
# Cloudera Open Data Lakehouse

# NDA & SAFE HARBOR COMPLIANCE REQUIRED



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# Agenda

| | | |
|---|---|---|
| 5 | Kick off | - Agenda<br>- Goals / Objectives<br>- Expectations |
| 40 | Intro to Cloudera Open Data Lakehouse | - What is Cloudera Open Data Lakehouse?<br>- Why Iceberg for Open Data Lakehouse?<br>- Features, value, benefits<br>- Roadmap |
| 40 | Iceberg Architecture Deep Dive | - Architecture<br>- Snapshots<br>- Partition Evolution<br>- Default Storage Location<br>- Table Mutations ( COW / MOR)<br>- Best Practices |
| 10 | Q & A | |
| 10 | Break | |
| 10 | Hands on labs | Logistics |
| 20 | - Key feature demonstrations | - Performance<br>- Migration from Hive to Iceberg table format<br>- Schema / Partition Evolution<br>- Time Travel<br>- SDX integration (FGAC, lineage) |

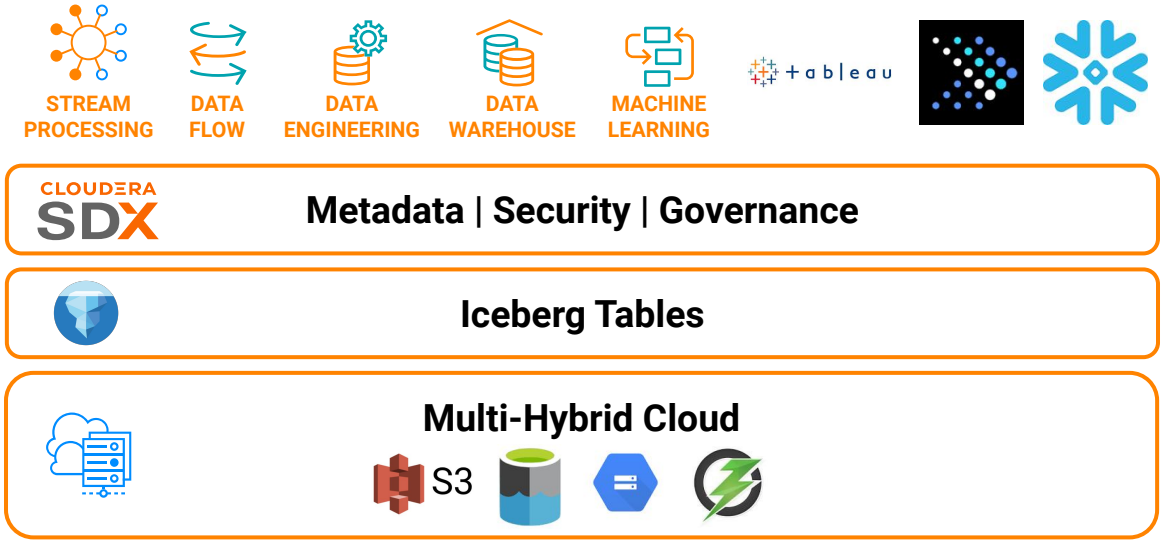
# Agenda

| | | |
|---|---|---|
| | - Ingestion (DiM) | - Ingest data from s3 into an existing Iceberg Table<br>- Ingest CDC data into an existing Iceberg Table to show how we can support Type 2 Slowly changing dimension tables |
| 20 | - Processing (CDE, CDW ) | - Migrate existing tables to Iceberg<br>- Creating Iceberg Tables<br>- Load data into an Icebeg table<br>- Schema Evolution<br>- Partition Evolution<br>- Time Travel |
| 20 | - Consumption (CDW, CML) | - Query Iceberg Tables<br>- Setup simple Data Viz Dataset<br>- Create simple Data Viz Dashboard<br>- Create simple CML data processing python code to read data from Iceberg into a DataFrame for further processing |
| 10 | - Recap | Recap & Observability |
| | Q & A | |

# Cloudera Open Data Lakehouse BI, AI, and Beyond

## Platform architecture delivers secure interoperability to any infrastructure cost-effectively

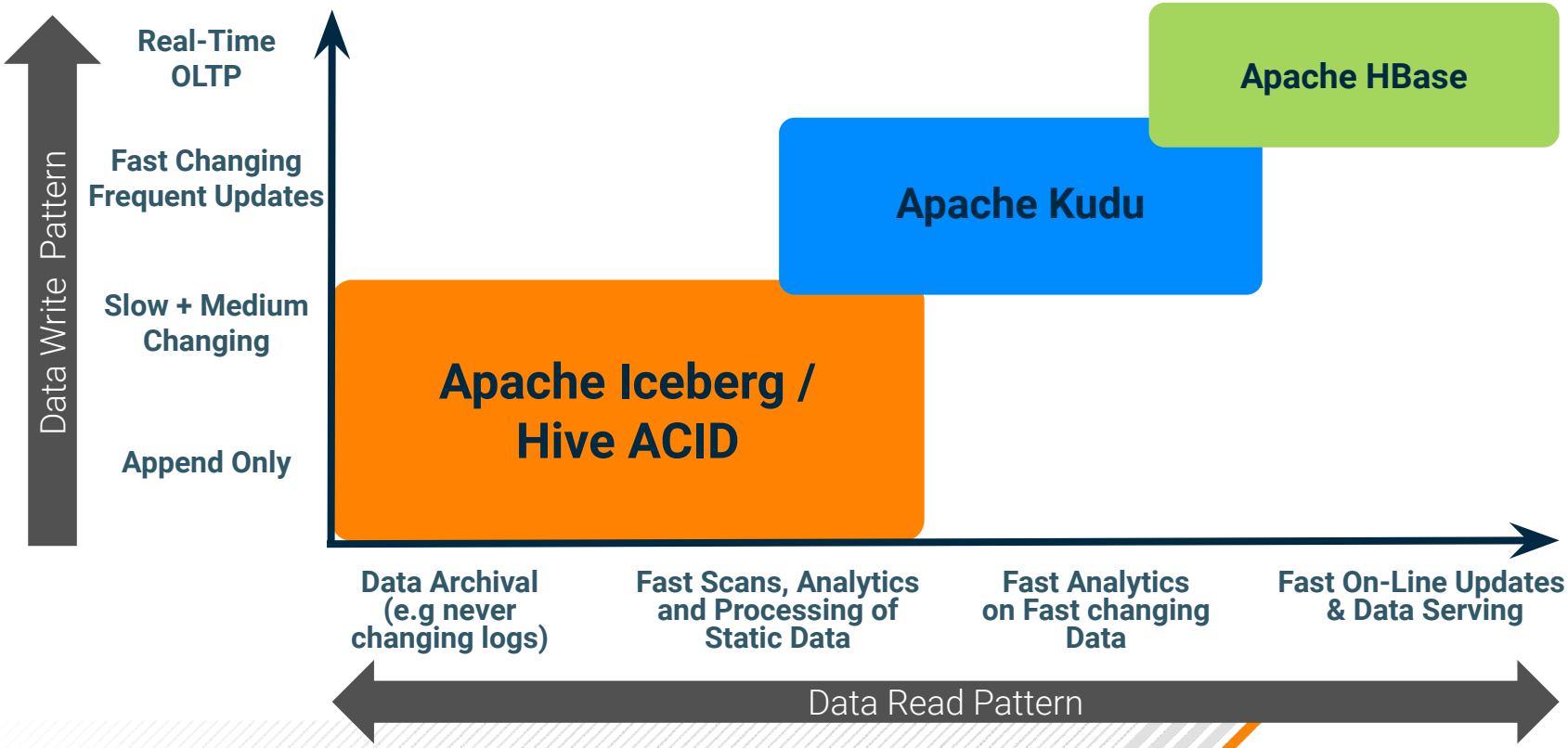
- Multi-function analytics for Streaming, Data Engineering, BI, & AI/ML
- Choose your engine: Cloudera integrated data services or 3rd party technologies
- SDX: Common security and governance with data lineage
- One Dataset: With all Compute engines. No data duplication or movement
- Deployment freedom with Multi-Hybrid Cloud on CPU & GPU Containers



# APACHE ICEBERG
## A Flexible, Performant & Scalable Table Format

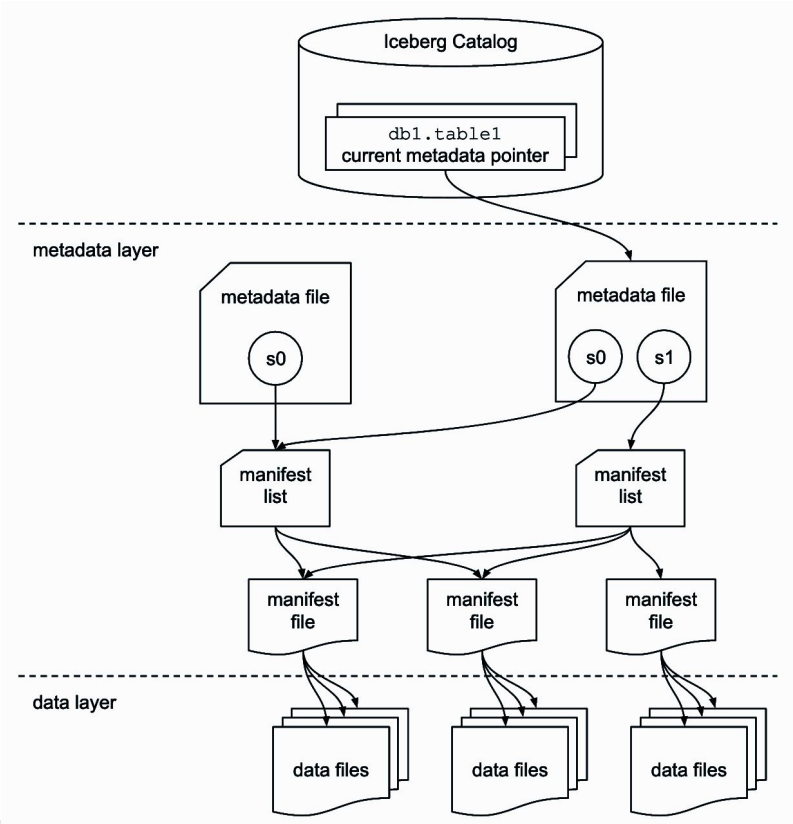
- Donated by Netflix to the Apache Foundation in 2018
- Flexibility
  - Hidden partitioning
  - Full schema evolution
- Data Warehouse Operations
  - ACID Transactions
  - Time travel and rollback
- Supports best in class SQL performance
  - High performance at Petabyte scale

# Where Apache Iceberg fits in the CDP Ecosystem

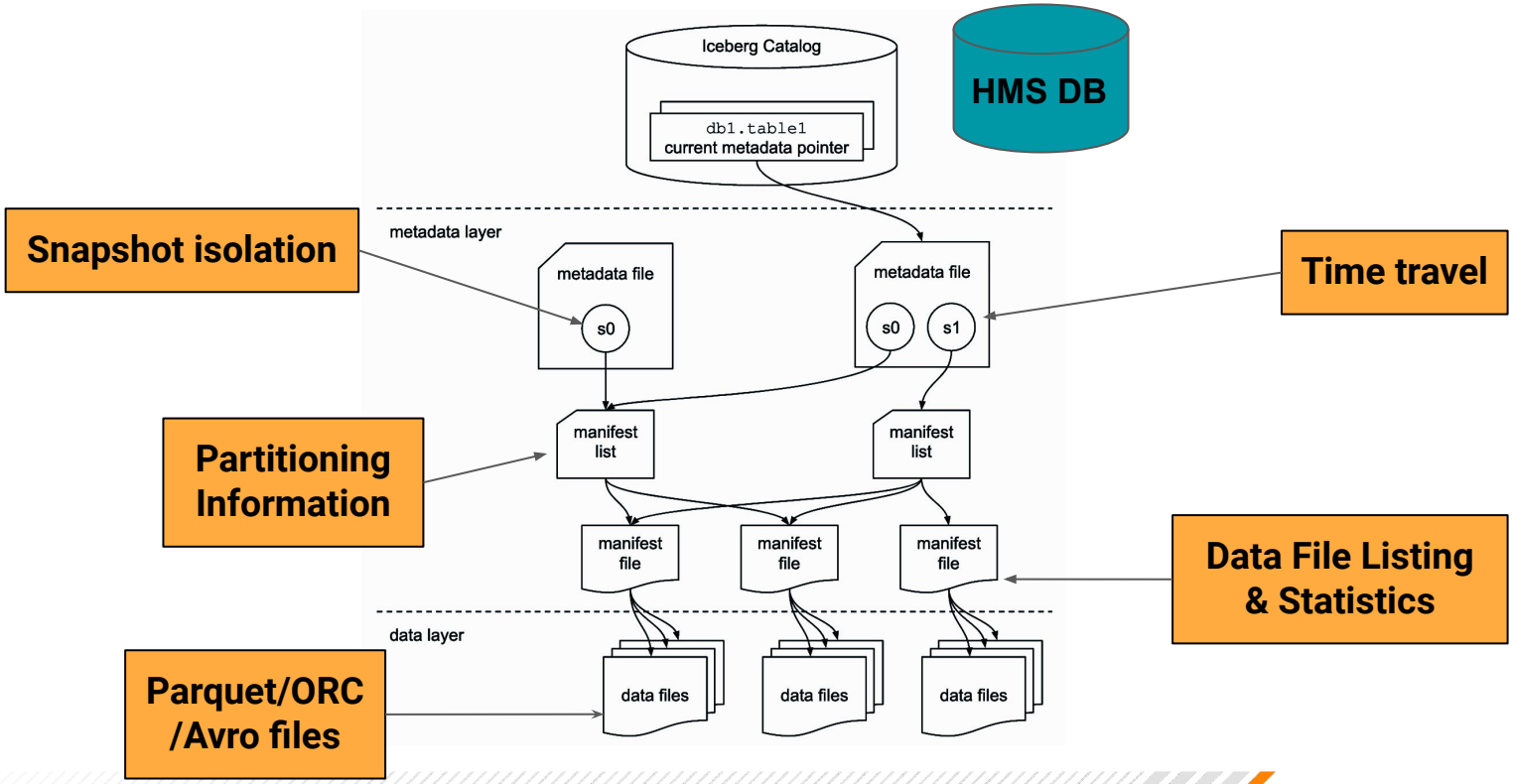


# What is Iceberg Table Format?

- Iceberg is a new Big Data scale **Table Format** that specifies how a table's files are organized in a file system or object store
- Iceberg offers advanced features and performance improvements over the default table format
- 3 file formats supported - Parquet, Avro, and ORC
    - Supported by Impala, Hive, Spark, Fink, etc

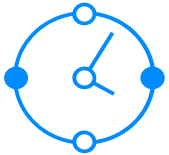


# How Does Iceberg Format Solve the Issues

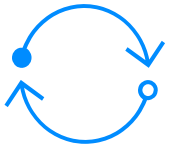


# KEY FEATURES

ACID Transaction



Time Travel / Table Rollback



In-place Table Evolution

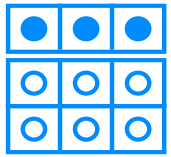
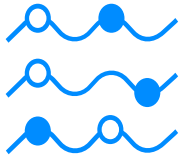
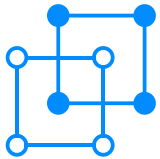


Table Maintenance

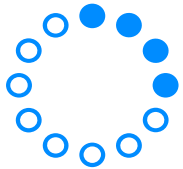


Streaming & Batch Ingestion



Iceberg Replication

SDX Integration



Ease of Adoption

Multi-Hybrid Cloud

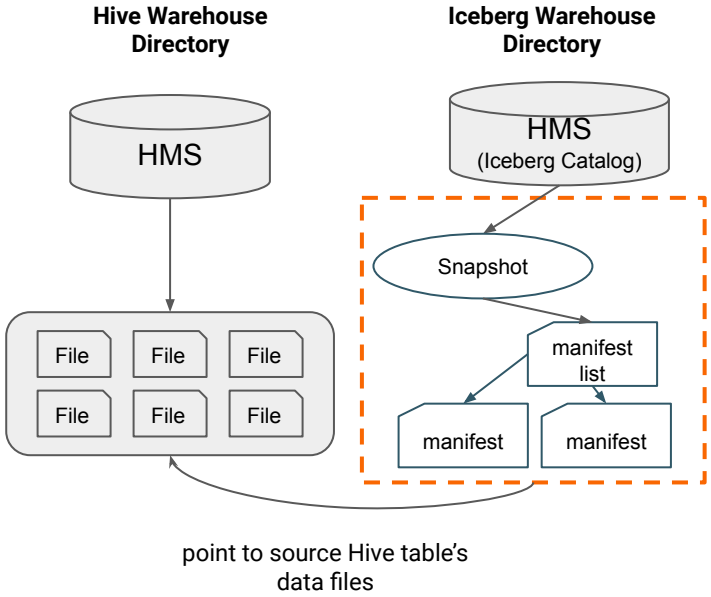
Performance / Scalability



# Table Migration

# Table Migration In-Place




**Avoids rewriting** data files, just **re-write** the metadata

- **Hive table migration**:

```
ALTER TABLE tbl SET TBLPROPERTIES
('storage_handler'='org.apache.iceberg.mr.hive.Hive
IcebergStorageHandler')
```

- **Spark 3:**

  **a. Import Hive tables into Iceberg**

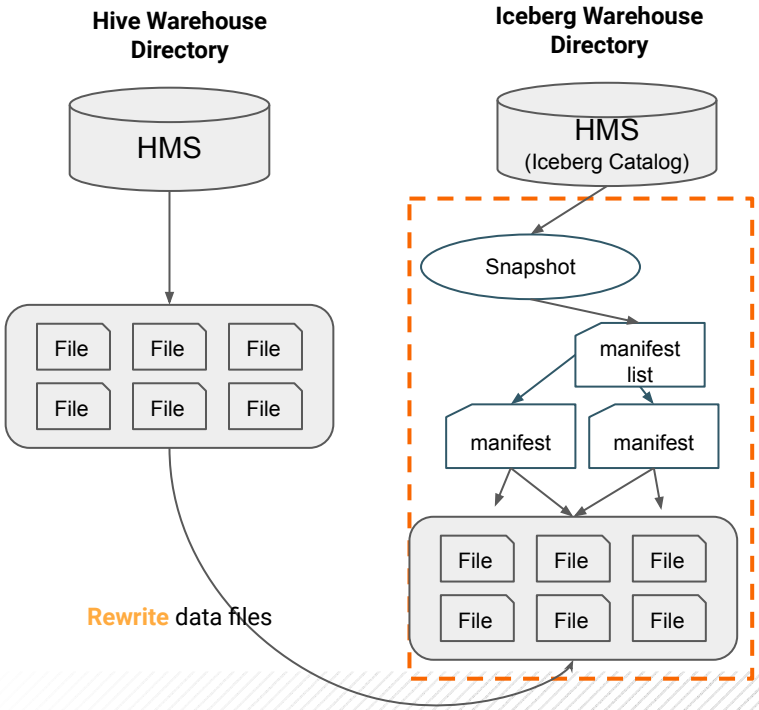
```
spark.sql("CALL
<catalog>.system.snapshot('<src>', '<dest>')")
```

  **b. Migrate Hive tables to Iceberg tables**

```
spark.sql("CALL
 <catalog>.system.migrate('<src>')")
```

# Table Migration CTAS / RTAS

Data files **recreated** in addition to creation of Iceberg tables and corresponding metadata



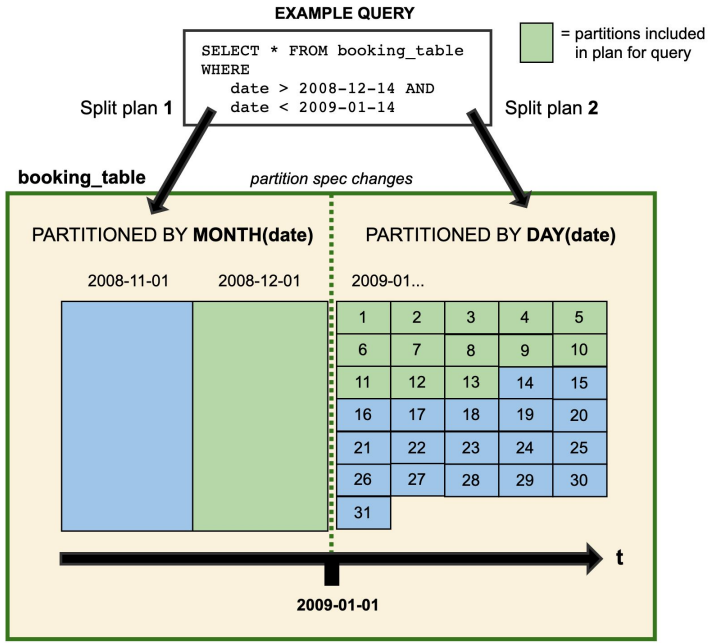

```
CREATE TABLE ctas PARTITIONED BY(z) STORED
BY ICEBERG AS SELECT x, y FROM t;
```

```
spark.sql("CREATE TABLE ctas PARTITIONED
BY(z) USING iceberg AS (SELECT x, y FROM
t)")
```

```
spark.sql("REPLACE TABLE rtas PARTITIONED
BY(z) USING iceberg AS (SELECT x, y FROM
t)")
```

# Partition Evolution

# Iceberg Partition Evolution




ALTER TABLE t1 SET PARTITION SPEC (hour(ts))
ALTER TABLE t1 ADD PARTITION FIELD (month(ts))

- Existing big data solution doesn't support **in-place** partition evolution. Entire table must be completely rewritten with new partition column
- With Iceberg's **hidden partition**, a separation between physical and logical, users are not required to maintain partition columns.
- Iceberg tables can **evolve partition** schemas over time as data volume changes.
- **Benefits**:
  - No costly table rewrites or table migration
  - No query rewrites
  - Reduce downtime and improve SLA

# PARTITION EVOLUTION

## From less to more granular

**Partitioned by year:**

- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
- 2021
- 2022
- 2023

Partition Evolution

**Partitioned by year, month:**

- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
- 2021
- 2022
- 2023
  - June
  - July
  - August
  - September
  - October
  - November
  - December

Partition Evolution

**Partitioned by year, month, day:**

- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
- 2021
- 2022
- 2023
  - June
  - July
  - August
  - September
  - October
  - November
  - December
    - 20
    - 21
    - 22
    - 23
    - 24
    - 25

Table structure, partitioned by year:

```
CREATE TABLE transaction (id INT,
time TIMESTAMP, ...)
PARTITIONED BY YEARS(time);
```

Adding new partitions. First, break down by month, then by day:

```
ALTER TABLE transaction ADD
PARTITION FIELD MONTH(time)

ALTER TABLE transaction ADD
PARTITION FIELD DAY(time)
```

# Time Travel

# TIME TRAVEL

Two rollback and time travel options: snapshot-id and as-of-timestamp


### Audit data changes (BMS)

- Creates automatic snapshots of past data
- History of all operations are recorded for audits

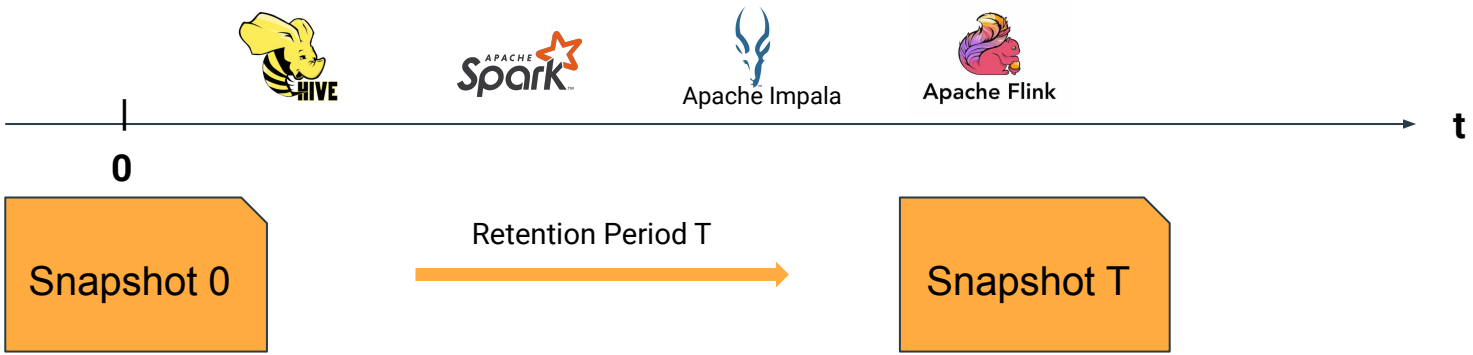
### Data Reproducibility

- Retrain ML models with past data
- Generate financial reports faithfully, on past data

### Rollback: Eliminate Data Errors

- Data pipeline debugging
- Rollback to any point to find source of bad data
- Root cause analysis
- Update, replace, or delete bad data

# Time Travel & Table Rollback




- **Time Travel** enables reproducible queries that use exactly the same table snapshot, or lets users easily examine changes
- **Rollback** allows users to quickly correct problems by resetting tables to a good state

```
SELECT * FROM table FOR SYSTEM_TIME AS OF '2021-08-09 10:35:57';
SELECT * FROM table FOR SYSTEM_VERSION AS OF 1234567;
ALTER TABLE table EXECUTE ROLLBACK ('2021-08-09 10:35:57')
ALTER TABLE table EXECUTE ROLLBACK (1234567)
```

# Row-level Mutation

COW vs MOR

# ROW-LEVEL MUTATION

| | Change actions | | Speed | | |
|---|---|---|---|---|---|
| **Mutation Strategy** | **DELETIONS** | **UPDATES** | **Read** | **Write** | **Recommendations** |
| COW | The entire file is rewritten excluding the deleted rows | The whole file is rewritten with the updated rows | Fastest | Slowest | Recommended where changes to data are low frequency and reads performance is significantly more important |
| MOR (Equality deletes) | New files are created containing the row conditions to be deleted | New files are created just with the updated rows | Slow | Fastest | Requires frequent complications depending on how frequent are the updates/deletes. |
| MOR (Position deletes) | New files are created containing the row positions to be deleted | New files are created just with the updated rows | Fast | Fast | Requires frequent complications depending on how frequent are the updates/deletes. |

# ROW-LEVEL MUTATION

**Icetip**

Understand the use case needs - how data will be ingested, processed and consumed

| Use case | Description | Requirements | Strategy |
|---|---|---|---|
| Batch processing | Process large chunks of files | Data can be consumed minutes/hours after processed | COW |
| Streaming analytics | (Near) real-time ingestion and processing | Data should be available immediately after ingestions | MOR, and run compactions to optimize reads; or consider Hbase or Kudu as better alternatives |
| Machine Learning | Run advanced analytics on static/batch data | Train ML models on vast datasets, creating new ones | COW |
| Real-time Business Intelligence | BI analytics for reporting and dashboards | Build snowflake or star schemas in 3NF | MOR, and run compactions to optimize reads |

# INSERT OVERWRITE VS. MERGE INTO

With Iceberg v2 format support (row-level deletes / updates), for **slow-changing** tables' **change data capture (CDC)**, **MERGE INTO** is recommended instead of INSERT OVERWRITE as **MERGE INTO** can replace only the affected data files instead of partitions.

# SQL MERGE FOR CDC IN SCD TABLES

| | SQL Examples |
|---|---|
| **HIVE** | MERGE INTO <target table> AS T USING <source expression/table> AS S<br>ON <boolean expression1><br>WHEN MATCHED [AND <boolean expression2>] THEN UPDATE SET <set clause list><br>WHEN MATCHED [AND <boolean expression3>] THEN DELETE<br>WHEN NOT MATCHED [AND <boolean expression4>] THEN INSERT VALUES <value list> |
| **SPARK** | MERGE INTO <target table> t<br>USING <source expression/table> s<br>ON <boolean expression1><br>WHEN MATCHED [AND <boolean expression2>] THEN UPDATE SET <set clause list><br>WHEN MATCHED [AND <boolean expression3>] THEN DELETE<br>WHEN NOT MATCHED [AND <boolean expression4>] THEN INSERT VALUES <value list> |

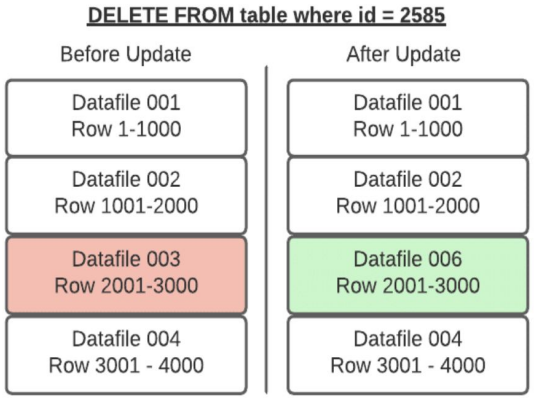
# Row-Level Changes on the Lakehouse: COW vs MOR

Iceberg table has two different table formats v1 & v2.

- **v1** format — defaults **copy-on-write**
- **v2** format — **copy-on-write** or **merge-on-read.**

# Copy-on-Write (COW)

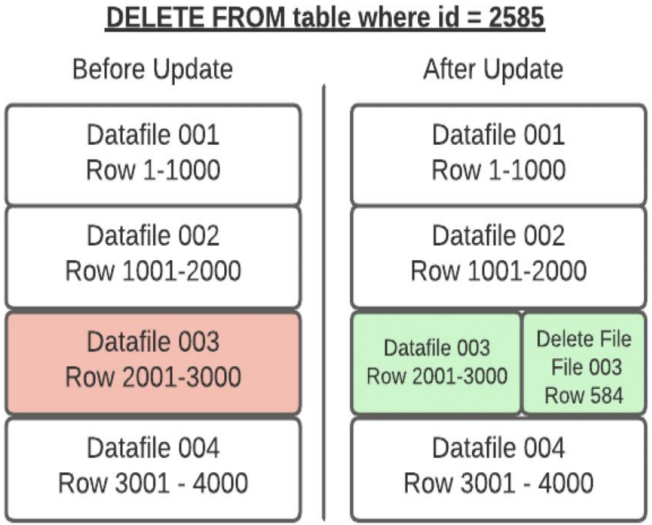
- With COW, when a change is made to delete or update a particular row or rows, the datafiles with those rows are duplicated, but the new version has the updated rows.
- This makes writes slower depending on how many data files must be re-written.
- If updating a large number of rows, COW is ideal.
- However, if updating just a few rows you still have to rewrite the entire data file, making small or frequent changes expensive.




| Summary of COW (Copy-On-Write) | |
|---|---|
| PROS | CONS |
| Fastest reads | Expensive writes |
| Good for infrequent updates/deletes | Bad for frequent updates/deletes |

# Merge-on-Read (MOR)

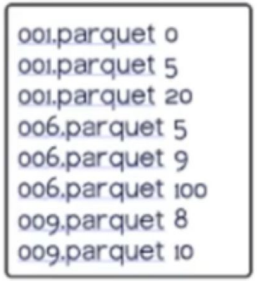
- With merge-on-read, **the file is not rewritten, instead the changes are written to a new file.**
- Then when the data is read, **the changes are applied or merged to the original data file** to form the new state of the data during processing.
- This makes writing the changes much quicker, but also means more work must be done when the data is read.
- If you **delete a row**, it gets added to **a delete file** and reconciled on each subsequent read till the files undergo compaction.
- If you **update a row**, that row is tracked **via a delete file** so future reads ignore it from the old data file and the updated row is added to a new data file.
- Again, once **compaction** is run, **all the data will be in fewer data files and the delete files will no longer be needed.**



# Types of Delete Files

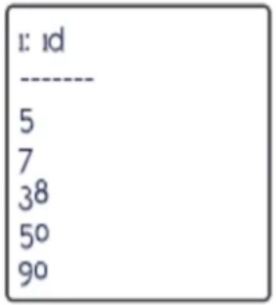
**Position Deletes:**

When Deleting a record, the file is read to determine its position in the file and the position of all deleted records (within files of a certain partition) are tracked in a delete file.




**Equality Deletes:**

Instead of reading the file to identify the position of the deleted record, equality deletes just track specified filter predicates from the query and then matches them during the read. Faster during write but slower during read than position deletes.



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# Table Maintenance with CDE / CML (Spark 3 SQL)

| Table Maint. | Examples |
|---|---|
| Snapshot Management | // **Remove snapshots** older than one day, but retain the last 100 snapshots<br>spark.sql("CALL <catalog>.system.expire_snapshots('db.sample',TIMESTAMP '2021-06-30 00:00:00.000', 100)")<br><br>// **Rollback** a table to specific snapshot ID<br>spark.sql("CALL <catalog>.system.rollback_to_snapshot('db.sample',12345)")<br>// **Rollback** a table to one day<br>spark.sql("CALL <catalog>.system.rollback_to_timestamp('db.sample', TIMESTAMP '2021-06-30 00:00:00.000')") |
| Compaction | // **Rewrite the data files** in db.sample using the default rewrite<br>// algorithm of bin-packing to combine small files and also split large //<br>files according to the default write size of the table<br>spark.sql("CALL <catalog>.system.rewrite_data_files('db.sample')") |

Expiring old snapshots removes them from metadata, so they are no longer available for time travel operations. Data files are not deleted until they are no longer referenced by a snapshot that may be used for time travel. Regularly expiring snapshots deletes unused data files.

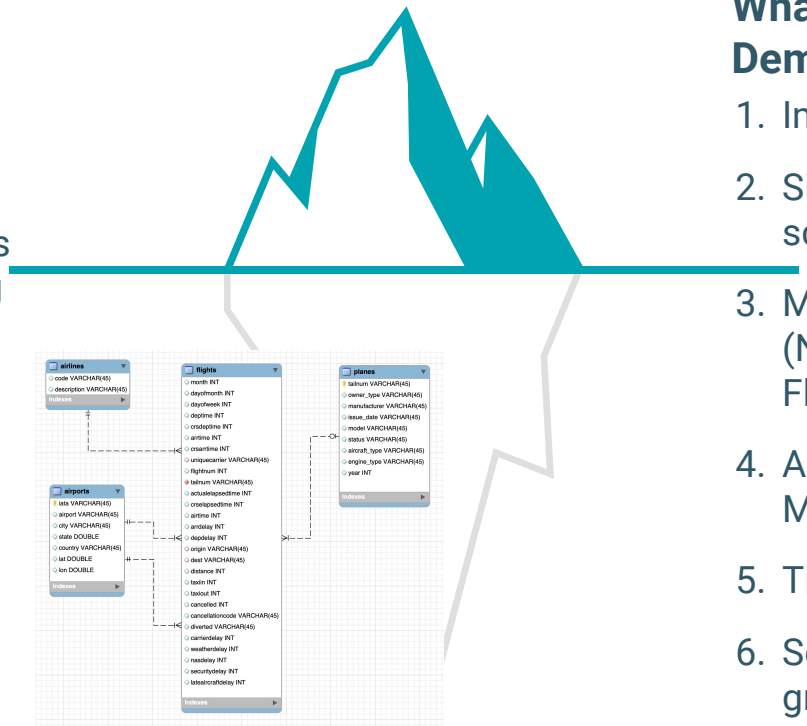
# Lakehouse Hands-on Lab

# OVERVIEW OF DEMO

## Try it out, what could it hurt?????

### Airline Logistics Analytics Data Lakehouse

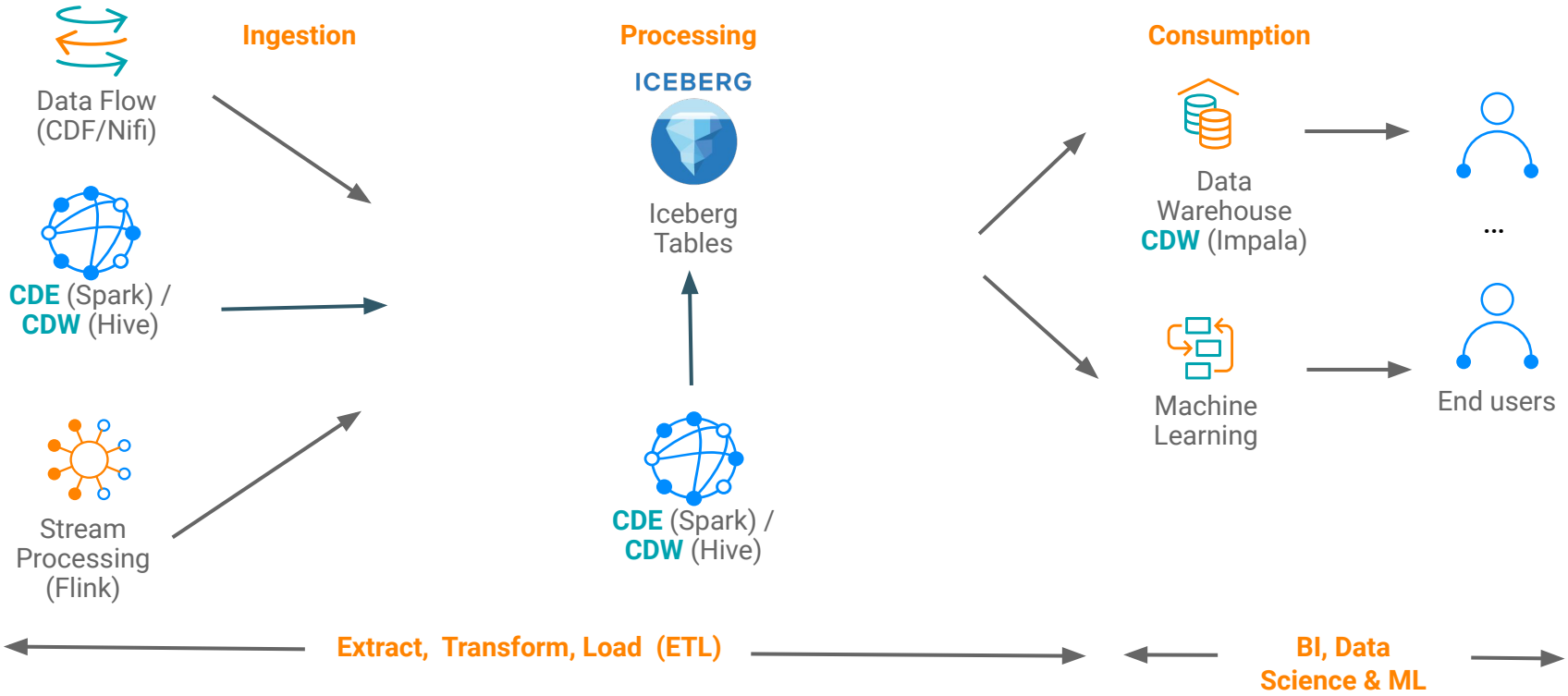
- Concerns with Flight Delays & Cancellations
- Data volumes growing fast, stressing current solution(s)
- Stream in additional data - Fare data to augment analytics
- Need to prepare data for AI use cases




### What to Expect in the Demo

1. Improved performance
2. Simplified management - schema/partition evolution
3. Multi-function analytics (NiFi, Spark, Impala, Flink/SSB)
4. ACID - Insert, Update, & Merge
5. Time Travel
6. Security & Lineage - incl. fine grained access control

# Open Data Lakehouse Reference Architecture



# Q&A

# Thank You

# Iceberg Replication

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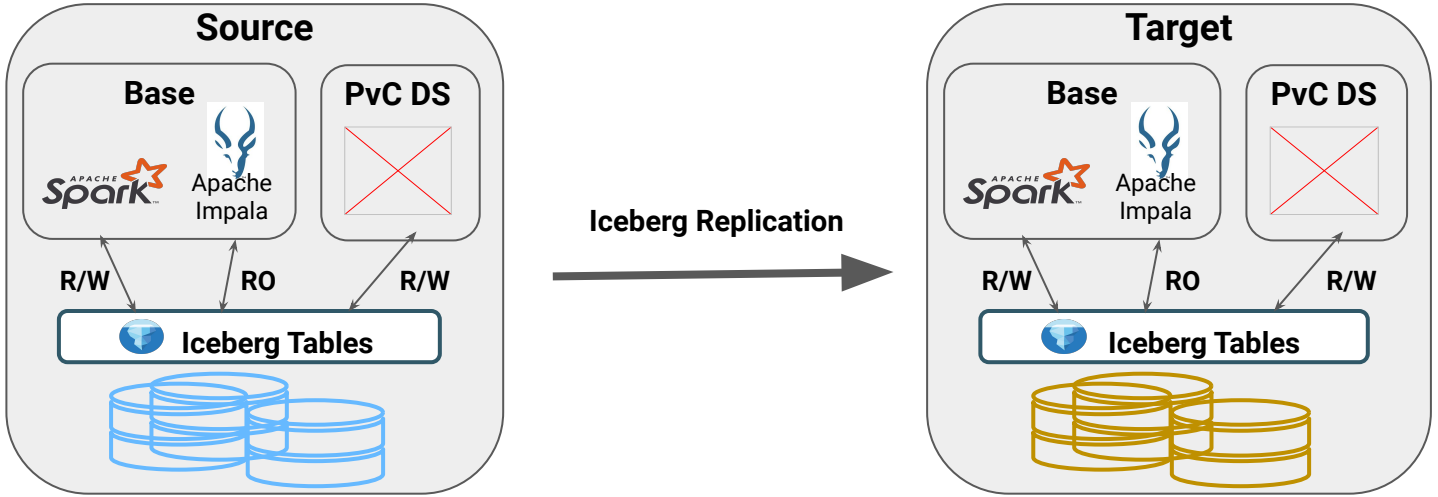
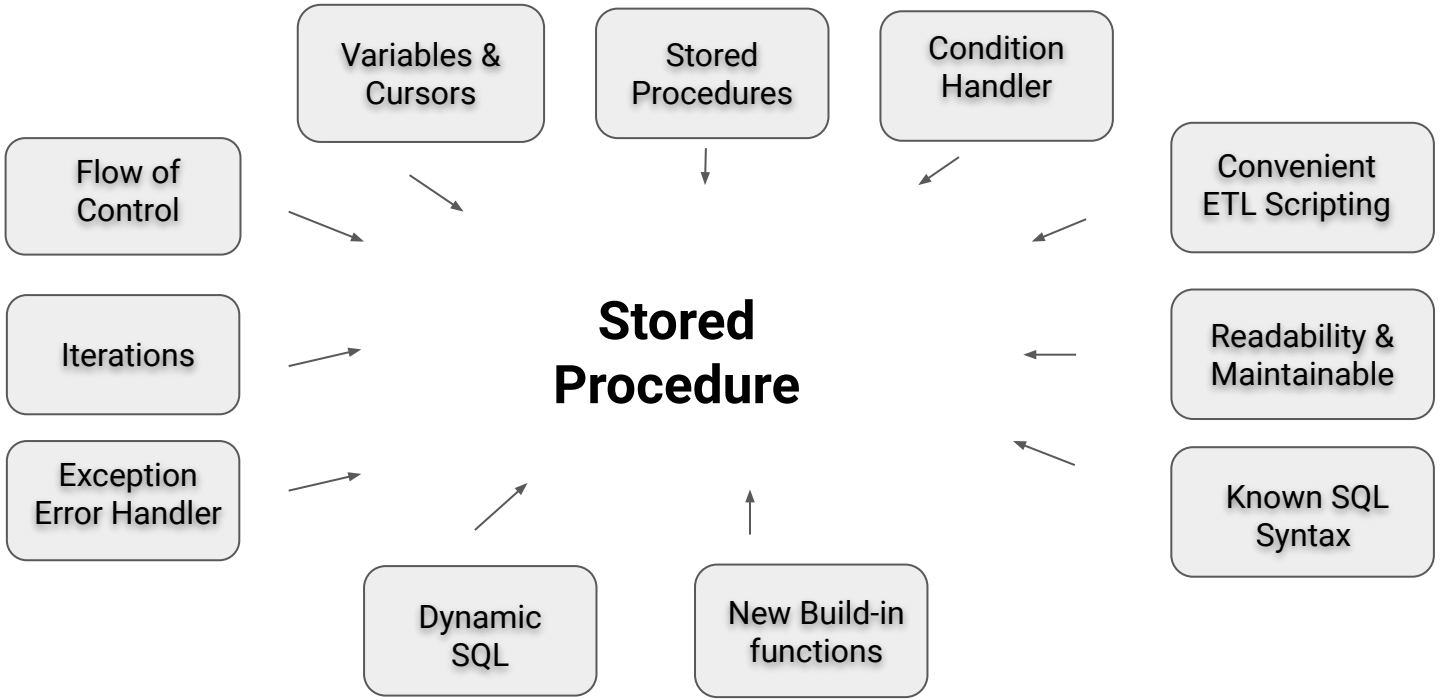



- Bootstrap and Incremental Replication Support
- Iceberg Version V1/V2 support
- Table level replication scope with inclusion and exclusion filters

# CDW Stored Procedure - HPL/SQL

# CDW Stored Procedures - HPL/SQL

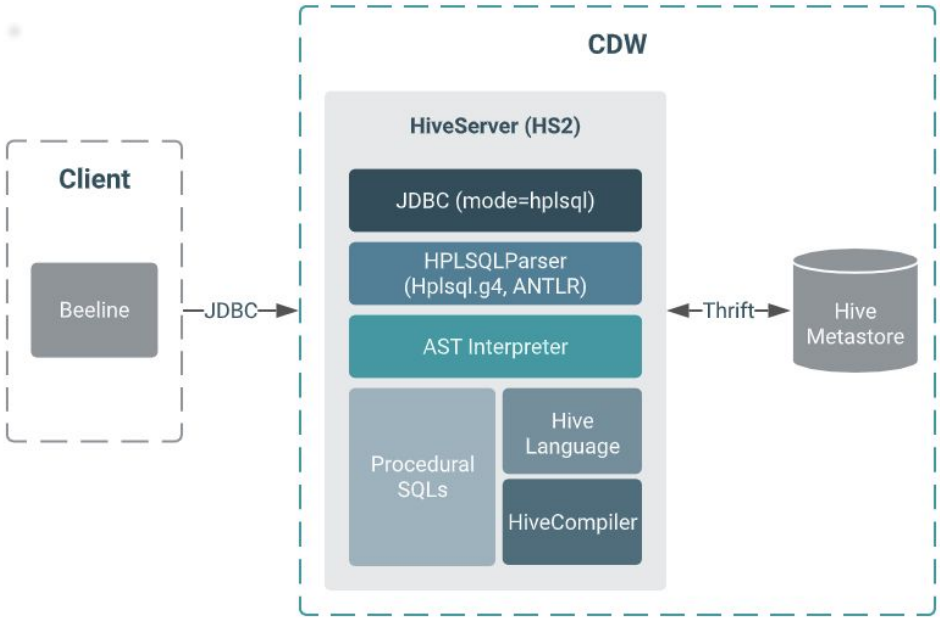


# Stored Procedure Architecture

CDW Stored Procedure has been re-architected from a command line tool to an **integrated part of HiveServer (HS2).**

The **interpreter** executes the abstract syntax tree (AST) from the parser.

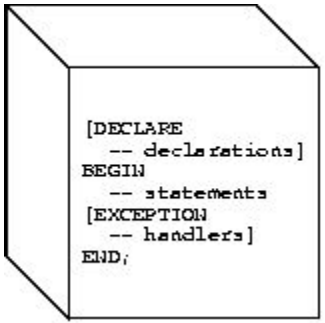
**Hive metastore** securely stores the function and procedure code permanently.




The procedure is loaded and cached on demand to the interpreter's memory when needed.

# Procedural Language & SQL

CDW Stored Procedure is (partial) compatible with Oracle PL/SQL, IBM DB2, MySQL and Teradata.



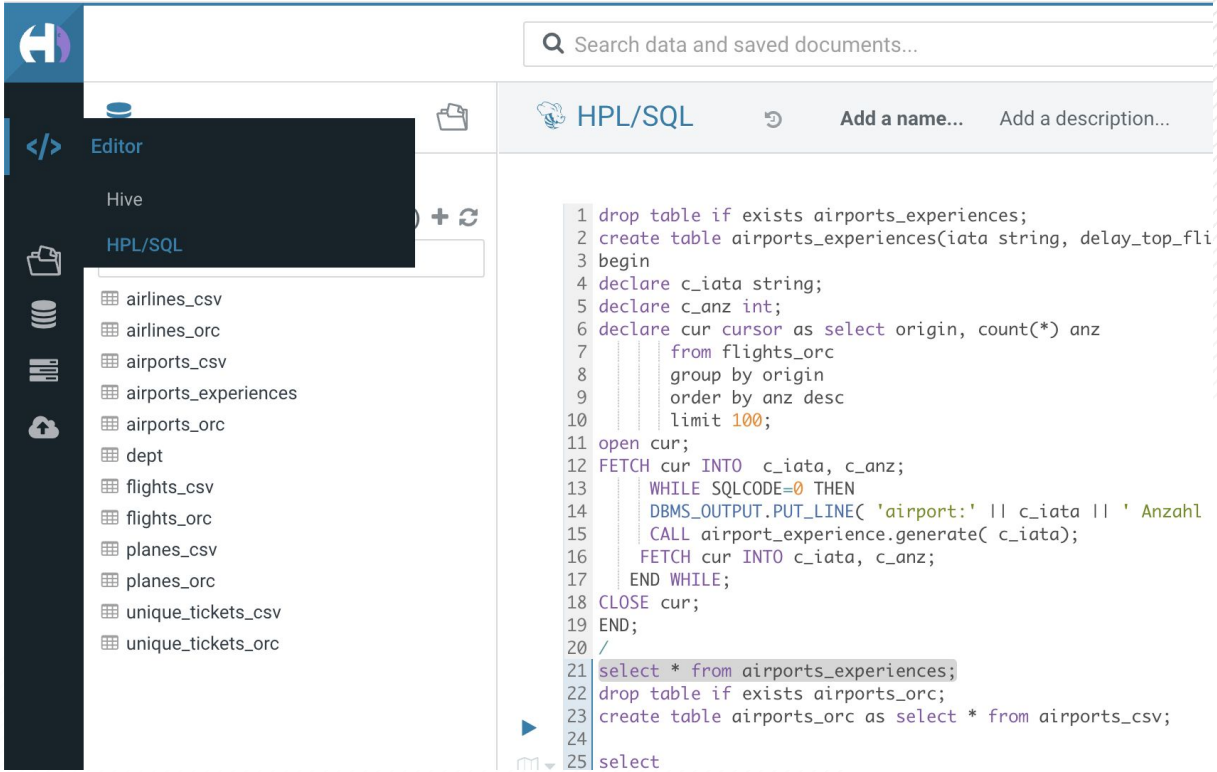

```
create procedure hello(name STRING)
begin
  print 'Hello ' || name;
end;

call hello ('World!');
```

```
declare row_cnt    int = 0;
declare rows       flights_csv%rowtype;
declare cur cursor for SELECT * FROM flights_csv;

OPEN cur;
FETCH cur INTO rows;
WHILE SQLCODE=0 THEN
  row_cnt = row_cnt + 1;
  FETCH cur INTO rows;
END WHILE;
CLOSE cur;

PRINT 'row count ' || row_cnt;
```


Search data and saved documents...
Editor
Hive
HPL/SQL
HPL/SQL
Add a name...
Add a description...
airlines_csv
airlines_orc
airports_csv
airports_experiences
airports_orc
dept
flights_csv
flights_orc
planes_csv
planes_orc
unique_tickets_csv
unique_tickets_orc
1 drop table if exists airports_experiences;
2 create table airports_experiences(iata string, delay_top_fli
3 begin
4 declare c_iata string;
5 declare c_anz int;
6 declare cur cursor as select origin, count(*) anz
7 from flights_orc
8 group by origin
9 order by anz desc
10 limit 100;
11 open cur;
12 FETCH cur INTO c_iata, c_anz;
13 WHILE SQLCODE=0 THEN
14 DBMS_OUTPUT.PUT_LINE( 'airport:' || c_iata || ' Anzahl
15 CALL airport_experience.generate( c_iata);
16 FETCH cur INTO c_iata, c_anz;
17 END WHILE;
18 CLOSE cur;
19 END;
20 /
21 select * from airports_experiences;
22 drop table if exists airports_orc;
23 create table airports_orc as select * from airports_csv;
24
25 select