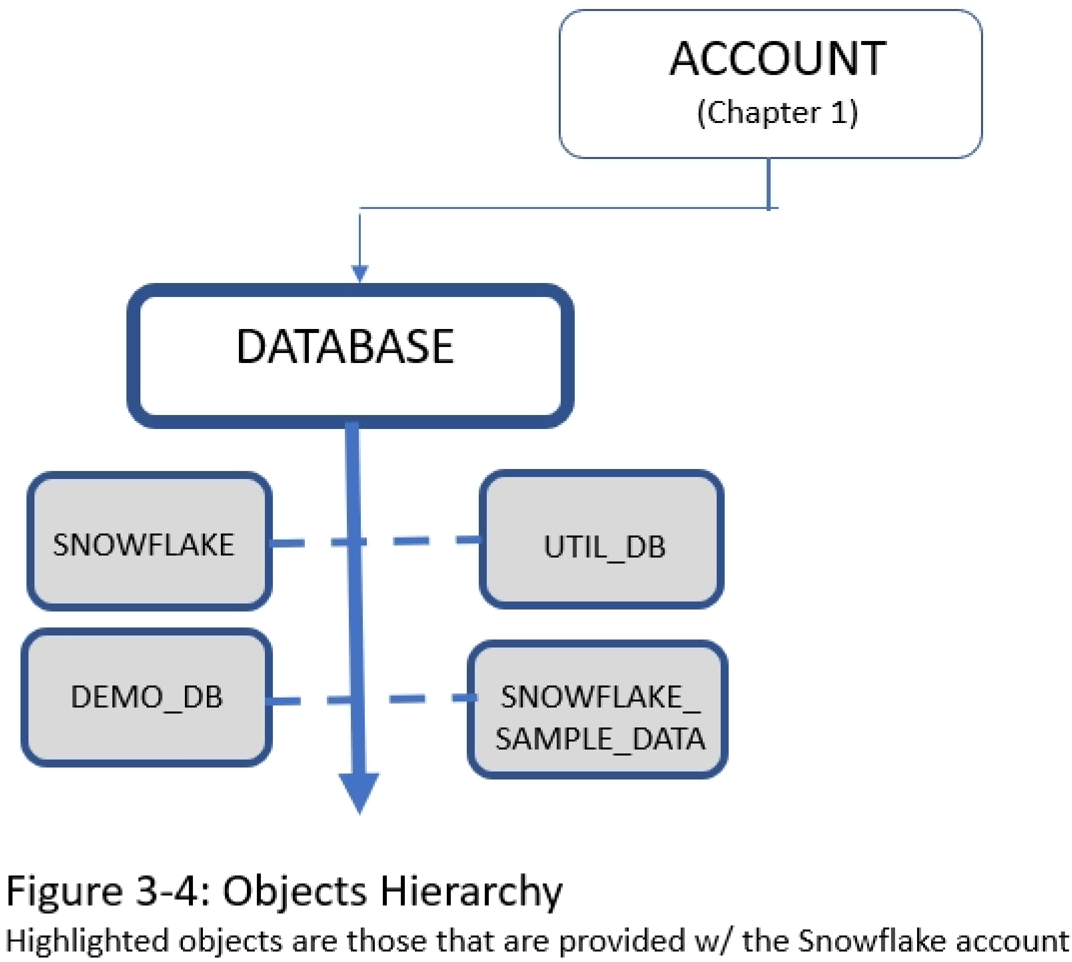


Figure 2-4. Highlighted objects are those that are provided with the Snowflake account

The SNOWFLAKE database is owned by Snowflake Inc. and is a system-defined, read-only shared database which provides object metadata and usage metrics about your account. Unlike the other three databases imported into your account at the time of setup, the SNOWFLAKE database cannot be deleted from your account.

The UTIL_DB database and DEMO_DB database, also imported into your account at the time of setup, contains no data and, as such, there is no storage charges for those databases, and they can be dropped at any time.

Upon first look, the SNOWFLAKE_SAMPLE_DATA database appears to be something similar to what you might create in your Snowflake account. However, the sample database is actually one that has been shared from the Snowflake SFC_SAMPLES account and the database is read-only in your account which means that no DDL commands can be issued. In other words, database objects cannot be added, dropped, or altered within the sample database. In addition, no DML commands for actions such as cloning can be performed on the tables. You can, however, view the sample database and execute queries on the tables.

We'll be using the SNOWFLAKE_SAMPLE_DATA database in some of our examples in this chapter. In Chapter 10, we'll be learning about shared databases but, for now, what is important to know is that while we don't incur any storage costs for the shared sample database, we do need a running warehouse to run queries and so there will be an associated compute cost for running those queries on the Snowflake sample database.

One final important thought, when deciding which type(s) of storage objects to create and how to architect them, is that there is a monetary cost for storing data in Snowflake, as well as a potential cost in terms of possible degraded performance. This chapter is intended to give you the necessary understanding of Snowflake databases and database objects as a foundation for later chapters which address improving performance and reducing costs, data recovery, and data loading and unloading.

Creating and Managing Snowflake Schemas

When we created databases, we didn't have to specify the account because there is only one account. But when we create a schema, we need to let Snowflake know which database we want to use. If we don't specify a particular database, then Snowflake will use the one that is active.

Just like databases, schemas can be either permanent or transient with the default being permanent. Just like databases, we have available the same SQL commands. However, for schemas, we have something unique called a managed access schema. In a managed access schema, the schema owner manages grants on the objects within a schema, such as tables and views, but doesn't have any of the USAGE, SELECT, or DROP privileges on the objects.

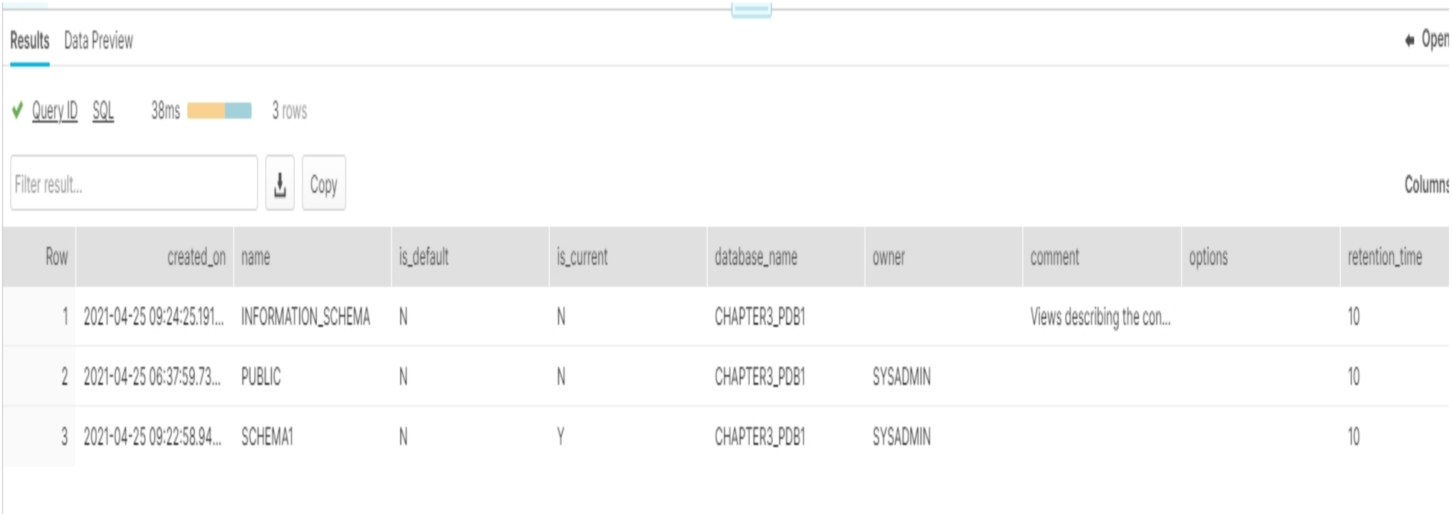
There are different ways to create a schema that will achieve the same result. Here below are two examples that accomplish the same thing. In this first example, the "USE" command lets Snowflake know for which database the schema will be created.

```
USE ROLE SYSADMIN;
USE DATABASE CHAPTER3_PDB1;
CREATE
OR REPLACE SCHEMA BANKING;
```

In the second example, we simply use the *fully qualified schema name.*

```
USE ROLE SYSADMIN;
CREATE
OR REPLACE SCHEMA CHAPTER3_PDB1.BANKING;
```

If we use the "SHOW SCHEMA" command as demonstrated in Figure 3-5, we notice that the retention time of the new schema also has a retention time of 10 days, just like the database in which it was created, rather than the default 1-day retention.



Results Data Preview

Query ID SQL 38ms 3 rows

Filter result... Copy Columns

Row	created_on	name	is_default	is_current	database_name	owner	comment	options	retention_time
1	2021-04-25 09:24:25.191...	INFORMATION_SCHEMA	N	N	CHAPTER3_PDB1		Views describing the con...		10
2	2021-04-25 06:37:59.73...	PUBLIC	N	N	CHAPTER3_PDB1	SYSADMIN			10
3	2021-04-25 09:22:58.94...	SCHEMA1	N	Y	CHAPTER3_PDB1	SYSADMIN			10

Figure 2-5. Worksheet results of the "SHOW SCHEMA" command.

However, we can always change the retention time to one day for the schema.

```
USE ROLE SYSADMIN;
ALTER SCHEMA CHAPTER3_PDB1.BANKING
SET
    DATA_RETENTION_TIME_IN_DAYS = 1;
```

Now, run the "SHOW SCHEMAS" command again and you'll see the retention time has been changed for the schema.

If we'd like to create a schema with managed access, we need to add the "WITH MANAGED ACCESS" command.

```
USE ROLE SYSADMIN;
USE DATABASE CHAPTER3_PDB1;
CREATE
OR REPLACE SCHEMA MSCHEMA WITH MANAGED ACCESS;
```

Now, when you run the "SHOW SCHEMAS" command, you'll notice that "Managed Access" will be displayed under the options column for the schema named MSCHEMA.

As discussed in Chapter 5, for regular schemas the object owner role can grant object access to other roles and can also grant those roles the ability to manage grants for the object. However, in managed schemas, object owners are unable to issue grant privileges. Instead, only the schema owner or a role with the MANAGE GRANTS privilege assigned to it can manage the grant privileges.

> **NOTE**
>
> The SECURITYADMIN and ACCOUNTADMIN inherently have the "MANAGE GRANTS" privilege, thus, they can manage the grant privileges on all managed schemas, in addition to the schema owner.

There are two database schemas, as shown in Figure 2-6, that are included in every schema that is created:

- INFORMATION_SCHEMA
- PUBLIC schema

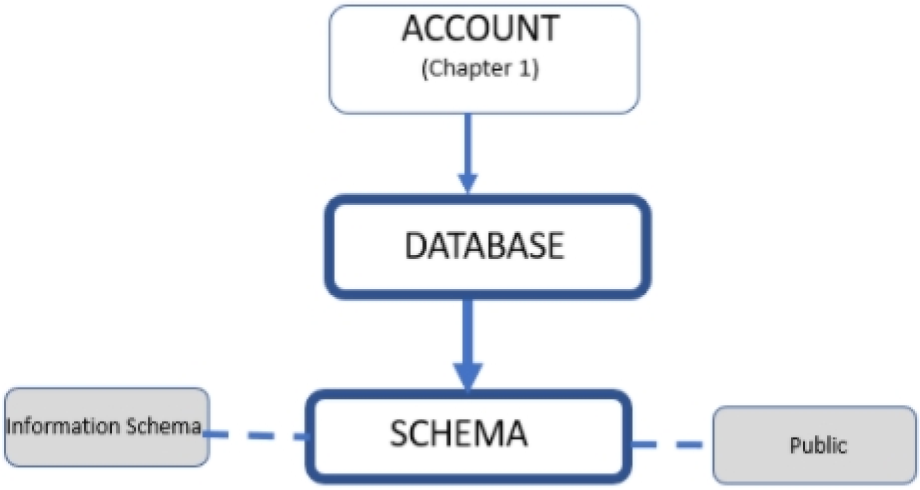


Figure 2-6. Objects hierarchy: Highlighted objects are those that are provided by the Snowflake account.

The PUBLIC schema is the default schema and can be used to create any other objects whereas the INFORMATION_SCHEMA is a special schema for the system that contains all metadata for the database. The Information Schema will be discussed in the next section.

INFORMATION_SCHEMA and Account Usage

As we just learned, the Snowflake INFORMATION_SCHEMA is included within every database created in Snowflake. The Information Schema, also known as the “Data Dictionary”, includes metadata information about the objects within the database as well as account-level objects like roles. More than 20 system-defined views are included in every Information Schema and can be divided between account views and database views.

Information Schema Account Views:

Applicable_Roles

Displays one row for each role grant

Databases

Displays a row for each database defined in your account

Enabled_Roles

Displays a row for each currently-enabled role in the session

Information_Schema_Catalog_Name

The name of the database in which the information_schema resides

Load_History

Displays one row for each file loaded into tables using the COPY INTO <table> command. Returns history for past 14 days except no history for data loaded using Snowpipe,

Replication_Databases

Displays a row for each primary and secondary database (i.e., database for which replication has been enabled) in your organization

You may want to look at what is within each of these views. You'll notice that for some of them, all views in the account contain the same information. Try the SQL statements below. What do you notice?

```
SELECT
    *
FROM
    "SNOWFLAKE_SAMPLE_DATA"."INFORMATION_SCHEMA"."DATABASES";
SELECT
    *
FROM
    "DEMO_DB"."INFORMATION_SCHEMA"."DATABASES";


SELECT
    *
FROM
    "SNOWFLAKE_SAMPLE_DATA"."INFORMATION_SCHEMA"."APPLICABLE_ROLES";

SELECT
    *
FROM
    "DEMO_DB"."INFORMATION_SCHEMA"."APPLICABLE_ROLES";
```

Information Schema Database Views:

Columns

Displays a row for each column in the tables defined in the specified (or current) database

External_Tables

Displays a row for each external table in the specified (or current) database

File Formats

Displays a row for each file format defined in the specified (or current) database

Functions

Displays a row for each user-defined function (UDF) or external function defined in the specified (or current) database

Object_Privileges

Displays a row for each access privilege granted for all objects defined in your account.

Pipes

Displays a row for each pipe defined in the specified (or current) database

Procedures

Displays a row for each stored procedure defined the specified (or current) database

Referential_Constraints

Displays a row for each referential integrity constraint defined in the specified (or current) database

Schemata:

Displays a row for each schema in the specified (or current) database

Sequences

Displays a row for each sequence defined in the specified (or current) database

Stages

Displays a row for each stage defined in the specified (or current) database

Table_Constraints

Displays a row for each referential integrity constraint defined for the tables in the specified (or current) database

Table_Privileges

Displays a row for each table privilege that has been granted to each role in the specified (or current) database

Table_Storage_Metrics

Displays table-level storage utilization information, includes table metadata, and displays the number of storage types billed for each table.

> **NOTE**
>
> Rows are maintained in this view until the corresponding tables are no longer billed for any storage, regardless of various states that the data in the tables may be in (i.e. active, Time Travel, Fail-safe, or retained for clones)

Tables

Displays a row for each table and view in the specified (or current) database

Usage_Privileges

Displays a row for each privilege defined for sequences in the specified (or current) database

Views

Displays a row for each view in the specified (or current) database

There are different ways to look at some of the metadata in Snowflake, some of which do use the Information Schema. If you try each of the commands below, you'll see that there are two ways we can get the information about schemas within the Snowflake sample database.

```
SELECT
    *
FROM
    "SNOWFLAKE_SAMPLE_DATA"."INFORMATION_SCHEMA"."SCHEMATA";
SHOW SCHEMAS IN DATABASE "SNOWFLAKE_SAMPLE_DATA";
```

However, one thing you will notice is that the metadata contained with the INFORMATION_SCHEMA is much more complete with several more columns of information than when you simply use the "SHOW" command.

If you try the following SQL statement, what happens?

```
SELECT
    *
FROM
    "DEMO_DB"."INFORMATION_SCHEMA"."TABLE_PRIVILEGES";
```

You will notice that no rows are returned in the results. The reason is because there are no tables in the database, thus, there will be no table privileges.

The INFORMATION_SCHEMA, one of the two schemas that are included with every Snowflake database, has a great many uses. The Information Schema provides a great deal of information about an account's object metadata and usage metrics. There is also another place within Snowflake where object metadata and usage metrics are stored.

The SNOWFLAKE database, viewable by the ACCOUNTADMIN, includes an ACCOUNT_USAGE view that is very similar to the INFORMATION_SCHEMA but with three differences. First, the SNOWFLAKE database ACCOUNT_USAGE view includes records for dropped objects whereas the INFORMATION_SCHEMA does not. The ACCOUNT_USAGE view also has a longer retention time for historical usage data. Whereas the INFORMATION_SCHEMA has data available ranging from seven days to six months, the ACCOUNT_USAGE view retains historical data for one year. Finally, there is no latency when querying the INFORMATION_SCHEMA but the latency time for ACCOUNT_USAGE could range from 45 minutes to three hours.

One of the common uses for the ACCOUNT_USAGE view is to keep track of credits used over time by each warehouse in your account (month-to-date):

```
USE ROLE ACCOUNTADMIN;
USE DATABASE SNOWFLAKE;
USE SCHEMA ACCOUNT_USAGE;
SELECT
    start_time::date AS USAGE_DATE,
    WAREHOUSE_NAME,
    SUM(credits_used) AS TOTAL_CREDITS_CONSUMED
FROM
    warehouse_metering_history
WHERE
    start_time >= date_trunc(Month, current_date)
GROUP BY
    1,
    2
ORDER BY
    2,
    1;
```

The SNOWFLAKE database, which includes the Account Usage view, is only available to the ACCOUNTADMIN role, unless the ACCOUNTADMIN grants data sharing privileges.

Introduction to Snowflake Tables

As previously mentioned, all Snowflake data is stored in tables. In addition to permanent and transient tables, it is also possible to create temporary and external tables as shown in Figure 2-7. Like database and schemas, we can use the CREATE, ALTER, DROP, and SHOW TABLES commands. In addition, we'll need to use INSERT INTO or COPY INTO to place data in a table. For Snowflake tables, we can also use the TRUNCATE command to remove data from a table but not remove the table object itself.

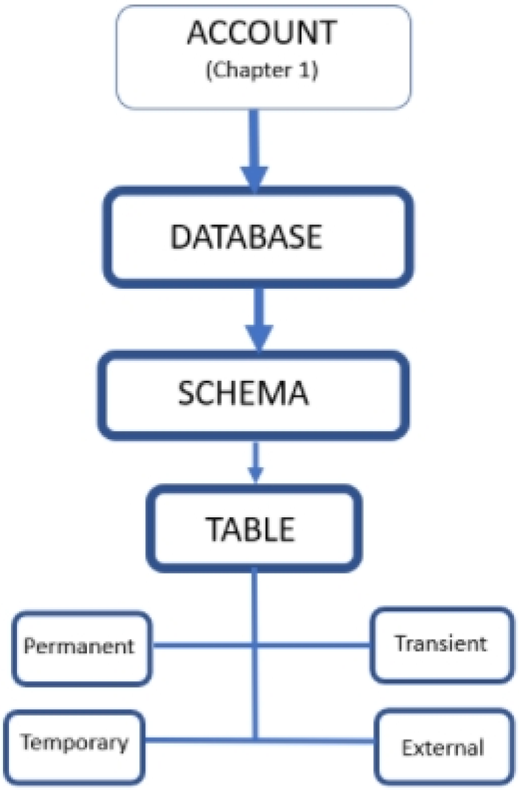


Figure 2-7. Object hierarchy

As we saw in the database section, Snowflake assumes it should create a permanent table if the table type is not specified, unless the table is created within a transient database. Transient tables are unique to Snowflake and have characteristics of both permanent and temporary table. One of the biggest differences is that the fail-safe service is not provided for transient tables. They are designed for transitory data that needs to be maintained beyond a session but doesn't need the same level of data recovery by permanent tables. As a result, the data storage costs for a transient table would be less than a permanent table.

It isn't possible to change a permanent table to a transient table by using the ALTER command because the TRANSIENT property is set at table creation time. Likewise, a transient table cannot be converted to a permanent table. If you would like to make a change to a transient or permanent table type, you'll need to create a new table, use the "COPY GRANTS" clause, and then copy the data.

It was mentioned that the default for creating tables is that a permanent table would be created unless otherwise specified. If it makes sense to have new tables automatically created as a transient type by default, you can first create a transient database or schema. As we saw in the databases section, all tables created afterward will be transient rather than permanent.

Transient tables can be accessed by other users who have the necessary permissions. On the other hand, temporary tables exist only within the session in which they are created. This means they are not available to other users and cannot be cloned. Temporary tables have many uses including being used for ETL data and for session-specific data needs.

> **TIP**
>
> The temporary table, as well as its data within, is no longer accessible once the session ends. During the time a temporary table exists, it does count toward storage costs; therefore, it is a good practice to drop a temporary table once you no longer need it.

> **WARNING**
>
> Interestingly, you can create a temporary table that has the same name as an existing table in the same schema since the temporary table is session-based. No errors or warnings will be given. It is also a best practice to give temporary tables unique names to avoid unexpected problems given that the temporary table takes precedence.

We will now create some tables that we'll use later in the chapter:>

```
USE ROLE SYSADMIN;
USE DATABASE CHAPTER3_PDB1;
CREATE
OR REPLACE SCHEMA BANKING;
CREATE
OR REPLACE TABLE CUSTOMER_ACCT (
    Customer_Account int,
    Amount int,
    transaction_ts timestamp
);
CREATE
OR REPLACE TABLE CASH (
    Customer_Account int,
    Amount int,
    transaction_ts timestamp
);
CREATE
OR REPLACE TABLE RECEIVABLES (
    Customer_Account int,
    Amount int,
    transaction_ts timestamp
);
```

After creating this table, the active role is the "SYSADMIN" role, the active database is "CHAPTER3_PDB1" and the active schema is "BANKING". Thus, a newly created table will be located within the BANKING schema if you create a new table without specifically using a different namespace. Let's try that now:

```
USE ROLE SYSADMIN;
CREATE
OR REPLACE TABLE NEWTABLE (
    Customer_Account int,
    Amount int,
    transaction_ts timestamp
);
```

In Figure 2-8, we can see that NEWTABLE was created in the active namespace.

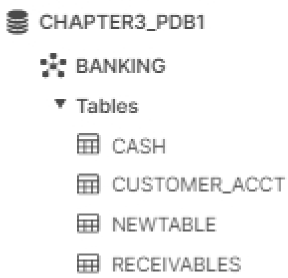


Figure 2-8. List of the tables in the Banking schema of the CHAPTER3_PDB1 database

Let's now drop the new table we just created. We want to use the fully qualified table name. Type in "DROP TABLE" with a space afterward. Then, double click on the table name and Snowflake will insert the fully qualified table name. Be sure to put a semi-colon at the end and then run the statement.

```
USE ROLE SYSADMIN;
DROP TABLE "CHAPTER3_PDB1"."BANKING"."NEWTABLE";
```

We didn't have to use the fully qualified table name because we were in the active space where we wanted to drop the table. We could have just used the command "DROP TABLE NEWTABLE;". However, it is best practice to use a table's fully qualified name or the "USE" command, which achieves the same goal.

At this point, Figure 2-9 shows what your Account should look like.

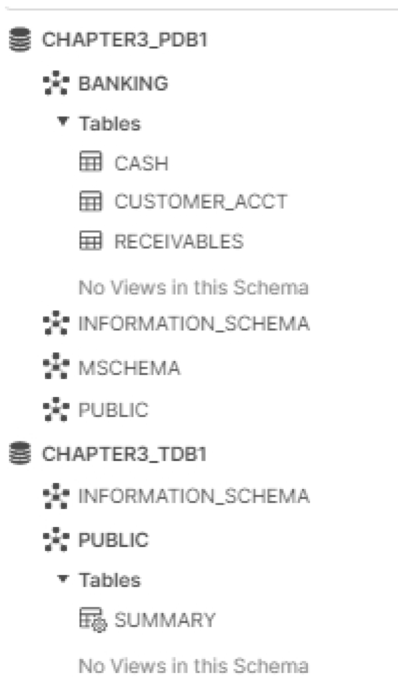


Figure 2-9. Databases and tables created thus far in this chapter

Creating and Managing Views

Along with tables, Snowflake views are the primary objects maintained in database schemas as shown in Figure 2-10. Views are of two types, materialized and non-materialized. Whenever the term "view" is mentioned and the type is not specified, it is understood that it is a non-materialized view.

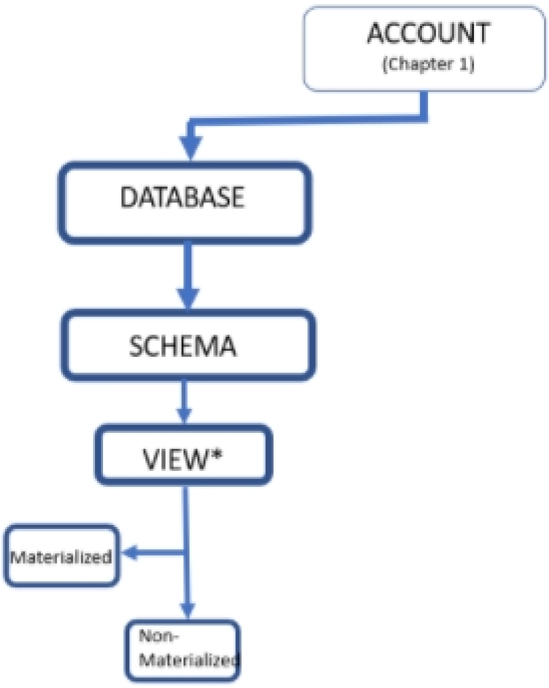


Figure 2-10. Object hierarchy (possible to have Secure view)*

A "view" is considered to be a virtual table created by a query expression; something like a window into a database. Let's create a new view by selecting one column from the Snowflake sample data.

> **WARNING**
>
> We've mentioned the importance of using fully qualified names for tables. The importance of using a fully qualified name for the table is even more important when creating views because the connected reference will be invalid if the namespace of the base table is not used and this table or the view is moved to a different schema or database later.

```
CREATE
OR REPLACE VIEW CHAPTER3_TDB1.PUBLIC.NEWVIEW AS
SELECT
    CC_NAME
FROM
```

```
    (
        SELECT
            *
        FROM
            SNOWFLAKE_SAMPLE_DATA.TPCDS_SF100TCL.CALL_CENTER
    );
```

One purpose of views is to display selected rows and columns from one or more tables. This is a way to provide some security by only exposing certain data to specific users. There is the ability for views to provide even more security by creating a specific *secure view* of either a non-materialized or materialized view. Most secure views are materialized views. Creating materialized views require Snowflake Enterprise Edition. Let's create a materialized view using the same query as before.

```
CREATE
OR REPLACE MATERIALIZED VIEW CHAPTER3_TDB1.PUBLIC.NEWVIEW_MATERIALIZED AS
SELECT
    CC_NAME
FROM
    (
        SELECT
            *
        FROM
            SNOWFLAKE_SAMPLE_DATA.TPCDS_SF100TCL.CALL_CENTER
    );
```

You can run a "SHOW VIEWS" command and both views will be returned in the results. If you run a "SHOW MATERIALIZED VIEWS" command, then only the materialized view result will be returned.

If you run a SELECT * command for each of the views, you'll notice that the results are identical. That is because we haven't really used a materialized view for its intended purpose. Unlike a regular view, a materialized view object gets periodically refreshed with the data from the base table. Thus, it is illogical to consider using a materialized view for the Snowflake sample database because the Snowflake sample database cannot be updated with new data.

Also, the query to retrieve a single column is not one typically used for materialized views. Materialized views are generally used to aggregate as well as filter data so that the results of resource-intensive operations can be stored in a materialized view for improved data performance. Improved data performance is especially good when that same query is frequently used.

The data within a materialized view is always current because Snowflake uses a background service to automatically update materialized views. To see that in action, we're going to create a materialized view. We will revisit the view later in the chapter.

```
CREATE
OR REPLACE MATERIALIZED VIEW CHAPTER3_TDB1.PUBLIC.BANKINGVIEW_MV AS
SELECT
    *
FROM
    (
        SELECT
            *
        FROM
            CHAPTER3_TDB1.PUBLIC.SUMMARY
    );
```

As you would expect, views are read-only. Thus, it isn't possible to use the INSERT, UPDATE, or DELETE commands on views. Further, Snowflake doesn't allow users to truncate views. While it is not possible to execute DML commands on a view, you can use a subquery within a DML statement that can be used to update the underlying base table. An example might be something like:

```
DELETE FROM <Base Table> WHERE <Column> > (SELECT AVG <Column> FROM View);
```

Other things to be aware of is that a view cannot be updated with the ALTER VIEW command. However, the ALTER MATERIALIZED VIEW command can be used to rename a materialized view, to add or replace comments, or to modify the view to be a secure view. The SHOW and DESCRIBE commands are also available for views.

If you wanted to change something structural about the view, you would have to recreate it with a new definition. Also, changes to a source table's structure do not automatically propagate to views. For example, dropping a table column won't drop the column in the view.

There are many considerations when deciding between a regular view and a materialized view. It is best to use a non-materialized view when the results of the view frequently change, the query isn't so complex and expensive to rerun, and the results of the view often change. Regular views do incur compute costs but not storage costs. The compute cost to refresh the view and the storage cost will need to be weighed against the benefits of a materialized view when the results of a view change often.

TIP

Generally, it is beneficial to use a materialized view when the query consumes a lot of resources as well as the results of the view are often used and the underlying table doesn't change frequently.

There are some limitations for materialized views, such as a materialized view can query only a single table and joins are not supported. It is recommended that you consult the Snowflake documentation for more detail on materialized view limitations.

WARNING

One thing to remember is that we are using the SYSADMIN role currently and we're creating the views using that role. For someone who doesn't have the SYSDAMIN role, they will need to have assigned to them the privileges on the schema, the database objects in the underlying table(s), and the view itself if they are to work with the view.

Introduction to Snowflake Stages – File Format Included

Snowflake stages are temporary storage spaces that are used as an intermediate step to load files to Snowflake tables or to unload data from Snowflake tables into files. Snowflake permanent and temporary stages are used to store data files internally whereas external stages reference data files that are stored in a location outside of Snowflake. Outside locations, whether private / protected, or public, like Amazon S3 buckets, Google Cloud Storage buckets, and Microsoft Azure containers, are supported by Snowflake and can be used in external stages.

Each Snowflake user has a stage for storing files which is accessible only by that user. The User stage can be referenced by @~. Likewise, each Snowflake table has a stage allocated for storing files and can be referenced by using @%*<name of table>*.

> **NOTE**
>
> Table stages are useful if multiple users need to access the files and those files only need to be copied into a single table whereas a user stage is best when the files only need to be accessed by one user but will need to be copied into multiple tables.

User and table stages cannot be altered or dropped and neither of these stages support setting the file format, but you can specify the format and copy options at the time the "COPY INTO" command is issued. Additionally, table stages do not support transforming the data while loading it. A table stage is tied to the table itself and is not a separate database object. To perform actions on the table stage, you must have been granted the table ownership role.

The command to list a user stage is ls@~; or LIST @~; . Figure 2-11 shows the results of the command to list a user stage.

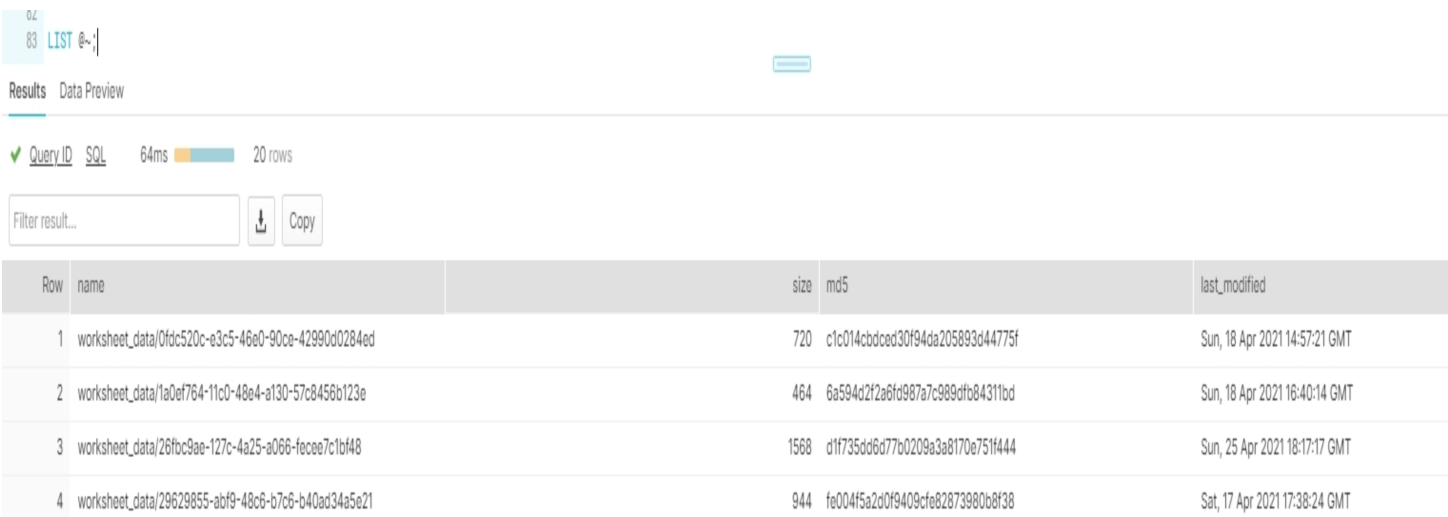


Figure 2-11. Results of the command to list a user stage

User stages and table stages, both of which are types of internal stages, are automatically provided for each Snowflake account. In addition to user and table stages, internal named stages can also be created (see Figure 2-12). Internal named stages are database objects, which means that they can be used not just by one user but by every user who has been granted the appropriate privileges.

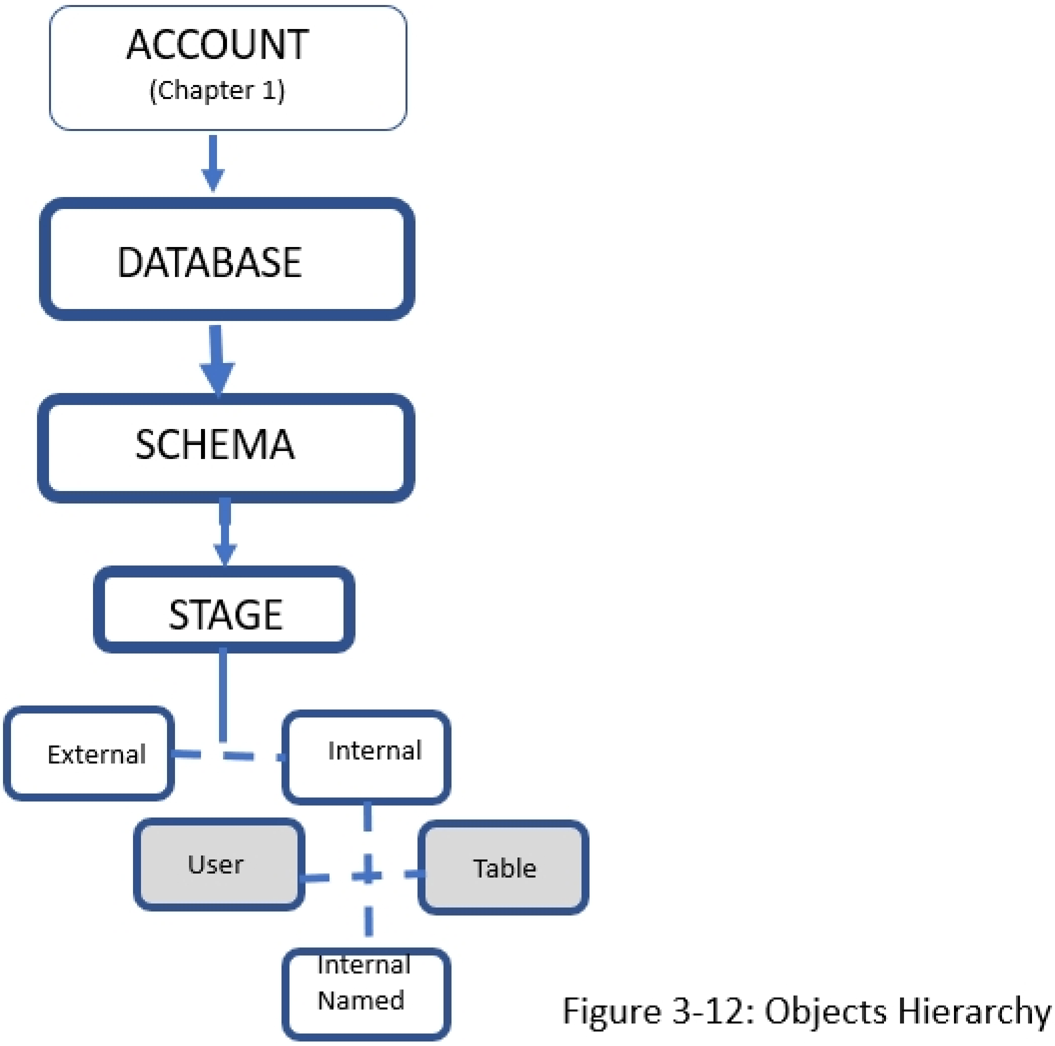


Figure 2-12. Object hierarchy

Internal named stages and external stages can be created as either a permanent or a temporary stage. When a temporary external stage is dropped, no data files are removed because those files are stored external to Snowflake. Only the stage is dropped. For a temporary internal stage, however, the data and stage are both dropped and the files are not recoverable.

When using stages, we can use file formats to store all the format information we need for loading data from files to tables. The default file format is CSV. However, you can create file formats for other formats such as JSON, AVRO, ORC, PARQUET, and XML. There are also optional parameters that can be included when you create a file format. We are going to create a file format for loading JSON data. Then we'll make use of that file format when we create a stage.

```
USE ROLE SYSADMIN;
USE DATABASE CHAPTER3_TDB1;
CREATE
```

```
OR REPLACE FILE FORMAT JSON_FILEFORMAT TYPE = JSON;

USE DATABASE CHAPTER3_TDB1;
USE SCHEMA PUBLIC;
CREATE
OR REPLACE STAGE TEMP_STAGE FILE_FORMAT = JSON_FILEFORMAT;
```

> **NOTE**
>
> The data is always in an encrypted state, whether data is in flight between the customer and internal stage or at rest and stored in a Snowflake database table.

Extending SQL with Stored Procedures and UDFs

To extend SQL capabilities in Snowflake, you can create stored procedures and user defined functions (UDFs) to achieve functionalities not possible with Snowflake built-in functions. Both stored procedures and UDFs encapsulate business logic and return a single value (scalar) or multiple values (tabular). You can create stored functions in JavaScript and UDFs in both SQL and JavaScript languages. It is possible to create secure UDFs (see Figure 2-13).

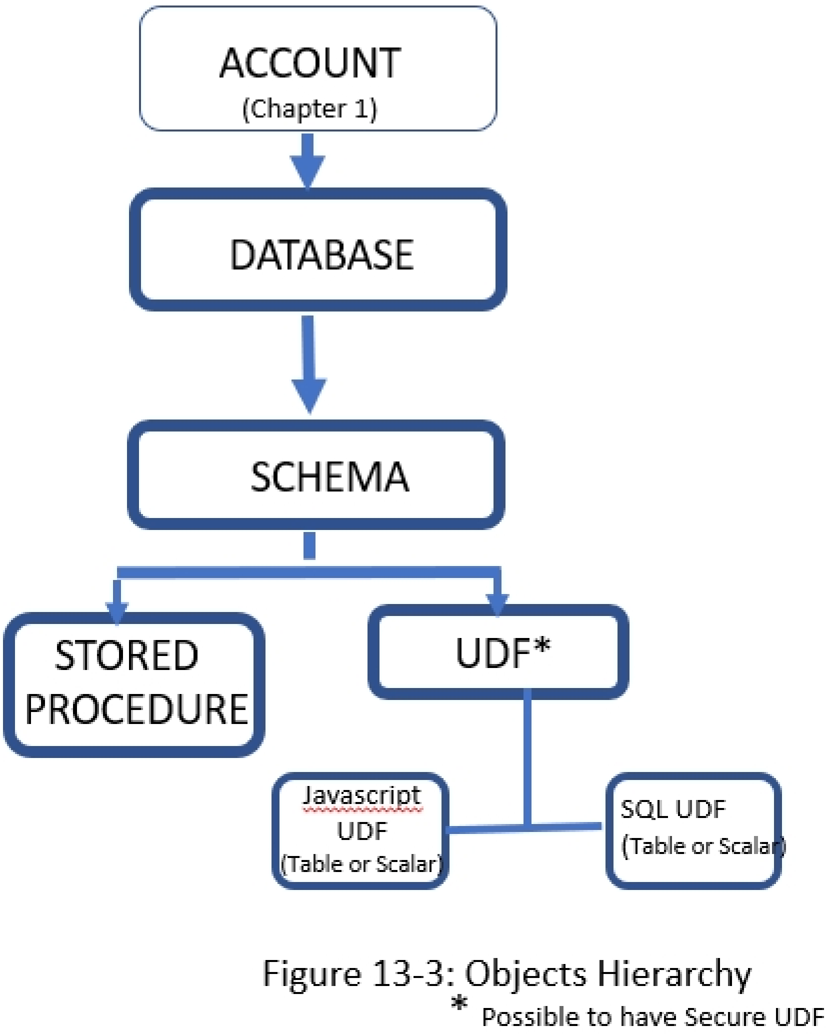


Figure 2-13. Objects hierarchy (possible to have secure UDF)*

Both stored procedures and UDFs extend SQL capabilities but there are many differences between the two. One of the most important differences is how they are used.

> **NOTE**
>
> If you need to perform database operations such as SELECT, DELETE, or CREATE, you'll need to use a stored procedure. If you want to use a function as part of the SQL statement or expression or if your output needs to include a value for every input row, then you'll want to use a Snowflake UDF.

A UDF is called as part of the SQL statement, but a stored procedure cannot be called within a SQL statement. Instead, a stored procedure is called as an independent statement using the "CALL" statement. The "CALL" statement can call only one stored procedure per statement.

A UDF is required to return a value and you can use the UDF return value inside your SQL statements. Although not required, a stored procedure is allowed to return a value, but the "CALL" command doesn't provide a place to store the returned value. The stored procedure also doesn't provide a way to pass it to another operation.

In the next two sections, there are a total of five examples provided. The first is a simple JavaScript UDF that returns a scalar value and the next is a secure SQL UDF that returns tabular results. Following those are three stored procedures examples. The first is where an argument is directly passed in. The next example is lengthier and demonstrates the basics of an Accounting Information System where each banking transaction has a debit and credit entry. The last example is an advanced example that combines a stored procedure with a task.

User Defined Function (UDF) – Task Included

UDFs allow you to perform some operations that are not available through the built-in, system-defined functions provided by Snowflake. There are two types of UDFs supported by Snowflake. Both SQL and JavaScript can return either scalar or tabular results.

A SQL UDF evaluates SQL statements and it can refer to other UDFs, although a SQL UDF cannot refer to itself either directly or indirectly.

A JavaScript UDF is useful for manipulating variant and JSON data. A JavaScript UDF expression can refer to itself recursively, although it cannot refer to other UDFs. JavaScript UDFs also have size and depth limitations that don't apply to SQL UDFs. We'll see that demonstrated in one of our examples.

JavaScript UDFs have access to the basic standard JavaScript library needed to create arrays, variables, and simple objects. You cannot use math functions or use error handling because Snowflake does not let you import external libraries. The properties that are available for both JavaScript UDFs and JavaScript Procedures can be found by using the commands below.

```
USE ROLE SYSADMIN;
CREATE
OR REPLACE DATABASE DB_CHAPTER3;
USE DATABASE DB_CHAPTER3;
CREATE
OR REPLACE FUNCTION JS_PROPERTIES() RETURNS string LANGUAGE JAVASCRIPT AS $$
        return Object.getOwnPropertyNames(this);
    $$;
SELECT
    JS_PROPERTIES();
```

For our first UDF example, we are going to create a simple JavaScript UDF which returns a scalar result. We mentioned that JavaScript UDFs have size and depth limitations and we'll be able to demonstrate that in this example.

```
USE ROLE SYSADMIN;
USE DATABASE DB_CHAPTER3;
CREATE
OR REPLACE FUNCTION FACTORIAL(n variant) RETURNS variant LANGUAGE JAVASCRIPT AS '
```

```
     var f=n;
     for (i=n-1; i>0; i--) {
  f=f*i
    }
 return f';
SELECT
    FACTORIAL(5);
```

The result returned is 120 when the number 5 is used. If you use a number greater than 33, you'll receive an error message. Try finding the result of FACTORIAL(50) and see what happens.

Secure SQL or JavaScript UDFs take a specific set of inputs that are used to evaluate the expression using raw data but only return a limited result data set. Secure SQL UDFs and JavaScript secure UDFs are both shareable but operate differently and are generally used for different purposes. JavaScript secure UDFs are often used for data cleansing, address matching, or other data manipulation operations.

Unlike JavaScript secure UDFs, a secure SQL UDF can run queries. For a secure shared UDF, the queries can only be run against the provider's data. When a provider shares a secure UDF with a customer, the cost of data storage is paid for by the provider and the compute cost is paid for by the consumer. In this example created for you, there will be no data storage cost incurred because we are using the Snowflake sample data set.

Secure SQL UDF That Returns Tabular Value (Market Basket Analysis Example)

Market basket analysis is a common use of secure SQL UDFs and that is what we'll be demonstrating. In our example, the output is aggregated data where a consumer would like to see how many times other items were sold with their particular individual item. We wouldn't want the consumer account to have access to our raw sales data, so we'll wrap the SQL statement in a secure UDF and create an input parameter. Using the secure UDF with an input parameter, the consumer still gets the same results as running the SQL statement directly on the underlying raw data.

We want to use data that is already provided for us in the Snowflake sample database but there are more records than we need for this demonstration. Let's create a new table and select 100,000 rows from the sample database. That will be more than enough.

```
USE ROLE SYSADMIN;
CREATE
OR REPLACE DATABASE DB_UDF;
CREATE
OR REPLACE SCHEMA SCHEMA1;
CREATE
OR REPLACE TABLE DB_UDF.SCHEMA1.SALES AS (
    SELECT
        *
    FROM
        "SNOWFLAKE_SAMPLE_DATA"."TPCDS_SF100TCL"."WEB_SALES"
)
LIMIT
    100000;
```

Next, we'll run our query directly on the new table. In this instance, we are interested in the product with the SK of 87. We want to know the different items that were sold with this produce in the same transaction. We can use this query to find that information.

```
SELECT
    87 AS INPUT_ITEM,
    WS_WEB_SITE_SK AS BASKET_ITEM,
    COUNT (DISTINCT WS_ORDER_NUMBER) BASKETS
FROM
    DB_UDF.SCHEMA1.SALES
WHERE
    WS_ORDER_NUMBER IN (
        SELECT
            WS_ORDER_NUMBER
        FROM
            DB_UDF.SCHEMA1.SALES
        WHERE
            WS_WEB_SITE_SK = 87
    )
GROUP BY
    WS_WEB_SITE_SK
ORDER BY
    3 DESC,
    2;
```

The results of this query shows us the product with SK of 87 was sold in 152 unique transactions within our records. The item with SK of 9 and the item with SK of 72 were each sold in the same transaction as the item with SK of 87 a total of 34 times. For the manufacturers of product with SK of 9 and 72, this could be valuable information. We might be willing to share those details but we wouldn't want to allow access to the underlying sales data. Thus, we'll want to create a secure SQL UDF function.

```
USE ROLE SYSADMIN;
CREATE
OR REPLACE SECURE FUNCTION DB_UDF.SCHEMA1.GET_MKTBASKET(INPUT_WEB_SITE_SK number(38))
RETURNS TABLE (
    INPUT_ITEM NUMBER(38, 0),
    BASKET_ITEM NUMBER(38, 0),
    BASKETS NUMBER(38, 0)
) AS 'SELECT input_web_site_sk, WS_WEB_SITE_SK as BASKET_ITEM, COUNT(DISTINCT
WS_ORDER_NUMBER) BASKETS
FROM DB_UDF.SCHEMA1.SALES
WHERE WS_ORDER_NUMBER IN (SELECT WS_ORDER_NUMBER FROM DB_UDF.SCHEMA1.SALES WHERE
WS_WEB_SITE_SK = input_web_site_sk)
GROUP BY ws_web_site_sk
ORDER BY 3 DESC, 2';
```

If we were to share with another user this secure UDF through a Snowflake consumer account, that user could run the secure UDF without seeing any of the underlying data, table structures, or the SQL code. This is the command that the owner of the consumer account would use to obtain the results. You can try this command with the number 87 that we used earlier when we queried the table directly and you'll get the same exact result with the UDF function. You can also try other product SKs.

```
SELECT
    *
FROM
    TABLE(DB_UDF.SCHEMA1.GET_MKTBASKET(9));
```

> **TIP**
>
> Using Secure UDFs should be specifically used for instances where data privacy is of concern, and you want to limit access to sensitive data. It is important to consider the purpose and necessity of creating a secure UDF and weigh that against the decreased query performance that is likely to result from using a secure UDF.

Stored Procedures

Stored procedures are similar to functions in that they are created once and can be executed many times. Stored procedures allow you to extend Snowflake SQL by combining it with JavaScript in order to include branching and looping, as well as error handling. Stored procedures, which must be written in JavaScript, can be used to automate tasks that require multiple SQL statements performed frequently.

While you can "SELECT" statements inside a stored procedure, the results must be used within the stored procedure. If not, then only a single value result can be returned. Stored procedures are great for batch actions because a stored procedure runs by itself and, similar to a trigger, can be conditionally tied to database events.

In the first stored procedures example, we are going to pass in an argument to the stored procedure.

```
USE ROLE SYSADMIN;
CREATE
OR REPLACE DATABASE DB_CHAPTER3;
CREATE
OR REPLACE PROCEDURE STOREDPROC1(ARGUMENT1 VARCHAR) RETURNS STRING NOT NULL LANGUAGE
javascript AS $$ var INPUT_ARGUMENT1 = ARGUMENT1;
var result = `${INPUT_ARGUMENT1}` return result;
$$;
CALL STOREDPROC1('I really love Snowflake ❄');
```

Figure 2-14 shows the results of the passing in an argument to the stored procedure.

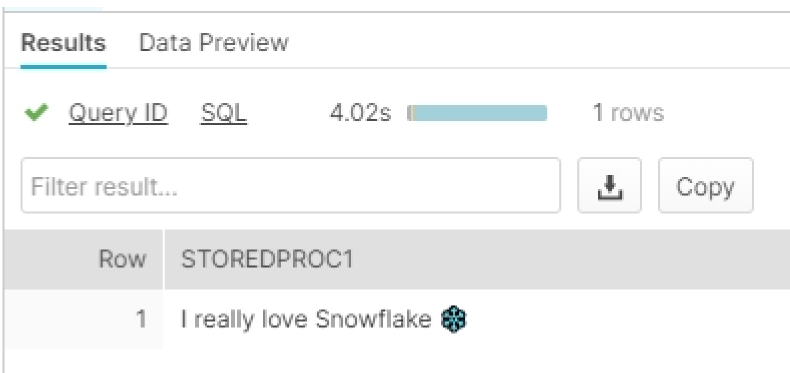


Figure 2-14. Results of passing in an argument to the stored procedure created in the chapter

You can use the INFORMATION_SCHEMA to take a look at the information for Snowflake Procedures in the database.

```
SELECT
    *
FROM
    "DB_CHAPTER3"."INFORMATION_SCHEMA"."PROCEDURES";
```

The next stored procedure example is one where we are demonstrating the very basics of an Accounting Information System where tabular results are returned for banking transactions that record debits and credits. If you remember, earlier in the chapter we created the tables needed for this example so we can just dive right into creating the stored procedure.

We are recording the accounting transactions for a bank that deals with customer's giving cash to the bank and getting cash from the bank. We'll keep the accounting portion of the example limited to three types of transactions – deposits, withdrawals, and loan payments.

First, we'll want to create a stored procedure for a deposit transaction where the bank's cash account is debited and the customer account on the bank's balance sheet is credited whenever a customer gives the bank cash to add to their account.

```
USE ROLE SYSADMIN;
CREATE
OR REPLACE PROCEDURE deposit(PARAM_ACCT FLOAT, PARAM_AMT FLOAT) returns STRING LANGUAGE
javascript AS $$
    var ret_val = "";
    var cmd_debit = "";
    var cmd_credit = "";

    // INSERT data into tables
    cmd_debit = "INSERT INTO CHAPTER3_PDB1.BANKING.CASH VALUES (" + PARAM_ACCT + "," +
PARAM_AMT + ",current_timestamp());";
    cmd_credit = "INSERT INTO CHAPTER3_PDB1.BANKING.CUSTOMER_ACCT VALUES (" + PARAM_ACCT +
"," + PARAM_AMT + ",current_timestamp());";

    // BEGIN transaction
    snowflake.execute ({sqlText: cmd_debit});
    snowflake.execute ({sqlText: cmd_credit});
        ret_val = "Deposit Transaction Succeeded";
    return ret_val;
    $$;
```

Next, we'll create the transaction for a withdrawal. In this case, it is just the reverse of what happens for a deposit.

```
USE ROLE SYSADMIN;
CREATE OR REPLACE PROCEDURE withdrawal (PARAM_ACCT FLOAT,PARAM_AMT FLOAT)
    returns STRING
    LANGUAGE javascript
    AS
    $$
    var ret_val = "";
    var cmd_debit = "";
    var cmd_credit = "";

    // INSERT data into tables
    cmd_debit = "INSERT INTO CHAPTER3_PDB1.BANKING.CUSTOMER_ACCT VALUES (" + PARAM_ACCT +
"," + (-PARAM_AMT) + ",current_timestamp());";
    cmd_credit = "INSERT INTO CHAPTER3_PDB1.BANKING.CASH VALUES (" + PARAM_ACCT + "," +
(-PARAM_AMT) + ",current_timestamp());";
```

```
    // BEGIN transaction
    snowflake.execute ({sqlText: cmd_debit});
    snowflake.execute ({sqlText: cmd_credit});
        ret_val = "Withdrawal Transaction Succeeded";
    return ret_val;
    $$;
```

Finally, the transaction for the loan payment is one where the bank's cash account is debited and the receivables account is credit.

```
USE ROLE SYSADMIN;
CREATE OR REPLACE PROCEDURE loan_payment (PARAM_ACCT FLOAT,PARAM_AMT FLOAT)
    returns STRING
    LANGUAGE javascript
    AS
    $$
    var ret_val = "";
    var cmd_debit = "";
    var cmd_credit = "";

    // INSERT data into the tables
    cmd_debit = "INSERT INTO CHAPTER3_PDB1.BANKING.CASH VALUES (" + PARAM_ACCT + "," +
PARAM_AMT + ",current_timestamp());";
    cmd_credit = "INSERT INTO CHAPTER3_PDB1.BANKING.RECEIVABLES VALUES (" + PARAM_ACCT + ","
+ (-PARAM_AMT) + ",current_timestamp());";
    //BEGIN transaction
    snowflake.execute ({sqlText: cmd_debit});
    snowflake.execute ({sqlText: cmd_credit});
        ret_val = "Loan Payment Transaction Succeeded";
    return ret_val;
    $$;
```

Now, let's run a few quick tests to see if the functions are working.

```
CALL withdrawal(21, 100);
CALL loan_payment(21, 100);
CALL deposit(21, 100);
```

After using the "CALL" command to test a few transactions, we are going to truncate the tables which leaves the tables intact but removes the data.

```
USE ROLE SYSADMIN;
USE DATABASE CHAPTER3_PDB1;
USE SCHEMA BANKING;
TRUNCATE TABLE "CHAPTER3_PDB1"."BANKING"."CUSTOMER_ACCT";
TRUNCATE TABLE "CHAPTER3_PDB1"."BANKING"."CASH";
TRUNCATE TABLE "CHAPTER3_PDB1"."BANKING"."RECEIVABLES";
```

Now, we'll go ahead and input some transactions.

```
USE ROLE SYSADMIN;
CALL deposit(21, 10000);
CALL deposit(21, 400);
CALL loan_payment(14, 1000);
CALL withdrawal(21, 500);
CALL deposit(72, 4000);
CALL withdrawal(21, 250);
```

We'd like to see a transaction summary, so we'll create one final stored procedure.

```
USE ROLE SYSADMIN;
 CHAPTER3_TDB1;
USE SCHEMA PUBLIC;
CREATE OR REPLACE PROCEDURE Transactions_Summary()
    returns STRING
    LANGUAGE javascript
    AS
    $$
    var cmd_truncate = `TRUNCATE TABLE IF EXISTS CHAPTER3_TDB1.PUBLIC.SUMMARY;`
    var sql = snowflake.createStatement({sqlText: cmd_truncate});
    var cmd_cash = `Insert into CHAPTER3_TDB1.PUBLIC.SUMMARY (CASH_AMT) select sum(AMOUNT)
from "CHAPTER3_PDB1"."BANKING"."CASH";`
    var sql = snowflake.createStatement({sqlText: cmd_cash});
    var cmd_receivables = `Insert into CHAPTER3_TDB1.PUBLIC.SUMMARY (RECEIVABLES_AMT) select
sum(AMOUNT) from "CHAPTER3_PDB1"."BANKING"."RECEIVABLES";`
    var sql = snowflake.createStatement({sqlText: cmd_receivables});
    var cmd_customer = `Insert into CHAPTER3_TDB1.PUBLIC.SUMMARY (CUSTOMER_AMT) select
sum(AMOUNT) from "CHAPTER3_PDB1"."BANKING"."CUSTOMER_ACCT";`
    var sql = snowflake.createStatement({sqlText: cmd_customer});


    //BEGIN transaction
        snowflake.execute ({sqlText: cmd_truncate});
        snowflake.execute ({sqlText: cmd_cash});
        snowflake.execute ({sqlText: cmd_receivables});
        snowflake.execute ({sqlText: cmd_customer});
        ret_val = "Transactions Successfully Summarized";
        return ret_val;
     $$;
```

Now, we can see the Transaction Summary. We'll call the stored procedure so that all the debit and credit transactions are summarized and then we'll take a look at the table.

```
CALL Transactions_Summary();

SELECT
    *
FROM
    CHAPTER3_TDB1.PUBLIC.SUMMARY;
```

Let's also take a look now at the materialized view we created earlier.

```
USE ROLE SYSADMIN;
USE DATABASE CHAPTER3_TDB1;
USE SCHEMA PUBLIC;
SELECT
    *
FROM
    "CHAPTER3_TDB1"."PUBLIC"."BANKINGVIEW_MV";
```

Now, we have our final stored procedural example. It's an advanced example because we are going to add a task to this stored procedure. We are creating a stored procedure that will delete a database. Thus, it's important that we create the stored procedure in a different database than the one we'll want to delete using the stored procedure.

```
USE ROLE SYSADMIN;
USE DATABASE DB_CHAPTER3;
CREATE
OR REPLACE PROCEDURE drop_db() RETURNS STRING NOT NULL LANGUAGE javascript AS $$
    var cmd = `DROP DATABASE "CHAPTER3_PDB1";`
```

```
    var sql = snowflake.createStatement({sqlText: cmd});
    var result = sql.execute();
    return 'Database has been successfully dropped';
    $$;
```

Now we can call the stored procedure and the database will be dropped. This is part of our cleanup for this chapter.

```
CALL drop_db();
```

Now that you've seen how this stored procedure works, we'll modify it so that it will drop a different database, and we'll add a task so that the database will be dropped 15 minutes later. That way you can see how a task works.

Let's go ahead and change our drop_db procedure so that we'll be dropping the database CHAPTER3_TDB1.

```
USE ROLE SYSADMIN;
CREATE
OR REPLACE PROCEDURE drop_db() RETURNS STRING NOT NULL LANGUAGE javascript AS $$
    var cmd = `DROP DATABASE "CHAPTER3_TDB1";`
    var sql = snowflake.createStatement({sqlText: cmd});
    var result = sql.execute();
    return 'Database has been successfully dropped';
    $$;
```

Next, we'll want to create the task that will delay the stored procedure by 15 minutes.

```
USE ROLE SYSADMIN;
CREATE
OR REPLACE TASK wait_15_task WAREHOUSE = COMPUTE_WH SCHEDULE = '15 MINUTE' AS CALL drop_db();
```

The SYSADMIN role is going to need some privileges to execute the task so be sure to use the ACCOUNTADMIN role for this command.

```
USE ROLE ACCOUNTADMIN;
GRANT EXECUTE TASK ON ACCOUNT TO ROLE SYSADMIN;
```

Because tasks are always created in a suspended state, they'll need to be resumed.

```
USE ROLE SYSADMIN;
ALTER TASK IF EXISTS wait_15_task RESUME;
```

Now our task is in a scheduled state. We'll be able to see that by using this query.

```
SELECT
    *
FROM
    table(
        information_schema.task_history(
            task_name => 'wait_15_task',
            scheduled_time_range_start => dateadd('hour', -1, current_timestamp())
        )
    );
```

Figure 2-15 shows the results of the query.

SCHEDULED_TIME	QUERY_START_1	NEXT_SCHEDULED_TIME..	(
2021-04-18 09:13:38.188 -0700	NULL	2021-04-18 09:28:38.1...	

Figure 2-15. Query results to see the current status of the task named “wait_15_task”

You can use the next 15 minutes to answer the questions at the end of the chapter to test your knowledge and then come back. Once you see that the task has been completed and the database has been dropped (you can refresh your screen, or you can run the query again to see the state of the task) then you can suspend the task.

```
USE ROLE SYSADMIN;
ALTER TASK IF EXISTS wait_15_task SUSPEND;
```

After you suspend the task, you can run the query one last time and you’ll see that the task succeeded and that there are no tasks scheduled.

Other

Pipes, streams, and sequences are Snowflake objects we haven’t covered. *Pipes* are objects that contain a “COPY” statement that is used by Snowpipe. Snowpipes are used for continuous, serverless loading of data into a Snowflake target table. Snowflake table *streams* keep track of certain changes made to a table including inserts, updates, and deletes. Streams have many useful purposes including recording changes made in a staging table which are used to update another table.

A *sequence* object is used to generate unique numbers. Often, sequences are used as surrogate keys for primary key values. Here is how you can generate a sequence that begins with the number one and increments by one.

```
USE ROLE SYSADMIN;
USE DATABASE DB_CHAPTER3;
CREATE
OR REPLACE SEQUENCE SEQ_01 START = 1 INCREMENT = 1;
CREATE
OR REPLACE TABLE SEQUENCE_TEST_TABLE(i integer);
```

You can use the select command three or four times to see how the NEXTVAL increments by one every time.

```
SELECT
    SEQ_01.NEXTVAL;
```

What happens when you try this?

```
USE ROLE SYSADMIN;
USE DATABASE DB_CHAPTER3;
CREATE
OR REPLACE SEQUENCE SEQ_02 START = 1 INCREMENT = 2;
CREATE
```

```
OR REPLACE TABLE SEQUENCE_TEST_TABLE(i integer);
SELECT
    SEQ_02.NEXTVAL a,
    SEQ_02.NEXTVAL b,
    SEQ_02.NEXTVAL c,
    SEQ_02.NEXTVAL d;
```

Some important things to remember about sequences is that the first value in a sequence cannot be changed after the sequence is created and sequence values, although unique, are not necessarily gap-free.

WARNING

A consideration when using sequences is that they may not be appropriate for situations such as a secure UDF case. The reason is that, in some circumstances a consumer may be able to use the difference between sequence numbers to infer information about the number of records. In that case, one option is to exclude the sequence column from the consumer results or to use a unique string ID instead of a sequence.

Code Cleanup

Let's perform a code cleanup to remove the objects in your Snowflake account in preparation for working on another chapter example.

Note that there is no need to drop objects in the hierarchy below the database before dropping the databases. If you've been following along, you dropped all databases except DB_CHAPTER3 so you'll just need to drop that database now.

Exercises to Test Your Knowledge

The following exercises are based on the coverage in this chapter about databases and database objects such as schemas, tables, views, stages, stored procedures and UDFs.

1. What are the different types of databases, schemas, and tables that can be created? If a particular type is not specifically stated at the time of creation, what is the default type for each?
2. What is the difference between scalar and tablular UDFs?
3. What kinds of things can you do with a stored procedure that you cannot do with a UDF?
4. What would happen if we used the "CREATE DATABASE" command and the database we want to create already exists? What if we used the "CREATE OR REPLACE DATABASE" command?
5. What is the default retention time for a database, and can that be changed?
6. Why might you choose to use the "TRUNCATE TABLE" command rather than the "DROP TABLE" command?

7. Are there any storage or compute costs associated with views?
8. What is the difference between a *fully* and a *partially qualified name*?
9. When using stages, what is the default file format? What other file formats does Snowflake support?
10. What is unique about the SNOWFLAKE database that comes with every Snowflake account?

About the Author

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Joyce taught Accounting Information Systems master-level courses at the University of Texas in Arlington and is a Texas Certified Public Accountant. She has worked in software development; architecting and building custom software applications for a major financial institution, and she has conducted research at the UTA Robotics Institute.

Joyce holds one Amazon Web Services certification and one Snowflake certification. She also holds eleven Salesforce certifications, including one for Einstein Analytics and one for Application Architect. In 2020, she was designated as an Einstein Platform Champion by Salesforce and designated a Data Super Hero by Snowflake. In promotion of Salesforce and Snowflake, Joyce produces a running series of How-To videos on YouTube.