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The Snowflake Data Platform

Prerequisites

- Comfortable writing SQL queries to analyze data
- Some familiarity with working on the cloud

Set up for demos

- Please sign up for a free Snowflake account
  https://signup.snowflake.com/

- GitHub link for resources
  https://github.com/janani-ravi-loony/analyzing-processing-data-snowflake

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The Snowflake Data Platform

Snowflake

Snowflake is a cloud-native, software-as-a-service advanced data platform for data storage, processing and analytics.

Snowflake

Snowflake is a **cloud-native, software-as-a-service** advanced data platform for data storage, processing and analytics.

Data Platform as a Cloud Service

Not hardware to setup, install, configure, or manage

No software to install, configure, or manage

All administration, maintenance, upgrades managed by Snowflake

Data Platform as a Cloud Service

Snowflake

- Does not use any existing database technology
  - e.g. MySQL, PostgreSQL, SQL Server
- Is not built on top of any existing big data framework
  - e.g. Hadoop, Spark
- Proprietary big data SQL engine
- Innovative architecture designed for the cloud

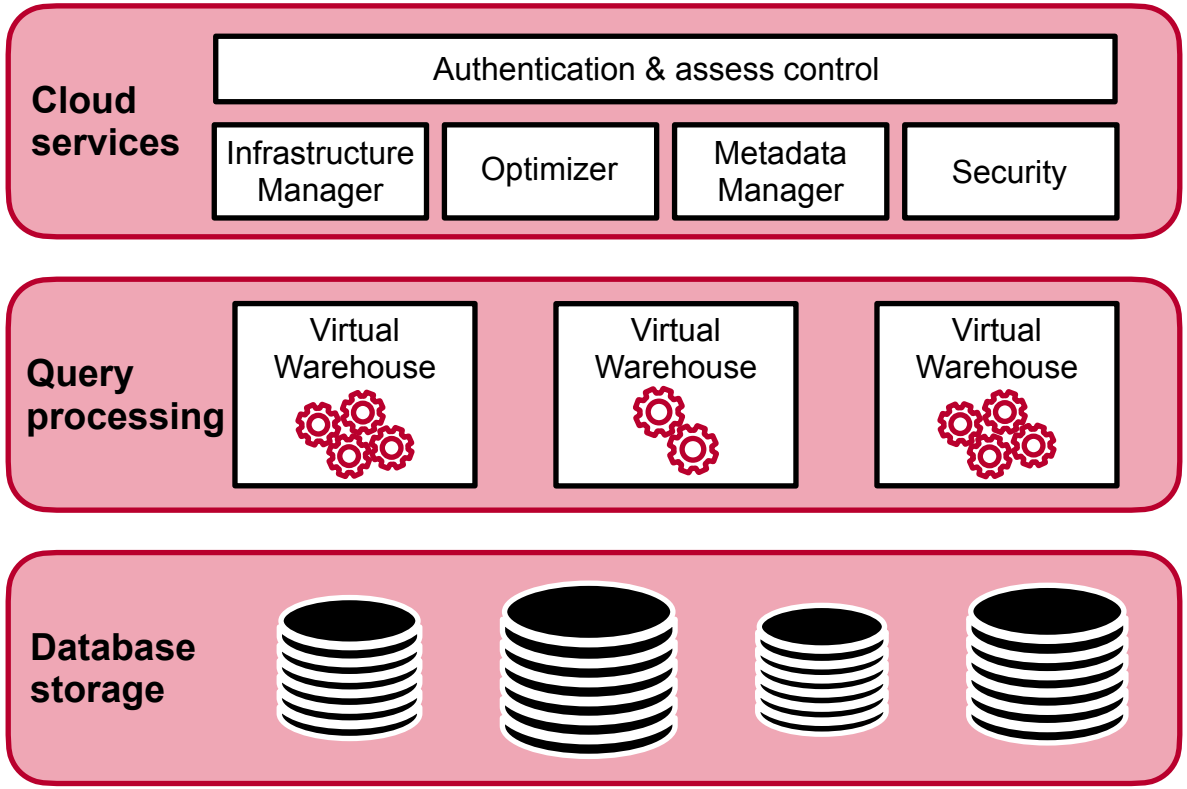
Where Does Snowflake Run?

Supported Cloud Platforms

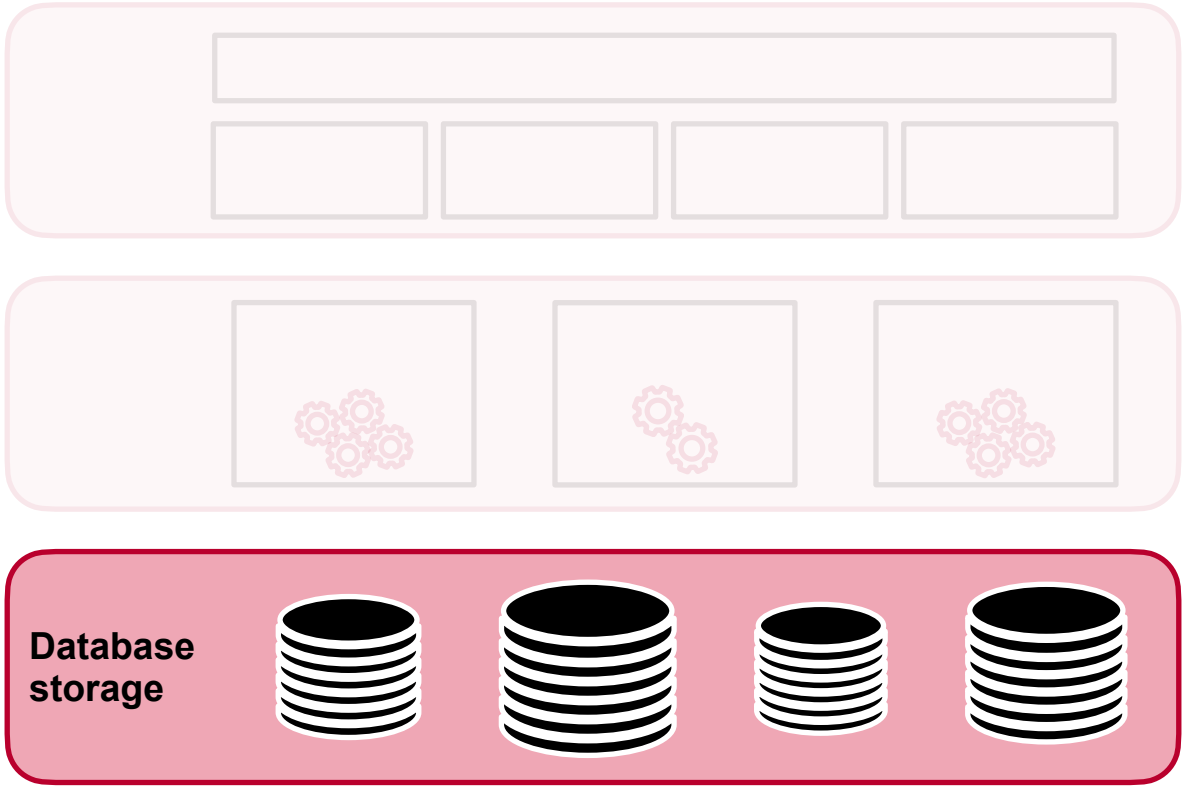
- On each platform Snowflake provides one or more regions where the account is provisioned
- Can choose to host all Snowflake accounts on the platform where you run other cloud services

Snowflake Architecture

Snowflake Architecture



Snowflake Architecture



Database Storage

- Persistent storage of data loaded into Snowflake
- Proprietary internal format:
  - Columnar, compressed, optimized
- Manages all aspects of data - organization, metadata, statistics, back up
- Snowflake users cannot access or view this data directly
- Data only accessible via SQL queries

Row Storage

product	quantity	warehouse
dryer	30	warehouse #2
microwave	20	warehouse #1
top load washer	10	NULL
dishwasher	30	warehouse #3
…	…	…

Each row stored together - data of different types laid out one after other in contiguous memory locations

Row Storage

product	quantity	warehouse
dryer	30	warehouse #2
microwave	20	warehouse #1
top load washer	10	NULL
dishwasher	30	warehouse #3
…	…	…

Efficient for looking up single records, but bad for analytical process since every field has to be read to access a record

Columnar Storage

product
dryer
microwave
top load washer
dishwasher
…

quantity
30
20
10
30
…

warehouse
warehouse #2
warehouse #1
NULL
warehouse #3
…

Each column stored together - in contiguous memory locations. Makes it easy to compress and query data

Columnar Storage

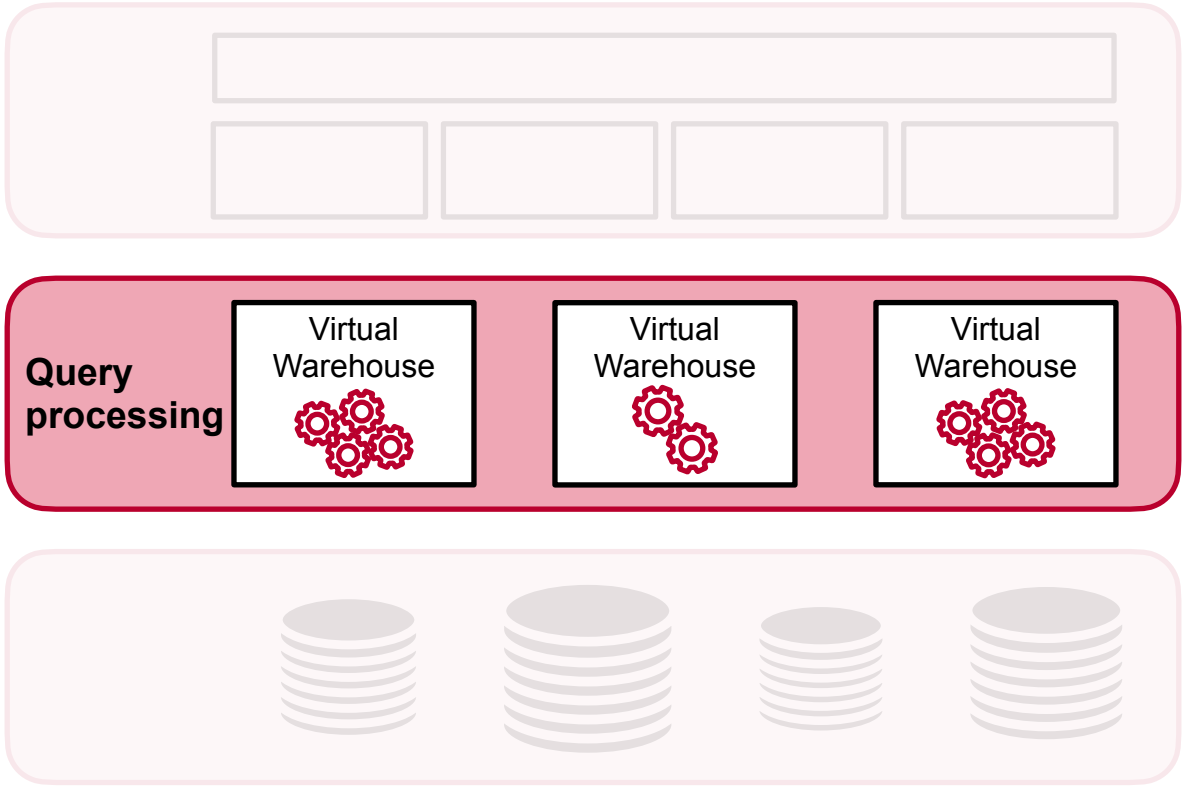
product
dryer
microwave
top load washer
dishwasher
…

quantity
30
20
10
30
…

warehouse
warehouse #2
warehouse #1
NULL
warehouse #3
…

Very efficient at scanning individual columns over an entire dataset - great for large aggregations on a few fields

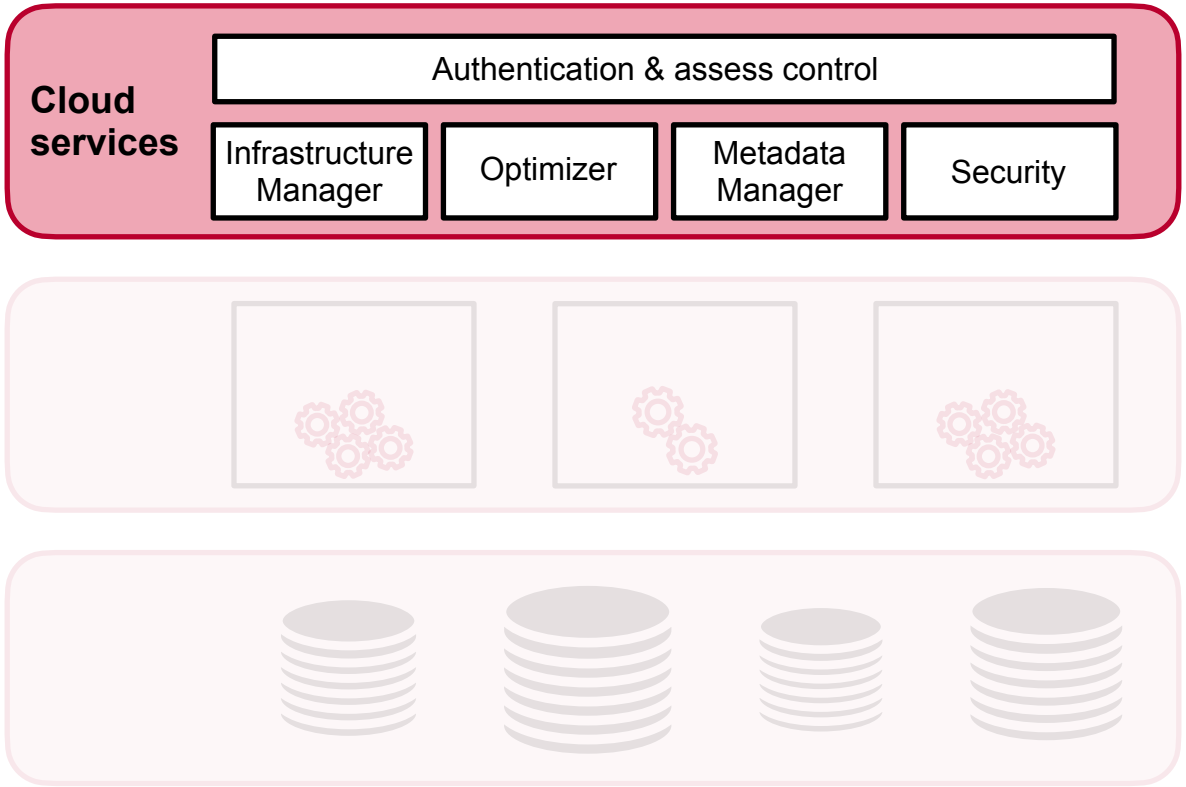
Snowflake Architecture



Query Processing

- Processing layer uses data warehouses
- Each warehouse a massively, parallel cluster
- Warehouses can have one or more compute nodes
- Each warehouse an independent compute cluster
- If queries run on different warehouses they don’t compete for the same resources

Snowflake Architecture



Cloud Services

- Collection of services that coordinate activities across Snowflake
- Services run on compute instances provisioned by Snowflake on the cloud platform

Working with Snowflake

Web-based user interface

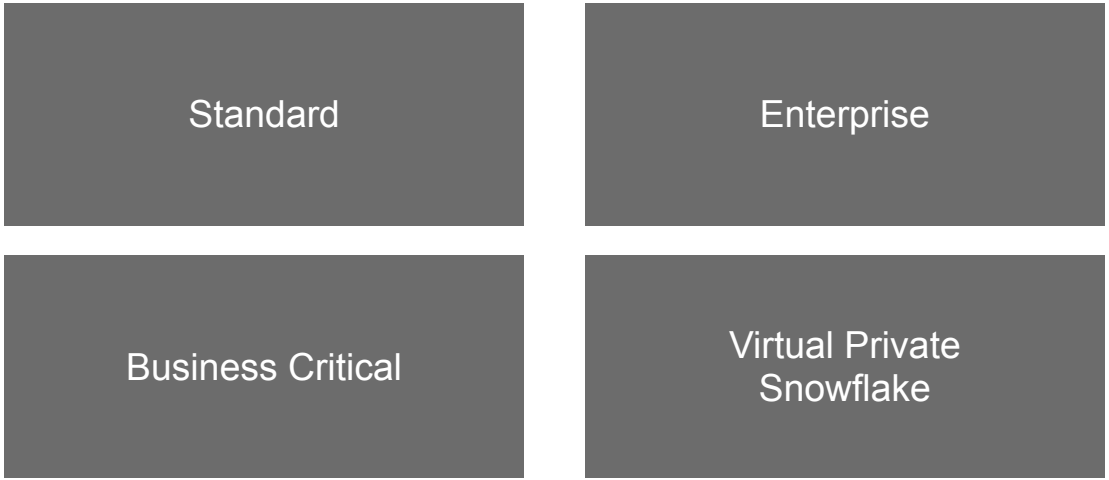
Command-line client (SnowSQL)

ODBC and JDBC drivers

Native connectors for Python, Spark etc.

Third-party connectors for BI, ETL tools

Snowflake Editions



Standard Edition

- Introductory offering, standard features
- Data encryption
- Object-level access control
- Time-travel up to 1 day
- Disaster recovery with fail-safe up to 7 days
- No multi-cluster warehouses, may not meet regulatory needs (government), no private connectivity

Enterprise Edition

- Includes everything in the Standard edition
- Extended time travel up to 90 days
- Additional security configurations
- May not meet regulatory needs (government), no private connectivity

Business Critical Edition

- Includes everything in the Enterprise edition
- Higher levels of data protection
- Database failover/failback for business continuity
- No dedicated metadata store and pool of compute resources

Virtual Private Snowflake

- Includes everything in the Business Critical edition
- Highest level of security for organizations with strictest requirements
- Financial institutions, government
- Snowflake environment completely isolated from other Snowflake accounts - no shared resources

Snowflake Billing Model

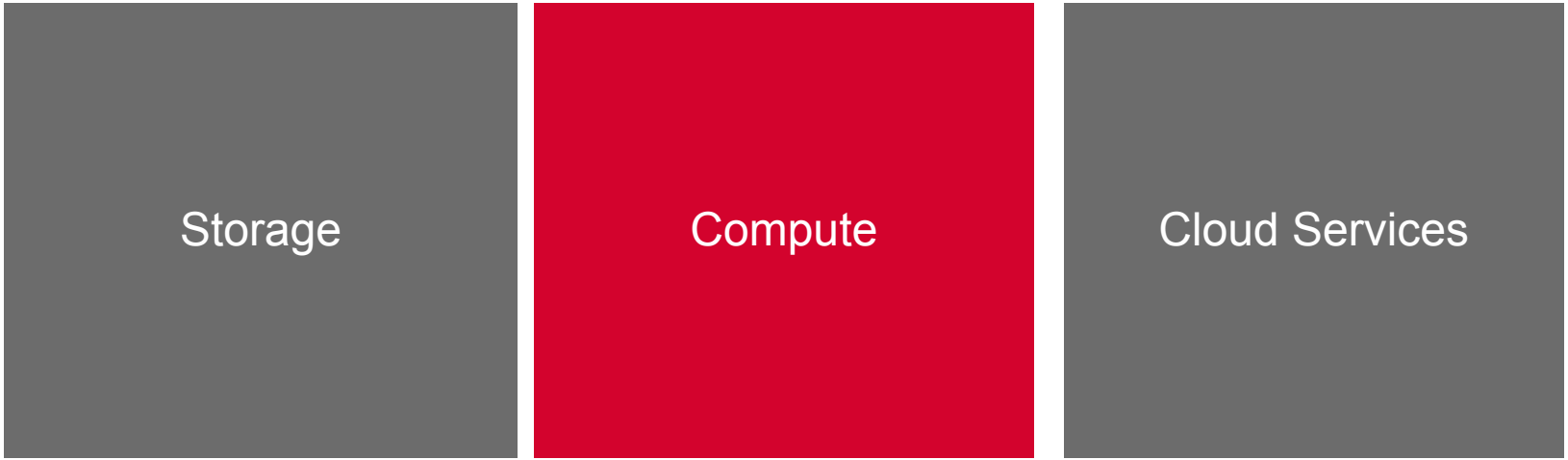
Snowflake Credit

A unit of measure to pay for the consumption of resources on Snowflake. Credit is used only when the customer is using resources.

Rate Per Terabyte (Data + Backups)

Computed using average storage used per month after compression

Virtual Warehouses

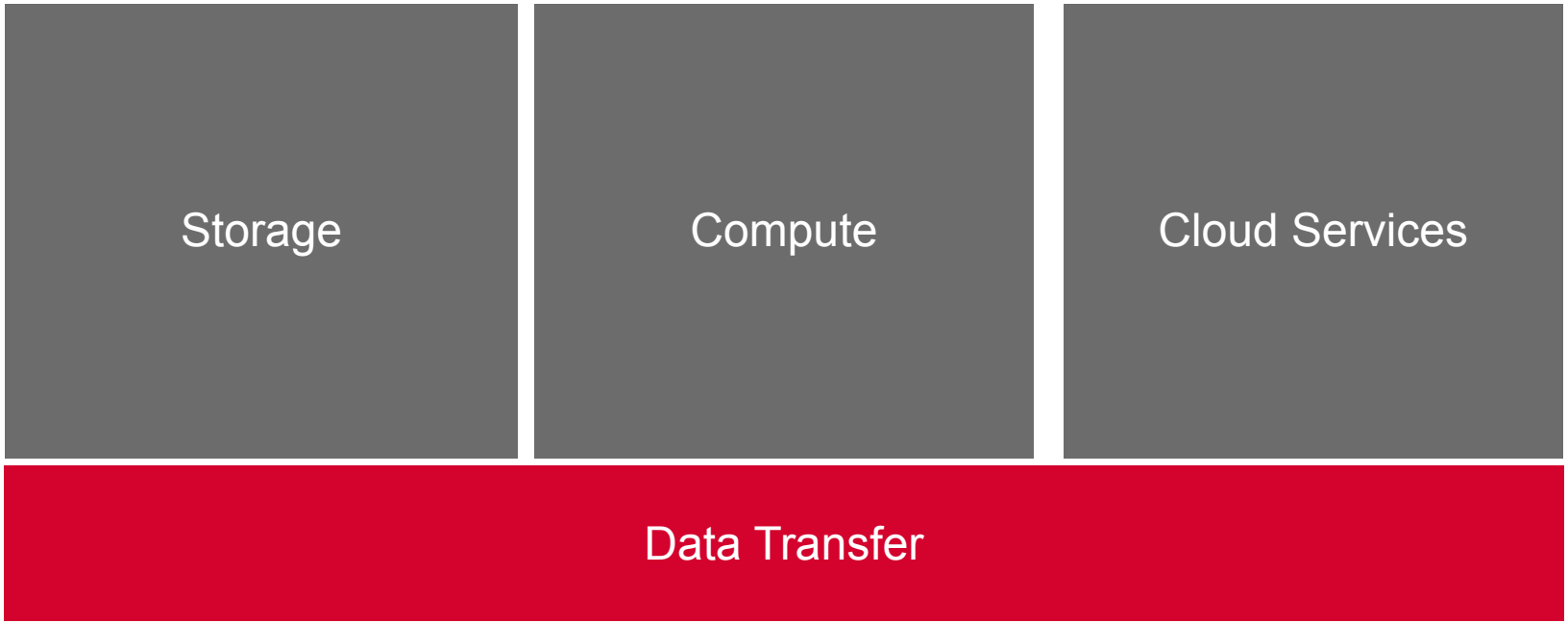


Compute needed to load data and perform queries

Management and Coordination

Uses additional compute

Cloud Provider Charge for Moving Data in and Out



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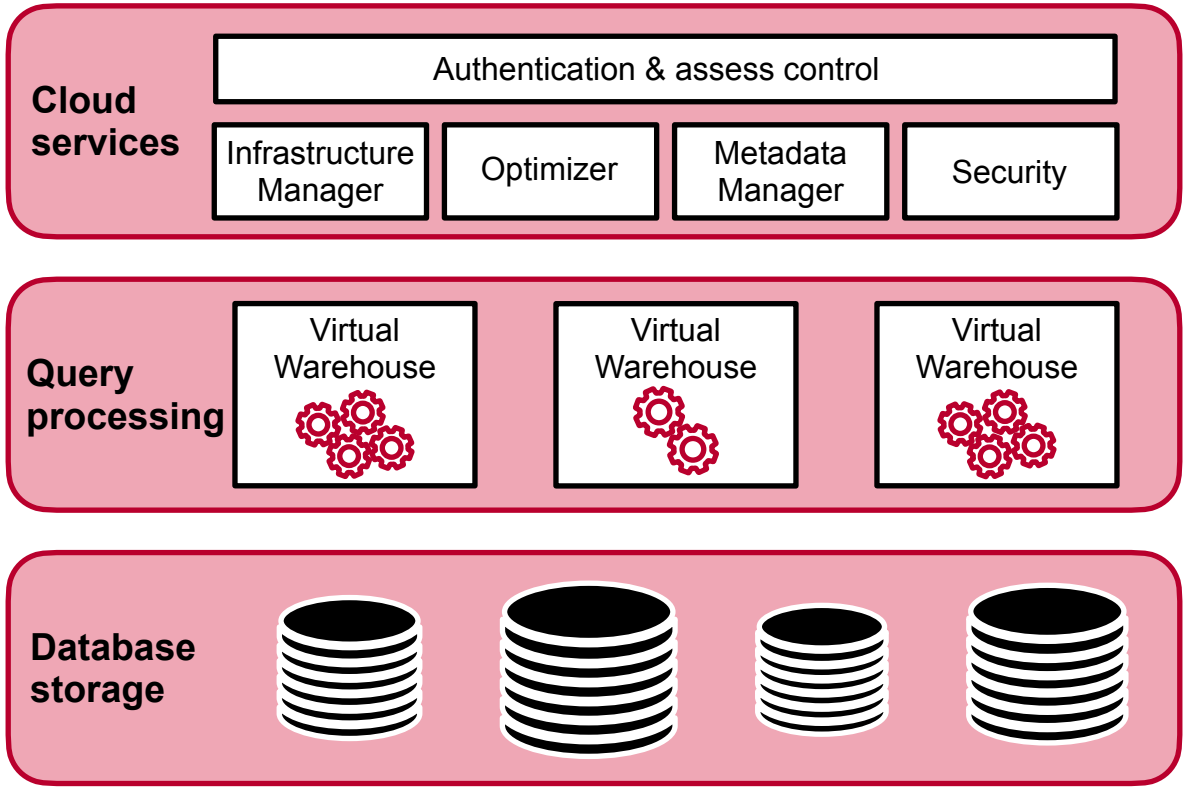
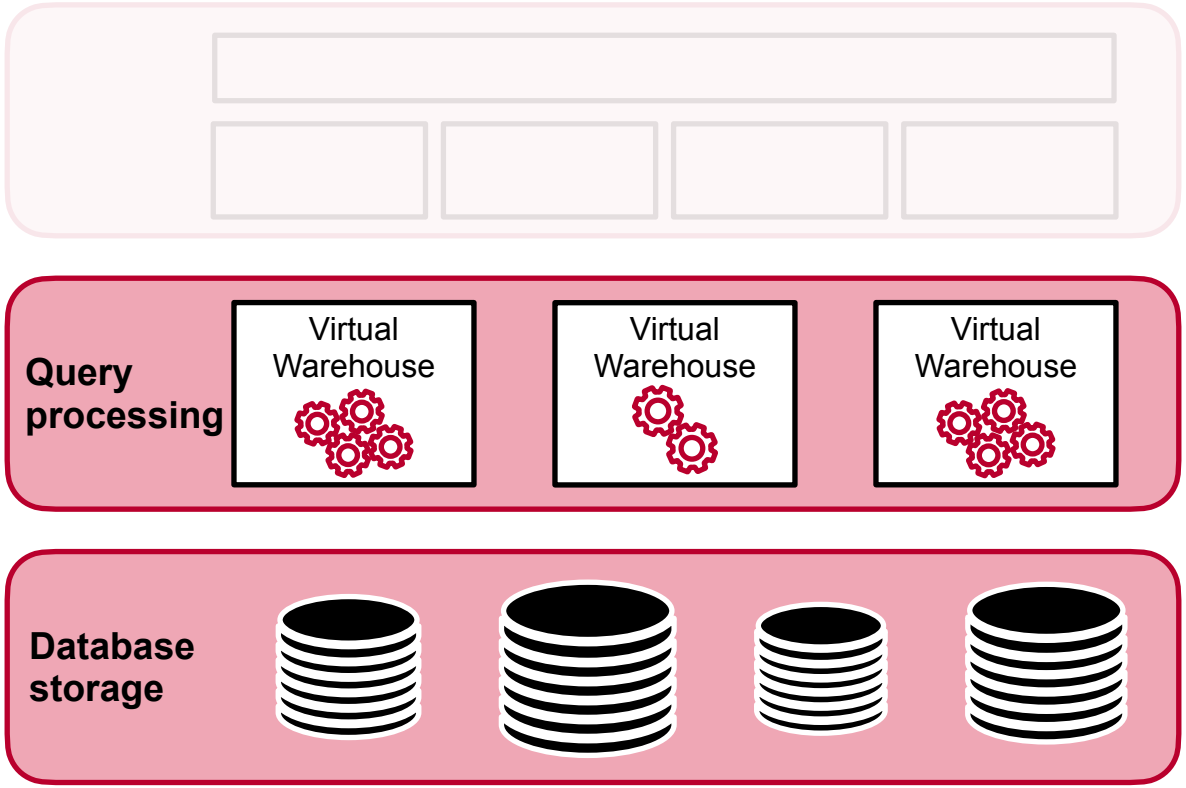
Virtual Warehouses

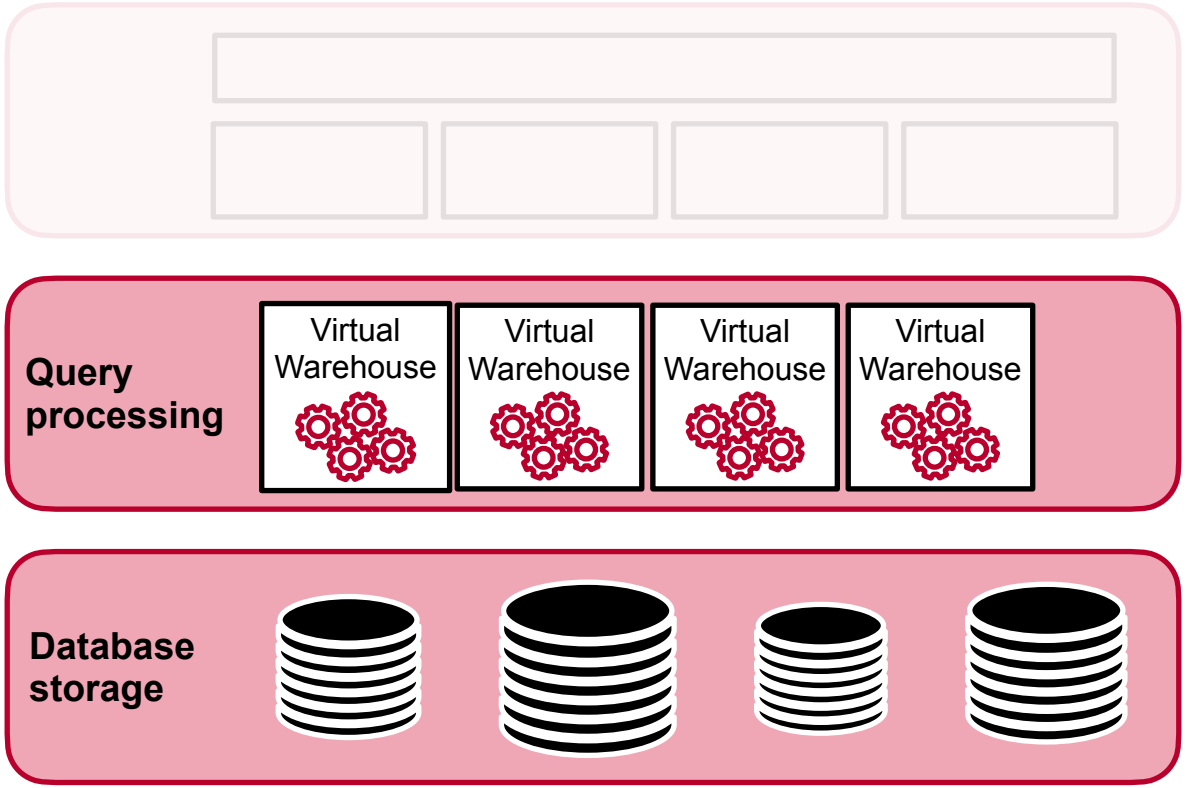
Snowflake Architecture



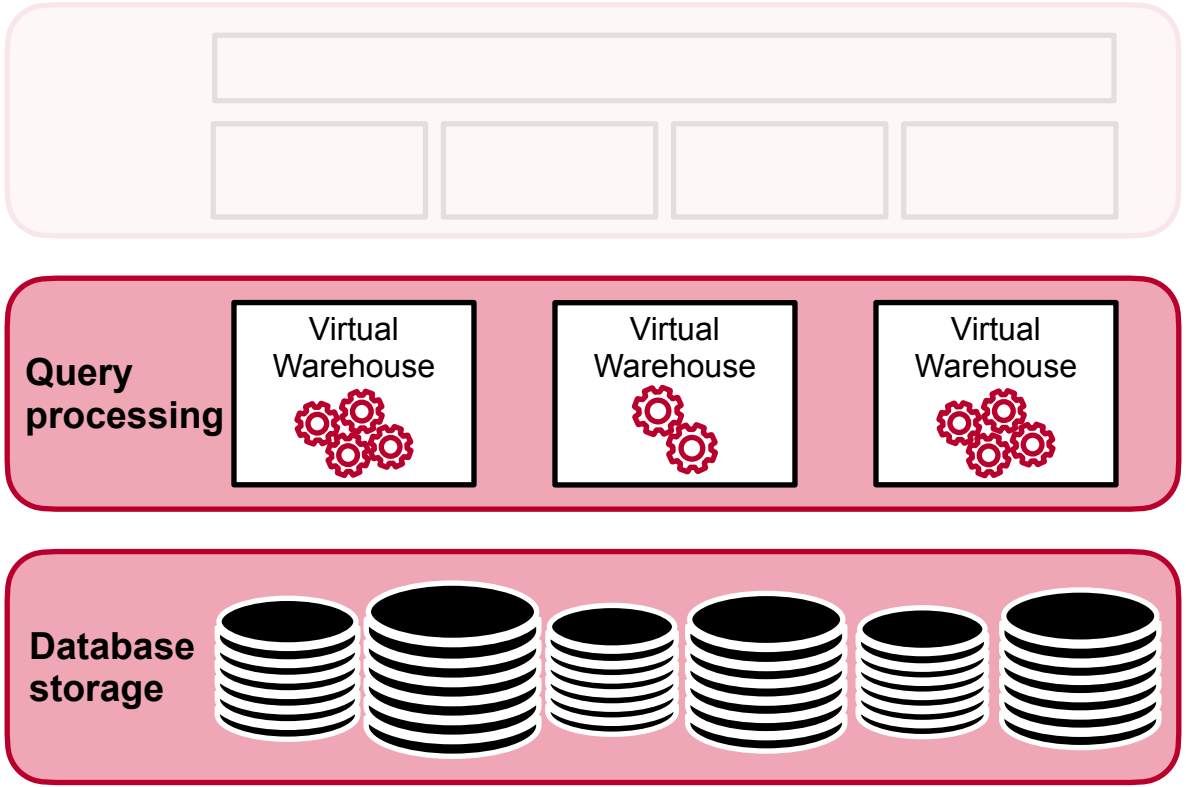
Independent Storage and Compute



Scale Compute



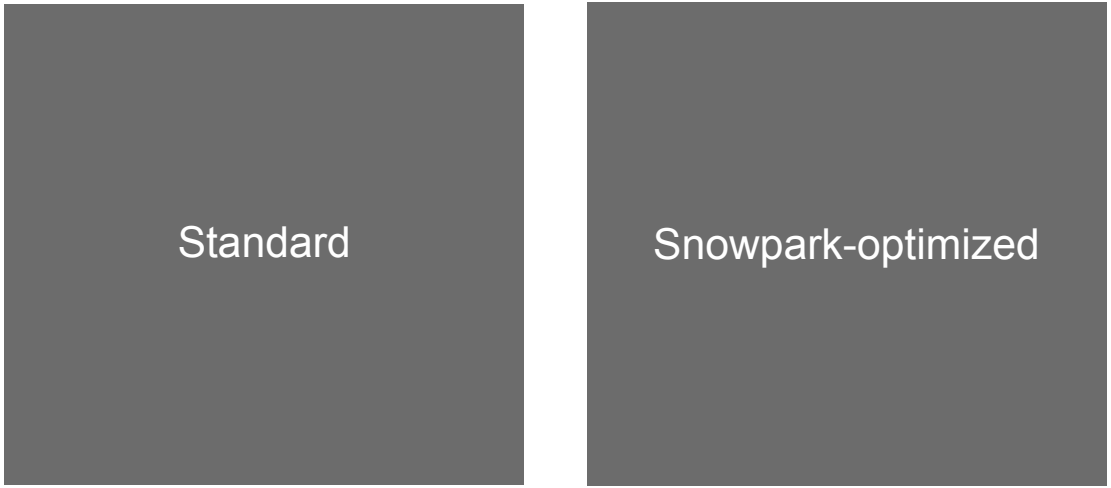
Scale Storage



Virtual Warehouse

Cluster of compute resources, such as CPU, memory, and temporary storage to perform operations in Snowflake.

Virtual Warehouses



Snowpark-optimized warehouse recommended for workloads with large memory requirements

Snowpark

Allows developers to write code in Java, Python, or Scala with custom support to build pipelines, ML workflows, and other data applications.

Virtual Warehouse Operations

Retrieving rows from tables and views

Updating rows in tables

Loading data into tables

Unloading data from tables

Virtual Warehouse Sizes

Warehouse Size	Credits / Hour	Credits / Second	Notes
X-Small	1	0.0003	Default size for warehouses created in Snowsight and using CREATE WAREHOUSE
Small	2	0.0006	
Medium	4	0.0011	
Large	8	0.0022	
X-Large	16	0.0044	Default size for warehouses created using the Classic Console
2X-Large	32	0.0089	
3X-Large	64	0.0178	
4X-Large	128	0.0356	
5X-Large	256	0.0711	Generally available in Amazon Web Services (AWS) and Microsoft Azure regions, and in preview in US Government regions
6X-Large	512	0.1422	Generally available in Amazon Web Services (AWS) and Microsoft Azure regions, and in preview in US Government regions

Gen1 and Gen2 Warehouses

- Gen2 is the next generation of standard warehouses (not Snowpark optimized)
- Built on faster hardware and has better optimizations
- Currently only available for some regions and some cloud providers

Virtual Warehouse

- Size and usage of warehouse impacts billing
- Data loading performance may not depend on warehouse size
    - Also impacted by size and number of files
- Query processing time directly impacted by warehouse size
    - Larger warehouses = more compute resources = faster queries (especially complex queries)

Virtual Warehouse

- Automatically suspended or resumed
- Warehouses consume credits only when they are running (not in suspended state)
- Query concurrency determined by size and complexity of queries
- Query is queued to be processed if the warehouse does not have sufficient resources

Multi-cluster Warehouses

Snowflake can statically or dynamically allocate additional clusters* to make more compute resources available.

*cluster refers to the compute resources made available to the warehouse for executing queries

Multi-cluster Warehouses

- Snowflake automatically starts and stops additional clusters as needed to handle fluctuating workloads
- Enables a large number of users to connect to the same warehouse

Multi-cluster Warehouses

Improve concurrency for users and queries

Do NOT improve the performance of slow running queries

Needs a Larger Warehouse

Improve concurrency for users and queries

Do NOT improve the performance of slow running queries

Warehouse Considerations

- Charges for warehouses depend on:
  - Warehouse size
  - Number of clusters (for multi-cluster warehouses)
  - Time the warehouse is running (and how many clusters in the warehouse are running)

Warehouse Considerations

- Compute resources for a query depends on query size and complexity
- Queries generally scale linearly w.r.t warehouse size
- Size of the tables being queried has more impact than number of rows
- Query filtering, joins, also impact processing

Best practice: Use separate warehouses for data load operations vs. compute operations

Data Loading Considerations

- Load multiple files with your data - each file between 100-250MB compressed
- Loading very large files 100GB or larger is not recommended
- Loading large datasets can impact query performance
- Separate warehouses for data loading and compute
- Data loading requires minimal resources so warehouses can be small

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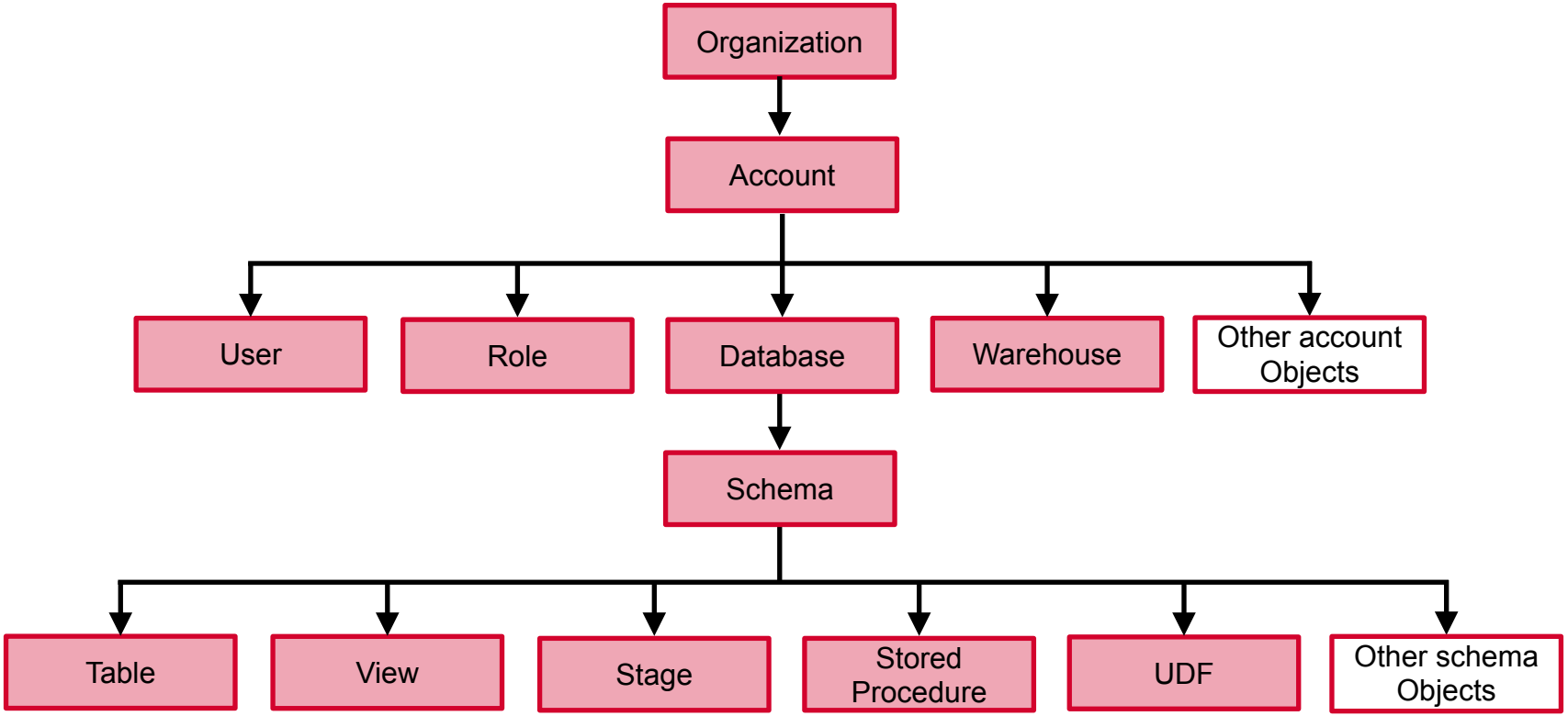
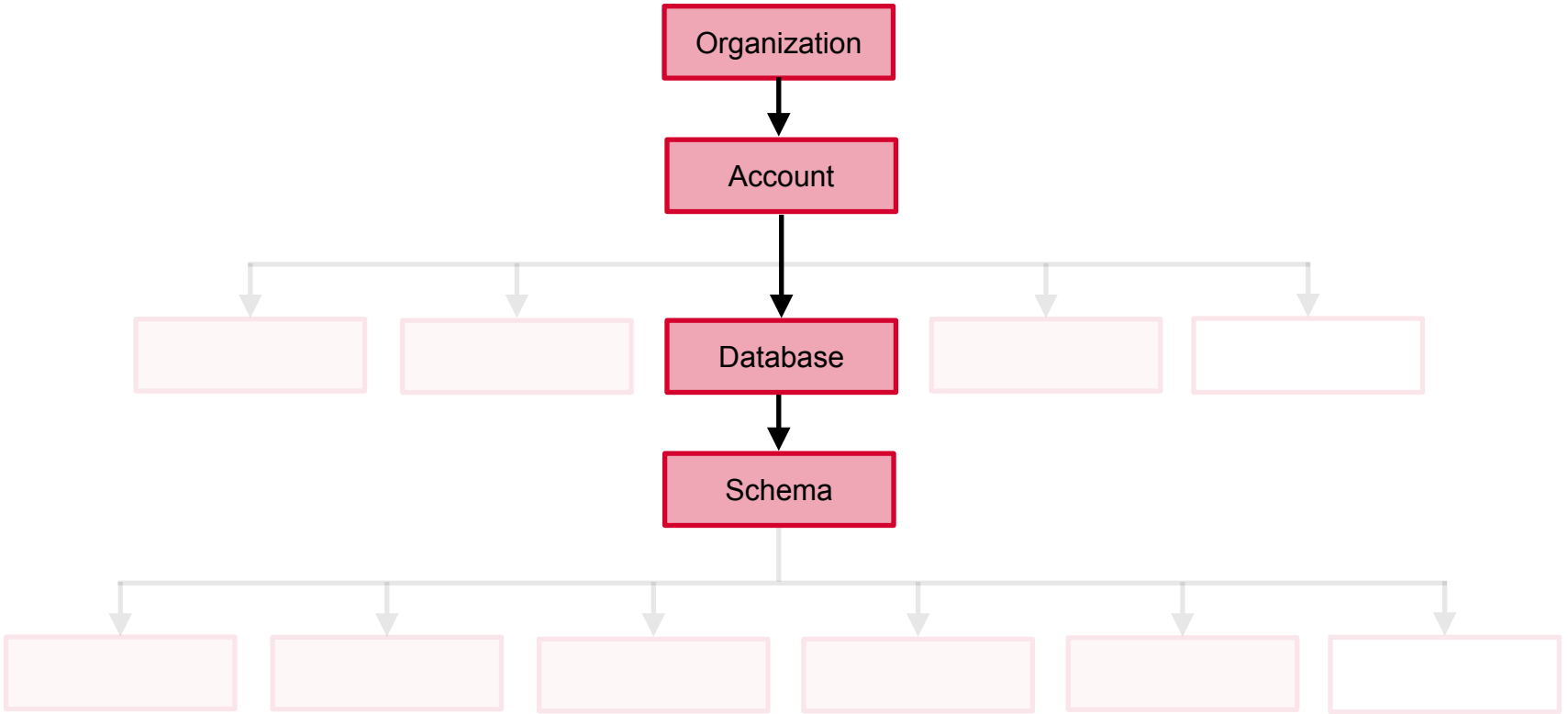
Snowflake Objects

Snowflake Hierarchy



Snowflake Hierarchy



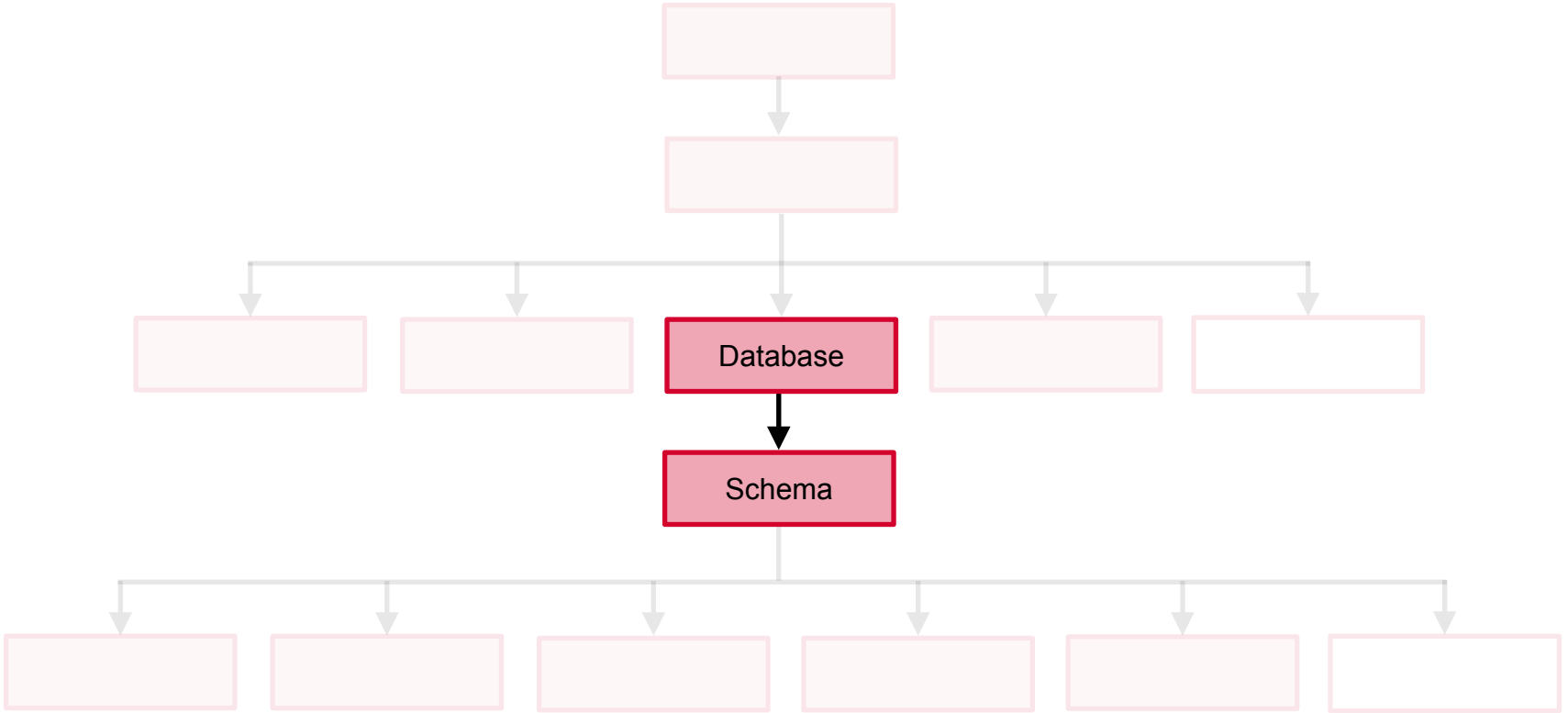
Database

Logical collection of schemas, each schema belongs to a single database.

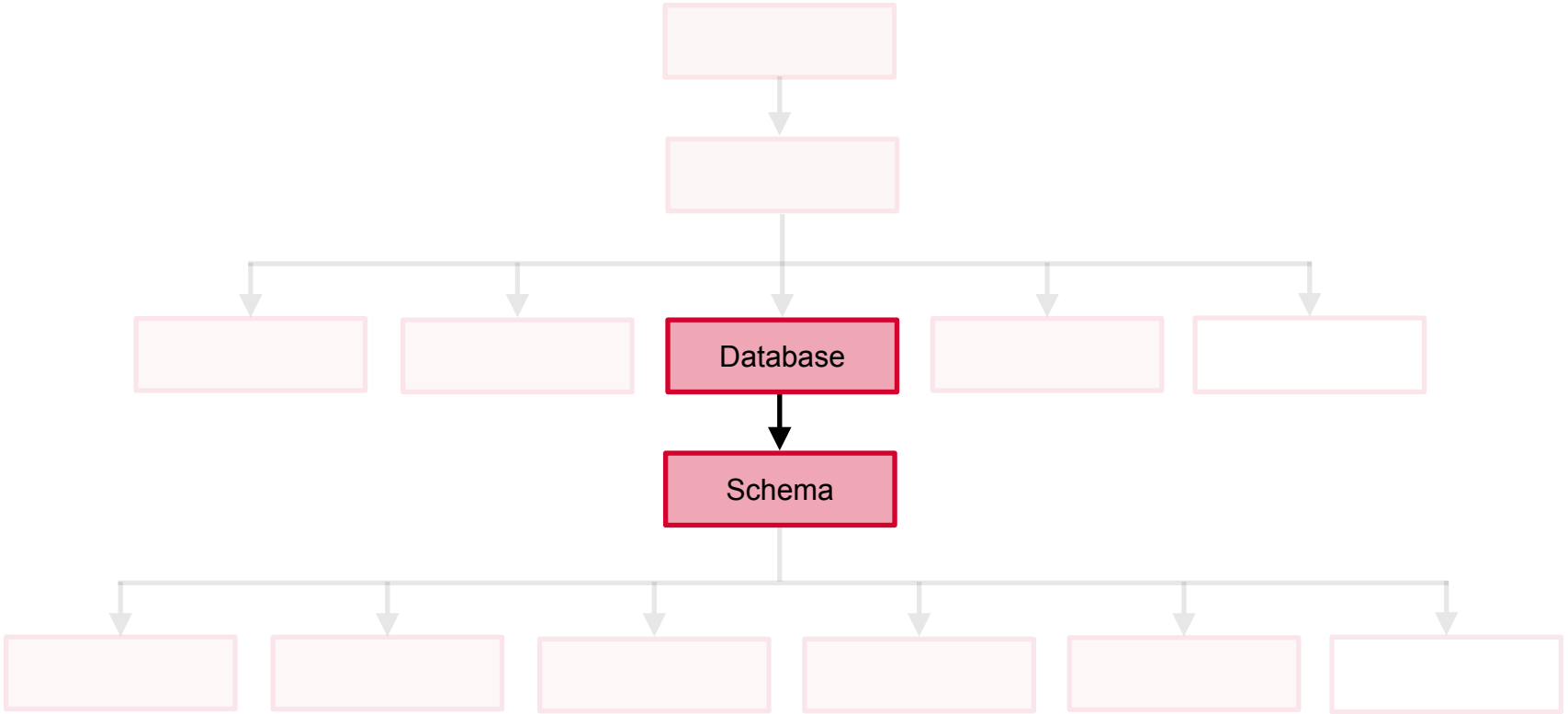
Schema

Logical grouping of database objects (tables, views, and other constructs).

Namespace = Database + Schema



Namespace Required for DB Ops



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Hands-on demos: Getting Started with Snowflake, Databases and Warehouses, Running Queries

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Table Structures in Snowflake

Querying Big Data

Several issues when queries are run on tables that are terabytes or petabytes in size:

- Queries run slowly
- No parallelism in query processing
- Entire data needs to be scanned for each query

Better performance and scaling is obtained using partitioning of tables

Partitioning

A unit of management of table data. Large datasets are split into partitions which help parallelize queries and reduce the amount of data scanned.

Table Structures in Snowflake

Micro-partitioning

- All tables divided into micro-partitions
- Contiguous units of storage which contain between 50MB to 500MB of uncompressed data
- Allows granular pruning of very large tables
- Snowflake stores metadata for each micro-partition
    - Range of values for each column
    - Number of distinct values
    - Additional properties for optimization and efficient query processing

Micro-partitioning Benefits

- Automatic, no manual intervention from the user
- Fine-grained pruning == faster queries
- Uniform size, will not result in skew
- Queries run in parallel on each micro-partition
- Columnar storage (only selected columns in the result will be scanned)

Clustering

- Data in tables sorted along natural dimensions based on columns i.e. clustered
- Clustering metadata recorded for each micro-partitioning when data is loaded into tables
    - Total number of micro-partitions
    - Number of micro-partitions with overlapping values
    - Depth of the overlapping micro-partitions (smaller depth = better clustering)

Clustering

- Optimize range and equality predicates of queries
- Scan only the micro-partitions which are likely to contain the required data

Not Clustered

Order_Date	Country	Status
2022-08-02	US	Shipped
2022-08-04	JP	Shipped
2022-08-05	UK	Canceled
2022-08-06 2022-08-02	KE KE	Shipped Canceled
2022-08-05	US	Processing
2022-08-04	JP	Processing
2022-08-04	KE	Shipped
2022-08-06 2022-08-02	UK UK	Canceled Processing
2022-08-05	JP	Canceled
2022-08-06	UK	Processing
2022-08-05	US	Shipped
2022-08-06	JP	Processing
2022-08-02	KE	Shipped
2022-08-04	US	Shipped

Clustered Table

Order_Date	Country	Status
2022-08-04	JP	Shipped
2022-08-04	JP	Processing
2022-08-05	JP	Canceled
2022-08-06	JP	Processing
2022-08-06	KE	Shipped
2022-08-02	KE	Canceled
2022-08-04	KE	Shipped
2022-08-02	KE	Shipped
2022-08-05	UK	Processing
2022-08-06	UK	Canceled
2022-08-02	UK	Canceled
2022-08-06	UK	Processing
2022-08-02	US	Shipped
2022-08-05	US	Processing
2022-08-05	US	Shipped
2022-08-04	US	Shipped

Search Optimization

- Needs to be explicitly enabled for a table
- Applies to all columns in a table
- Creates an additional data structure containing access paths for column values
- Improves performance of selective point lookup queries

Search Optimization

- Relies on a persistent data structure that serves as an optimized search access path
- Maintenance service runs in the background for creating and maintaining the search access path
- When data is updated, the service automatically updates the paths

Data Storage in Tables

Data Storage in Tables

Active Data

Data that can be actively queried. SQL queries, DDL, DML operations are all permitted on this data.

Data Storage in Tables

Time Travel

- Query data from the past that has since been updated or deleted
- Create clones of tables, schemas, and databases at or before specific points in the past
- Restore tables, schemas, and databases that have been dropped

Data Storage in Tables

Fail-safe

- Non-configurable 7-day period during which historical data may be recoverable by Snowflake
- Period starts immediately after the time travel retention period ends

Fail-safe

- No user operations allowed
- Snowflake makes best effort to recover data
- Data recovery may take hours or days to complete

Types of Tables

Permanent

Temporary

Transient

Types of Tables

Type	Persistence	Time Travel Retention Period	Fail-safe Period
Permanent (other editions)	Until explicitly dropped	0 to 90 (default configurable)	7
Permanent (Standard Edition)	Until explicitly dropped	0 or 1 (default 1)	7
Temporary	Remainder of session	0 or 1 (default 1)	0
Transient	Until explicitly dropped	0 or 1 (default 1)	0

External Tables

- Reference data files located on cloud storage
  - Amazon S3
  - Azure Data Lake
  - Google Cloud Storage
- Read-only tables, no updates allowed
- Query and join operations allowed

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Hands-on demos: Time travel SnowSQL

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Snowflake vs. Databricks

Databricks

Cloud-based data platform powered by Apache Spark for processing and analyzing big data.

Databricks

- Databricks SQL
  - Platform to run SQL queries to analyze data
- Databricks Data Science and Engineering
  - Interactive workspace for collaboration and to generate insights using Spark
- Databricks Machine Learning
  - Integrated end-to-end machine learning environment with managed services

Databricks Key Features

Delta Lake for the entire data lifecycle

Optimized Spark Engine for data processing

Machine Learning Environments

Collaborative Notebooks for Scala R, SQL, Python

Snowflake vs. Databricks

Snowflake

- Managed data platform
- Integrated with the 3 major cloud platforms
- Decoupled storage and processing layers
- Highly scalable

Databricks

- Managed data platform
- Integrated with the 3 major cloud platforms
- Decoupled storage and processing layers
- Highly scalable

Snowflake vs. Databricks

Snowflake

- SQL-based so easier and intuitive to use
- Data processing with Snowpark within Snowflake
- Batch-centric but can work with continuous data

Databricks

- SQL + R, Python, Scala more options to process data
- Spark at the core of the Databricks ecosystem
- Strong batch and streaming support (with Spark)

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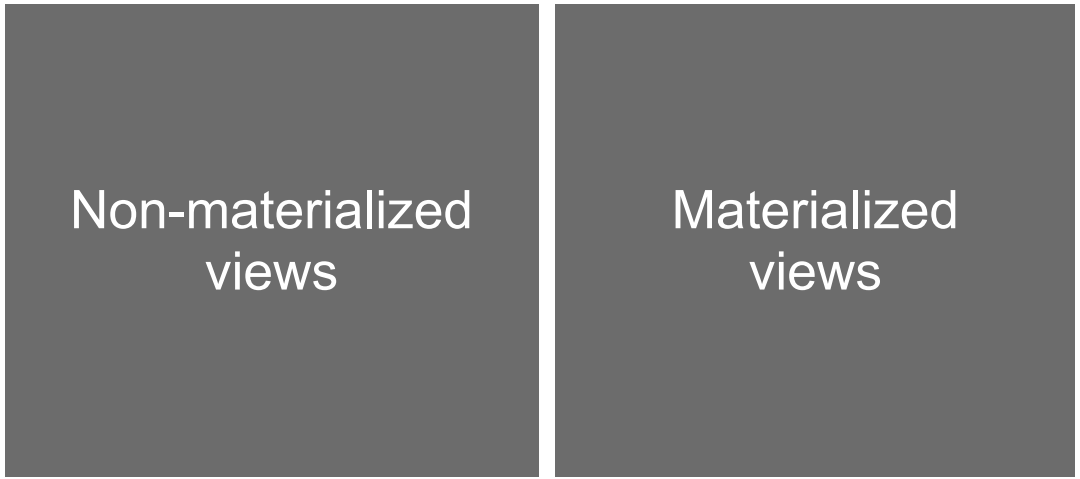
Regular, Secure, Materialized Views

View

A query which produces a result, this result can then be accessed as a table.

A view helps combine, segregate, or protect data.

Views in Snowflake



Non-materialized Views

Named definition of a query.

When a view is referenced in another query the view's query is executed. The view's results are not stored for future use.

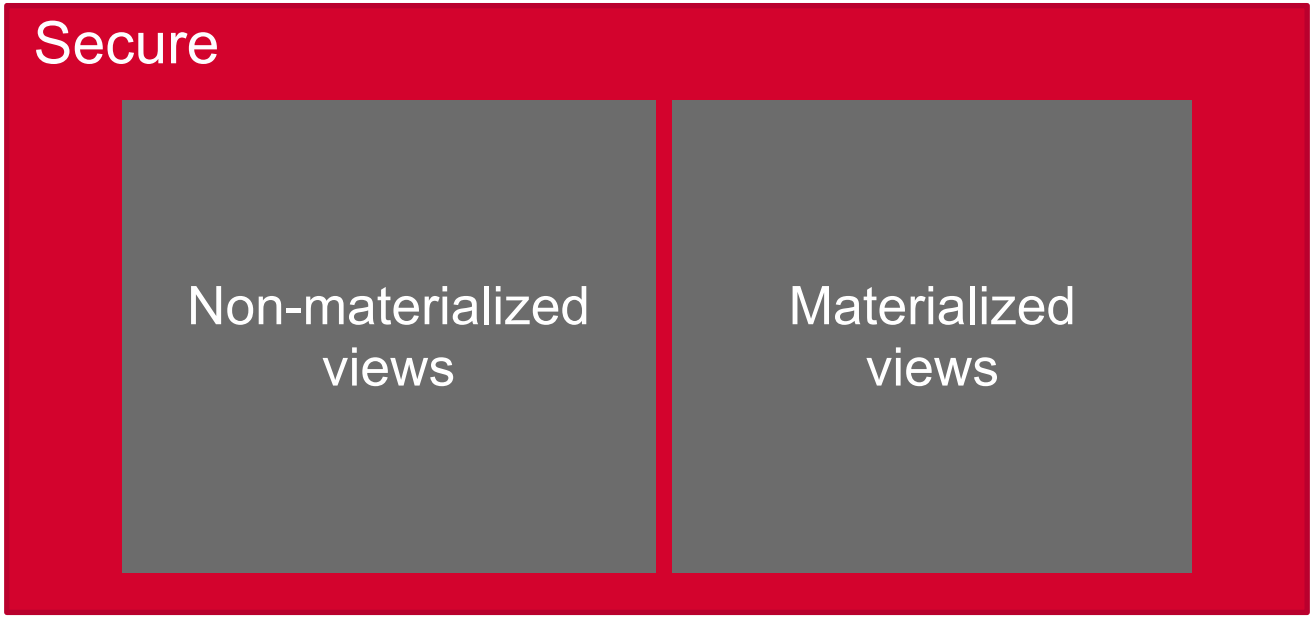
Materialized Views

Named definition of a query, however results of the view's query are stored as though they were a table.

When a view is referenced in another query that uses the stored query results of the materialized view.

Queries run faster but the stored results take up additional space.

Secure Views



Secure Views

Views with improved data privacy and sharing.

Does not allow query optimizations that might inadvertently expose data from the underlying table to the user.

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Hands-on demos: Views

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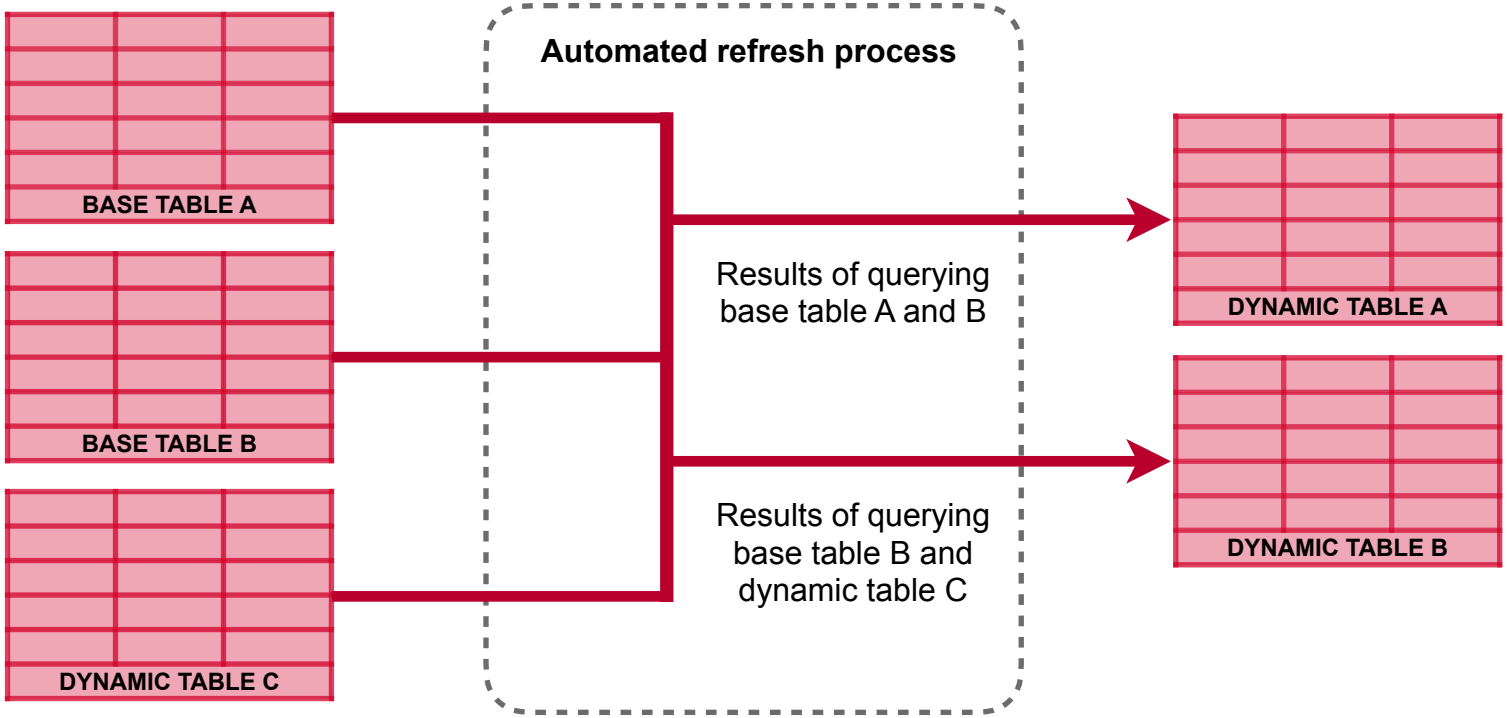
Dynamic Tables

Dynamic Tables

Dynamic tables are tables that automatically refresh based on a defined query and target freshness.

Makes data transformation and pipeline management simple - does not require any manual intervention.

Dynamic Tables

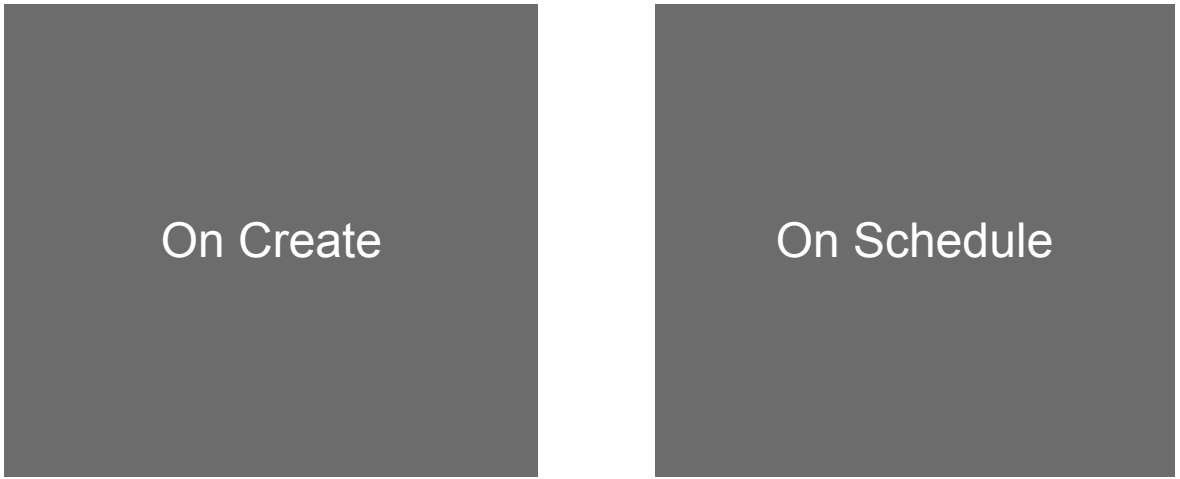


Transformation query executed on a regular basis to update the dynamic table

Ideal For

- Automated management of data dependencies and refresh schedules
- Multiple tables that are part of a data transformation pipeline
- You only need a target freshness for the data in a table - no fine-grained control

Initialization of Dynamic Tables



On Create, the table is initialized immediately. If you set On Schedule, initialization happens within the specified target lag timeframe.

Target Lag

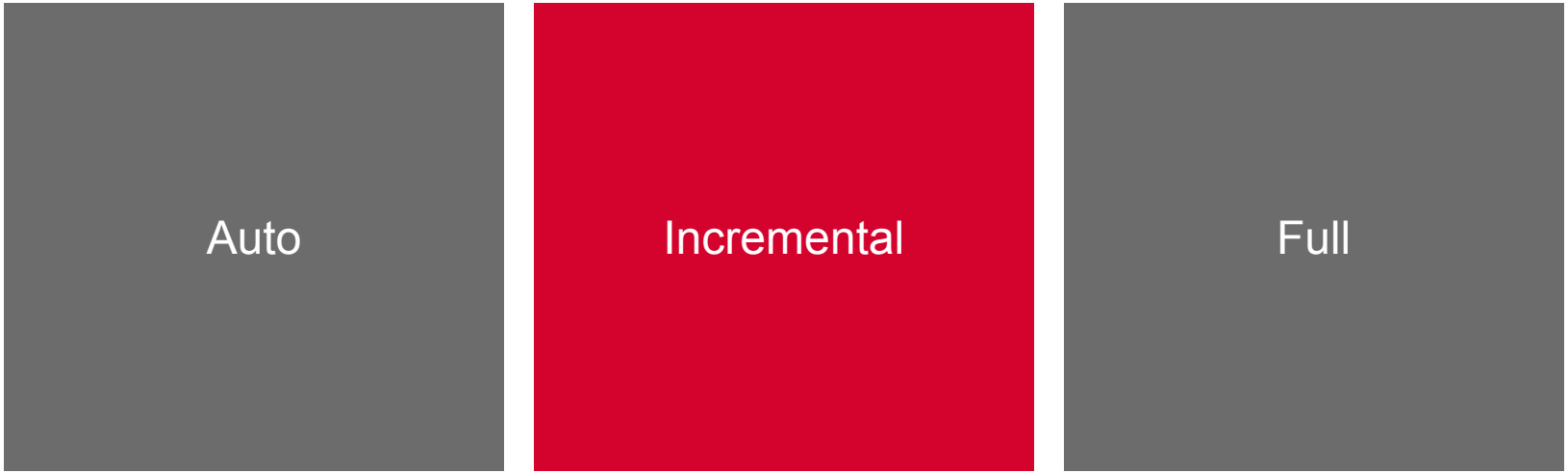
Target lag specifies how outdated the data in a dynamic table can be. Table refresh schedule is determined by the target lag.

Dynamic Table Refresh Mode

Dynamic Table Refresh Mode

Incremental refresh by default. When this is not supported or might not perform well, full refresh used

Dynamic Table Refresh Mode



Updates the dynamic table with only the changes since the last refresh, ideal for large datasets with frequent small updates.

Dynamic Table Refresh Mode

Reprocesses the entire dataset. Uses for complex queries or when significant data changes require a complete update.

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Hands-on demos: Dynamic Tables

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Sampling

Sampling

Return a subset of rows from the specified table

Snowflake allows you to:

- Sample a fraction of the table with a specified probability “p” for including a certain row
- Sample a fixed, specified number of rows

Sampling in Snowflake

Bernoulli or Row sampling

System or Block sampling

Bernoulli Sampling

Samples each row with a certain probability = p/100

Works well for smaller datasets as it reduces the bias of sampled data

Is slower for larger datasets because each row considered and included with a certain probability

Block Sampling

Samples each block with a certain probability = p/100

May result in biased samples for smaller datasets

Works well for larger dataset, is faster and more efficient

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Hands-on demos: Sampling Common Table Expressions

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Window Functions

Window Functions

Operate on windows - which are groups of rows which are related to one another.

Window Functions

Department	Name	Salary
Engineering	Carrie	7000
Sales	Dora	5000
Engineering	Jackson	6600
Sales	Stewart	6200
Sales	Ruby	4000
Engineering	Sonia	6850
Sales	Ivan	4200
Engineering	Steven	6550

Highest Salary in Department

Department	Name	Salary
Engineering	Carrie	7000
Sales	Dora	5000
Engineering	Jackson	6600
Sales	Stewart	6200
Sales	Ruby	4000
Engineering	Sonia	6850
Sales	Ivan	4200
Engineering	Steven	6550

Partition by Department

Department	Name	Salary
Engineering	Carrie	7000
Sales	Dora	5000
Engineering	Jackson	6600
Sales	Stewart	6200
Sales	Ruby	4000
Engineering	Sonia	6850
Sales	Ivan	4200
Engineering	Steven	6550

Partition by Department

Department	Name	Salary
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Engineering	Steven	6550
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Sales	Stewart	6200
Sales	Ruby	4000
Sales	Ivan	4200

Order by Salary DESC

Department	Name	Salary
Engineering	Carrie	7000
Engineering	Jackson	6600
Engineering	Sonia	6850
Engineering	Steven	6550
Sales	Dora	5000
Sales	Stewart	6200
Sales	Ruby	4000
Sales	Ivan	4200

Order by Salary DESC

Department	Name	Salary
Engineering	Carrie	7000
Engineering	Sonia	6850
Engineering	Jackson	6600
Engineering	Steven	6550
Sales	Stewart	6200
Sales	Dora	5000
Sales	Ivan	4200
Sales	Ruby	4000

Highest Salary in Department

Department	Name	Salary
Engineering	Carrie	7000
Engineering	Sonia	6850
Engineering	Jackson	6600
Engineering	Steven	6550
Sales	Stewart	6200
Sales	Dora	5000
Sales	Ivan	4200
Sales	Ruby	4000

Highest Salary in Department

Department	Name	Salary
Engineering	Carrie	7000
Engineering	Sonia	6850
Engineering	Jackson	6600
Engineering	Steven	6550
Sales	Stewart	6200
Sales	Dora	5000
Sales	Ivan	4200
Sales	Ruby	4000

Partition By Department Order by Salary

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ROWS BETWEEN UNBOUNDED PRECEDING AND CURRENT ROW

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ROWS BETWEEN CURRENT ROW AND UNBOUNDED FOLLOWING

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ROWS BETWEEN 1 PRECEDING AND 1 FOLLOWING

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Engineering	Jackson	6600
Engineering	Steven	6550
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Sales	Ruby	4000

ROWS BETWEEN 1 PRECEDING AND 1 FOLLOWING

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ROWS BETWEEN 1 PRECEDING AND 1 FOLLOWING

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Hands-on demos: Window functions

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Data Loading in Snowflake

Stage

Refers to the location of data files in cloud storage as a stage.

Types of Stages

External Stage

Internal Stage

External Stage

Cloud storage services that belong to the cloud platform that you are using:

- Amazon S3
- Azure Storage
- Google Cloud Storage

Internal Stages

Cloud storage that belongs to your Snowflake account

Internal Stages

User Stage

- Stage associated with a user
- Data in stage can be loaded into multiple tables

Table Stage

- Implicit stage associated with a table
- Stage can be managed by one or more users
- Data in this stage can only be loaded into the corresponding table

Named Stage

- A database object created in a schema
- Used and managed by one or more users
- Data in stage can be loaded into one or more tables

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Hands-on demos:
Bulk Loading
External stage
Semi-structured
Data