Trino on Ice: Using Iceberg to replace the Hive table format

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Overview

- Trino Overview
- Issues with Hive Table Format
- Iceberg Table Format
  - Column and Partition Model
  - Table Evolution
  - Cloud Compatibility
  - Concurrency Model
  - Time Travel
  - Iceberg Specification
Trino TL;DL

Trino is a fast distributed SQL query engine designed to query large data sets distributed over one or more heterogeneous data sources.
Hive: The perfect SQL HiveQL solution

Developers at Facebook created Hive, a SQL-on-Hadoop solution that takes a SQL like syntax, HiveQL, and transforms it into MapReduce operations on data in Hadoop.

- Simplified development process
- Queries still taking long
- Established a base for how to model SQL tables of generic data stores
Presto! Your queries are fast!

Martin Traverso, Dain Sundstrom, and David Phillips created Presto in 2012. It aimed to solve for the slow queries of Hive at Facebook and eventually many more.

Development Philosophies:

- Open source with neutral governance model
- It just works (Netezza was a commercial inspiration)
- Fast, interactive analytics
- Correct results
- Standards based (ANSI SQL, JDBC, etc.)

Facebook management unilaterally rewrites rules around committership in late 2018.
Trino (formerly known as PrestoSQL)

- If you know Presto or are using PrestoSQL...
  - same software
  - same people
  - same community
  - under a shiny new name
  - and a cute bunny
- Companies don’t run open source projects, people do.
- More details:

https://trino.io/blog/2020/12/27/announcing-trino.html
Hive Architecture

I'm the Hive Specification Boooooo
Trino Hive Connector Architecture
Issues with Hive Table Format

- Invisible specification
- Column model
- Partition model
- Schema evolution requires data migration
- Not built for the cloud
- No transactional guarantees (depends on filesystem)
- Data and metadata not synchronized
- No concept of “time travel”
- No capability to roll data back
Column and Partition Model

Create an events table partitioned on a TIMESTAMP field event_time by day

Hive Statement

```
CREATE TABLE hive.logging.events (  
    level VARCHAR,
    event_time TIMESTAMP,
    message VARCHAR,
    call_stack ARRAY(VARCHAR)
) WITH (  
    format = 'ORC',
    partitioned_by = ARRAY['event_time']
);
```

Goal partition file org
Column and Partition Model

- Creation of Hive table in Trino
- Causes an exception due to partition location in statement

```sql
CREATE TABLE hive.logging.events (
    level VARCHAR,
    event_time TIMESTAMP,
    message VARCHAR,
    call_stack ARRAY(VARCHAR)
) WITH (
    format = 'ORC',
    partitioned_by = ARRAY['event_time']
);
```

Partition keys must be the last columns in the table and in the same order as the table properties: [event_time]
Column and Partition Model

- Move timestamp to the last column
- TIMESTAMP is at the second granularity rather than the day granularity

```sql
CREATE TABLE hive.logging.events (
    level VARCHAR,
    message VARCHAR,
    call_stack ARRAY(VARCHAR),
    event_time TIMESTAMP
) WITH (
    format = 'ORC',
    partitioned_by = ARRAY['event_time']
);
```
Column and Partition Model

- A separate directory for every second you get an event file.
- Solution?
Column and Partition Model

- Create duplicate VARCHAR that requires the awareness of the user
- Use this field

```
CREATE TABLE hive.logging.events (  
  level VARCHAR,  
  event_time TIMESTAMP,  
  message VARCHAR,  
  call_stack ARRAY(VARCHAR),  
  event_time_day VARCHAR  
) WITH (  
  format = 'ORC',  
  partitioned_by = ARRAY['event_time_day']  
);
```
Column and Partition Model

- This works but...
- Inserts and reading require awareness of the second partition field
- Very error prone
Column and Partition Model

- TIMESTAMP and the last partition field must be aligned
- No internal validation performed to verify these align

```sql
INSERT INTO hive.logging.events
VALUES
(
    'ERROR',
    timestamp '2021-04-01 12:00:00.000001',
    'Oh noes',
    ARRAY [Exception in thread "main" java.lang.NullPointerException],
    '2021-04-01'
),
(
    'ERROR',
    timestamp '2021-04-02 15:55:55.555555',
    'Double oh noes',
    ARRAY [Exception in thread "main" java.lang.NullPointerException],
    '2021-04-02'
),
(
    'WARN',
    timestamp '2021-04-02 00:00:11.1122222',
    'Maybeh oh noes?',
    ARRAY ['Bad things could be happening??'],
    '2021-04-02'
);
```
Column and Partition Model

- Must filter on both timestamp field, as well as partition field and be aware both exist
- Easy to build query incorrectly, especially with multiple partitions

```
SELECT *
FROM hive.logging.events
WHERE event_time < timestamp '2021-04-02';
```

```
SELECT *
FROM hive.logging.events
WHERE event_time < timestamp '2021-04-02'
AND event_time_day < '2021-04-02';
```

|ERROR|2021-04-01 12:00:00|Oh noes|Exception in thread "main" java.lang.NullPointerException|
Column and Partition Model

- All fixed in Iceberg using hidden partitioning
- Partitioning specification is abstracted from user

```sql
CREATE TABLE iceberg.logging.events (  
  level VARCHAR,  
  event_time TIMESTAMP(6),  
  message VARCHAR,  
  call_stack ARRAY(VARCHAR)  
) WITH (  
  partitioning = ARRAY['day(event_time)']  
);```
Column and Partition Model

- User only insert the timestamp field and mapping to day partitioning happens internally
Column and Partition Model

- Reader also doesn’t need to be aware

```sql
SELECT *
FROM iceberg.logging.events
WHERE event_time < timestamp '2021-04-02';
```
Iceberg internally names the partition "event_time_day" based on transform function.
Table Evolution: Partition Evolution

- Want to update the granularity of your partition?
- No support for in-place partition evolution in Hive
- Must perform a full table migration
Table Evolution: Partition Evolution

- Iceberg supports in-place partition evolution
- Trino supports reads but not writes yet.
- Coming Soon!
Table Evolution: Schema Evolution

- Limited support for in-place schema evolution in Hive
- May need to perform a full table migration

Hive 2.2.0 schema evolution based on filetype and operation.

<table>
<thead>
<tr>
<th></th>
<th>Add</th>
<th>Delete</th>
<th>Rename</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSV/TSV</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>JSON</td>
<td>✔️</td>
<td>✔️</td>
<td>❌</td>
</tr>
<tr>
<td>ORC/Parquet/Avro</td>
<td>✔️</td>
<td>✔️</td>
<td>❌</td>
</tr>
</tbody>
</table>
Table Evolution: Schema Evolution

- Iceberg only supports ORC, Parquet, and Avro to ensure guarantees
Table Evolution: Schema Evolution

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Table Evolution: Schema Evolution

- Iceberg only supports ORC, Parquet, and Avro to ensure guarantees.

```sql
ALTER TABLE iceberg.logging.events
RENAME COLUMN severity TO priority;

SELECT level, message, priority
FROM iceberg.logging.events;

ERROR Double oh noes NULL
WARN Maybeh oh noes? NULL
ERROR Oh noes NULL
INFO es muy bueno 1

ALTER TABLE iceberg.logging.events
DROP COLUMN priority;
```
Cloud Compatibility

- Avoid expensive list operation
- Track files not directories
- Store manifest files and accurate file statistics in persistent tree structure
Concurrency Model

- Iceberg maintains a linear model of changes called immutable snapshots
- Optimistic concurrency between writers via lock-and-swap operation
- Serializable Isolation guarantees
- Git workflow analogy
Time Travel

- Snapshots enable cool capabilities like time travel
- You can view snapshots of a table in Trino by appending `$snapshots` to a table

```sql
SELECT level, message
FROM iceberg.logging.events;
```

```sql
ERROR Double oh noes
WARN Maybeh oh noes?
ERROR Oh noes
```

```sql
SELECT snapshot_id, parent_id, operation
FROM iceberg.logging."events$snapshots";
```

<table>
<thead>
<tr>
<th>snapshot_id</th>
<th>parent_id</th>
<th>operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>7620328658793169607</td>
<td></td>
<td>append</td>
</tr>
<tr>
<td>2115743741823353537</td>
<td>7620328658793169607</td>
<td>append</td>
</tr>
</tbody>
</table>
Time Travel

- Snapshots are just pointers to manifest lists
- Manifest lists avro files containing a list of other manifest files (also avro)
- Manifest files contain the file stats and a list of data files
Time Travel

- Each mutation to the data state creates a new snapshot

```sql
SELECT snapshot_id, parent_id, operation
FROM iceberg.logging."events$snapshots";
```

<table>
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<td>7620328658793169607</td>
<td>append</td>
</tr>
<tr>
<td>7030511368881343137</td>
<td>2115743741823353537</td>
<td>append</td>
</tr>
</tbody>
</table>

```sql
INSERT INTO iceberg.logging.events
VALUES
( 'INFO',
  timestamp '2021-04-02 00:00:11.1122222',
  'It is all good',
  ARRAY ['Just updating you!']
);
```

```sql
SELECT level, message
FROM iceberg.logging.events;
```

<table>
<thead>
<tr>
<th>level</th>
<th>message</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERROR</td>
<td>Oh noes</td>
</tr>
<tr>
<td>INFO</td>
<td>It is all good</td>
</tr>
<tr>
<td>ERROR</td>
<td>Double oh noes</td>
</tr>
<tr>
<td>WARN</td>
<td>Maybeh oh noes</td>
</tr>
</tbody>
</table>
Time Travel

- Append the ‘@<snapshot-id>’ syntax to your table to time travel to a specific snapshot of your data.
Time Travel

- Use the `system.rollback_to_snapshot(<schema>, <table>, <snapshot-id>)` function to permanently roll back to the given snapshot
- This doesn’t erase the original snapshot
Iceberg Specification

- Iceberg Spec: [https://iceberg.apache.org/spec/](https://iceberg.apache.org/spec/)
- No specific implementation of Iceberg is required, even the current Iceberg library.
- Any query engine can implement the spec as a standard to be compliant.
- Community is primarily focused on the specification over implementation.
Community

- Trino Slack
  - [https://trino.io/slack.html](https://trino.io/slack.html)

- Trino Community Broadcast
  - [https://trino.io/broadcast/](https://trino.io/broadcast/)

- Trino Virtual Meetups
  - [https://www.meetup.com/trino-americas](https://www.meetup.com/trino-americas)
  - [https://www.meetup.com/trino-emea](https://www.meetup.com/trino-emea)
  - [https://www.meetup.com/trino-apac](https://www.meetup.com/trino-apac)

- Contribute to the project
  - [https://trino.io/development/](https://trino.io/development/)

- Write blogs or docs
  - [https://trino.io/blog/](https://trino.io/blog/)
  - [https://github.com/trinodb/trino/tree/master/docs](https://github.com/trinodb/trino/tree/master/docs)
Thank you

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