

Exploring Apache Iceberg - A Modern Data Lake Stack

Engineering

Bloomberg

EuroPython 2024
July 12, 2024

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Enterprise Data Lake Engineering

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Who Am I?



Software Engineer at
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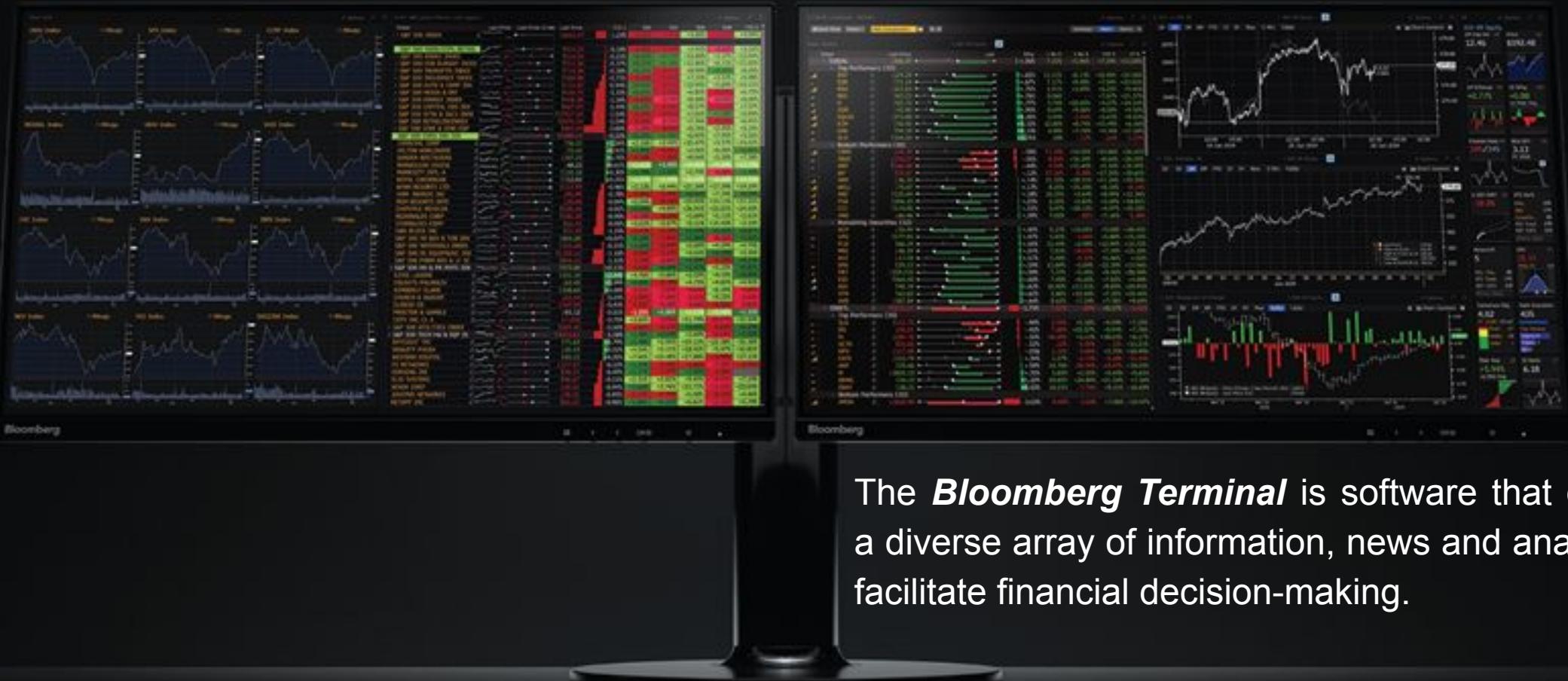
👉 <https://www.linkedin.com/in/gowthami-bhogireddy-7335427b>

/

👉 Pylceberg Open Source Contributor

👉 First time EuroPython speaker, yay!

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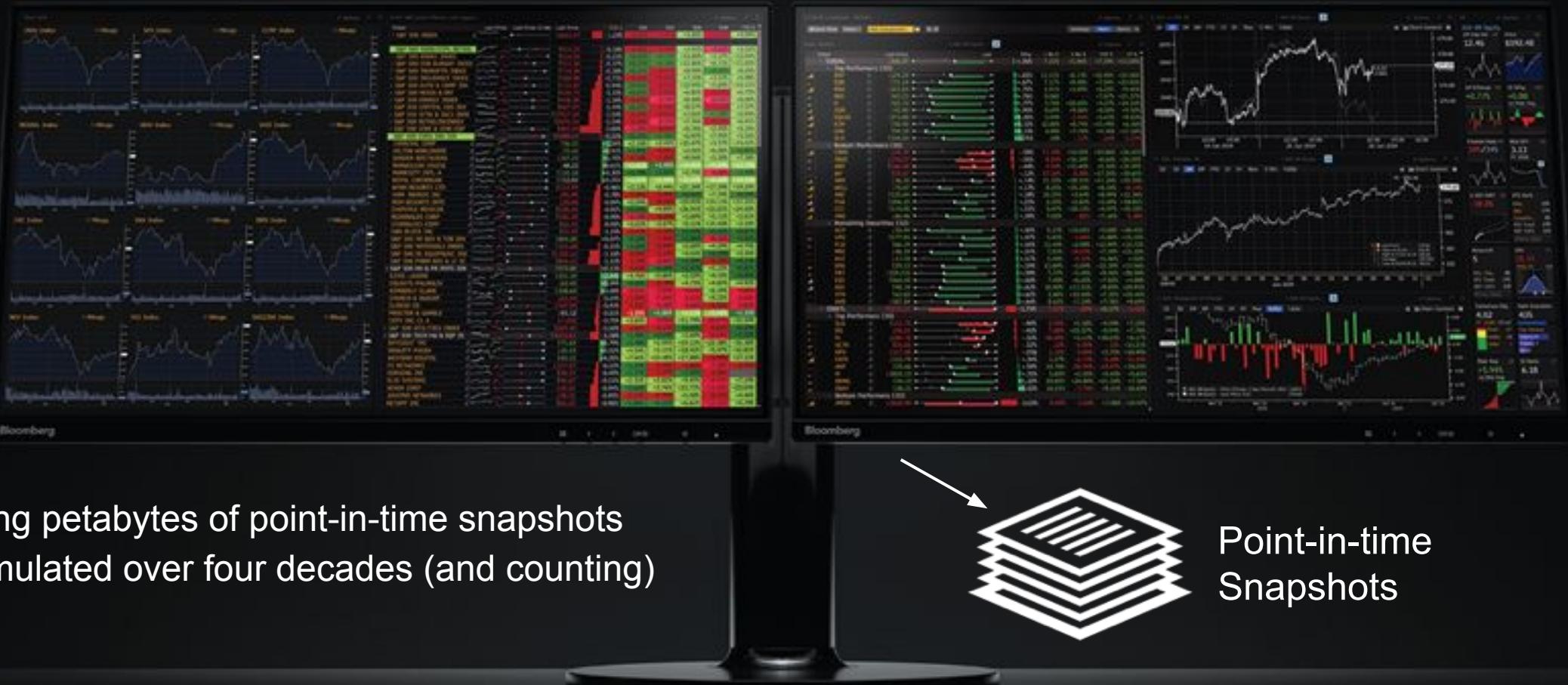


The **Bloomberg Terminal** is software that delivers a diverse array of information, news and analytics to facilitate financial decision-making.

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Using petabytes of point-in-time snapshots
accumulated over four decades (and counting)

Point-in-time
Snapshots

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1,000,000,000,000,000

1,000,000,000,000,000

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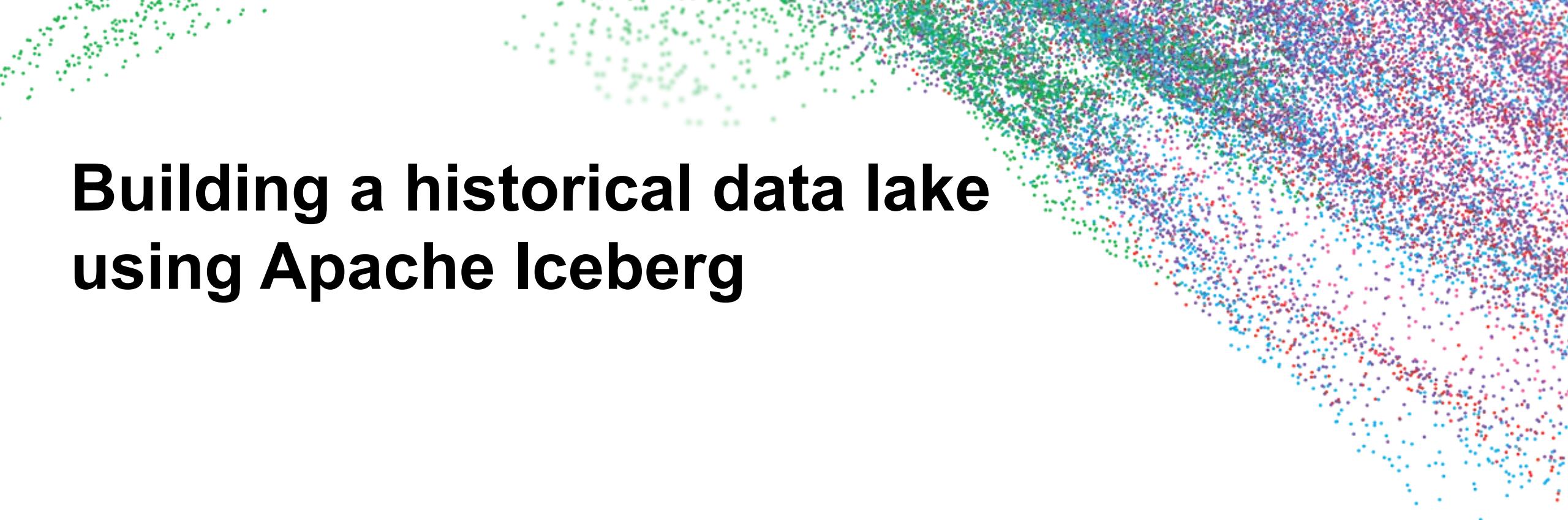
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Agenda

1. Building a historical data lake using Apache Iceberg
2. Demo - Ways to interact with Apache Iceberg

Building a historical data lake using Apache Iceberg



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Example data

TIMESTARTED=Wed Feb 23 17:32:22 EST 2022

COMPANY_ID

TICKER

PRICE

START-OF-DATA

AAPL US Equity|0|3|BBG000B9XRY4|AAPL|173.46|Common Stock

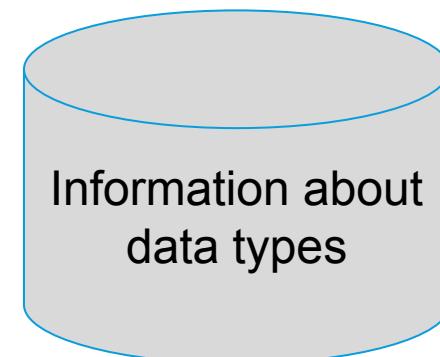
IBM US Equity|0|3|BBG000BLNNH6|IBM|129.43|Common Stock

...

END-OF-DATA

DATARECORDS=2

TIMEFINISHED=Wed Feb 23 17:41:32 EST 2022



COMPANY_ID: string
TICKER: string
PRICE: double

Summary of Problems

- **Data Format** - Text files
- **Data Volume** - PBs of data
- **Scale** - Tens of millions of files (and only growing)

Data Lake Requirements

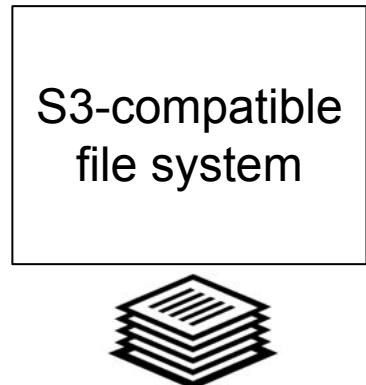
Golden copy of data

Audit trail

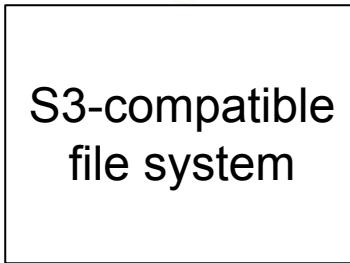
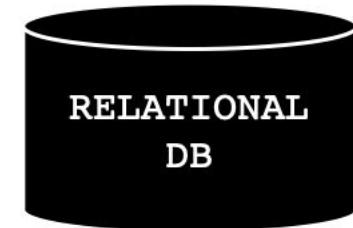
Schema
Evolution

ACID guarantees

Data Analysis



Thousands of daily jobs
using custom sources;
async historical backfills



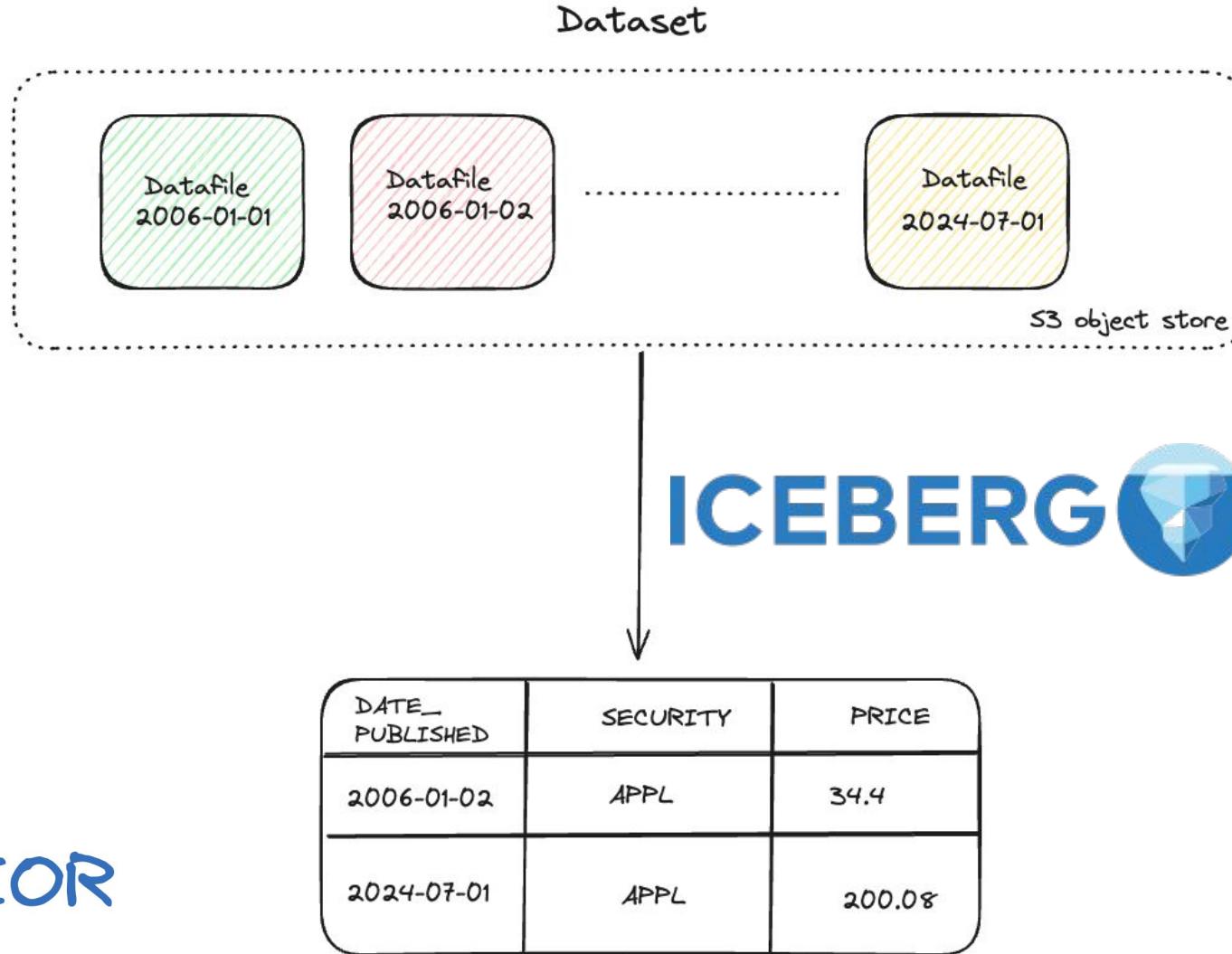
What is Iceberg?

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SQL
LIKE
BEHAVIOR



 Open table format

 Storage layer

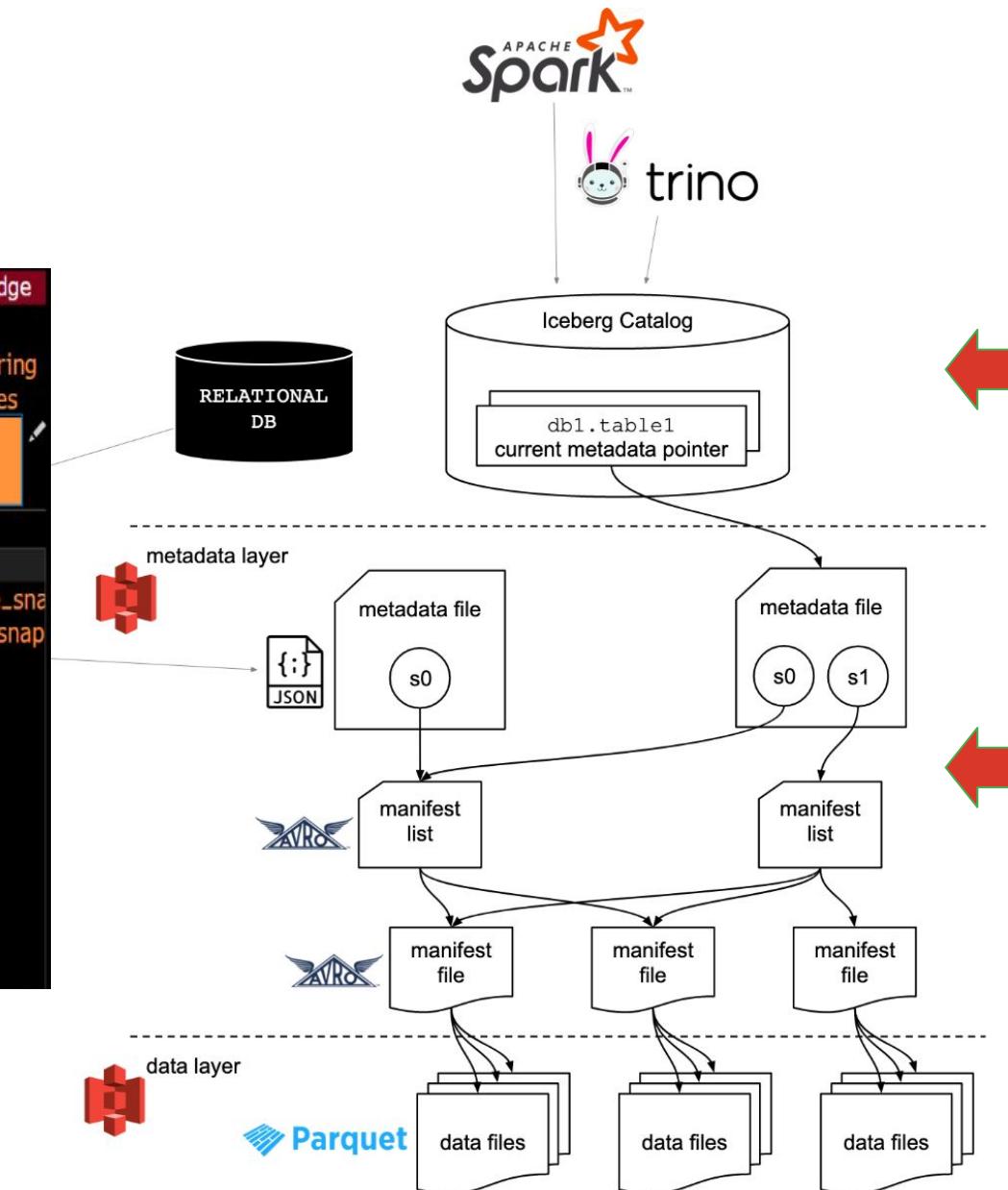
 Compute Engine

Iceberg Internals

The screenshot shows the Bloomberg Database UI interface. At the top, there is a navigation bar with tabs: Run Query, Show Tables, Clear Query, History, C2DB, More, and DB Bridge. Below the navigation bar, there are several input fields: DB Type (comdb2), Name (iceberg), Env (dev), Precision, Time Zone, Column Width (200), Blob As String, Authenticate, Explain Only, and View Spaces. A query is entered in the text area: `SELECT * FROM 'iceberg_tables'`. The results section displays the output of the query, showing 2 rows returned in 37 ms. The table has four columns: catalog_name, table_namespace, table_name, and metadata_location. The data is as follows:

catalog_name	table_namespace	table_name	metadata_location
1. iceberg	demo	fake_snaps	s3a://lacus-warehouse/demo/fake_snaps
2. iceberg	test	fake_snaps	s3a://lacus-warehouse/test/fake_snap

Bloomberg Database UI



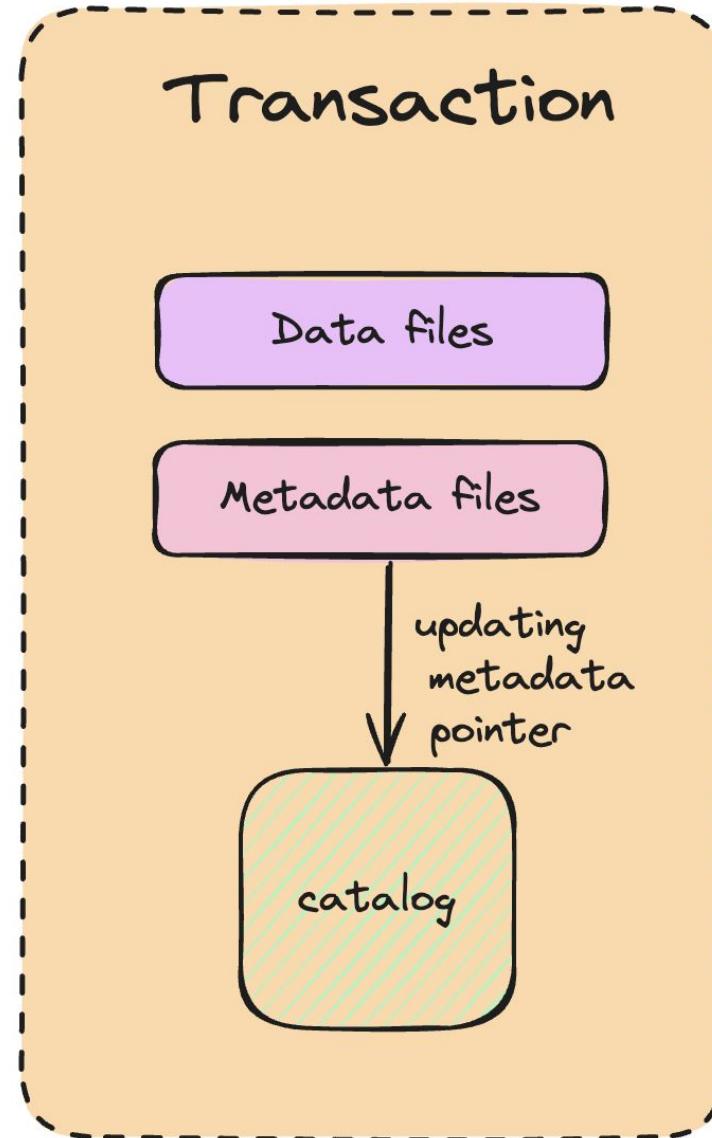
Why Iceberg?

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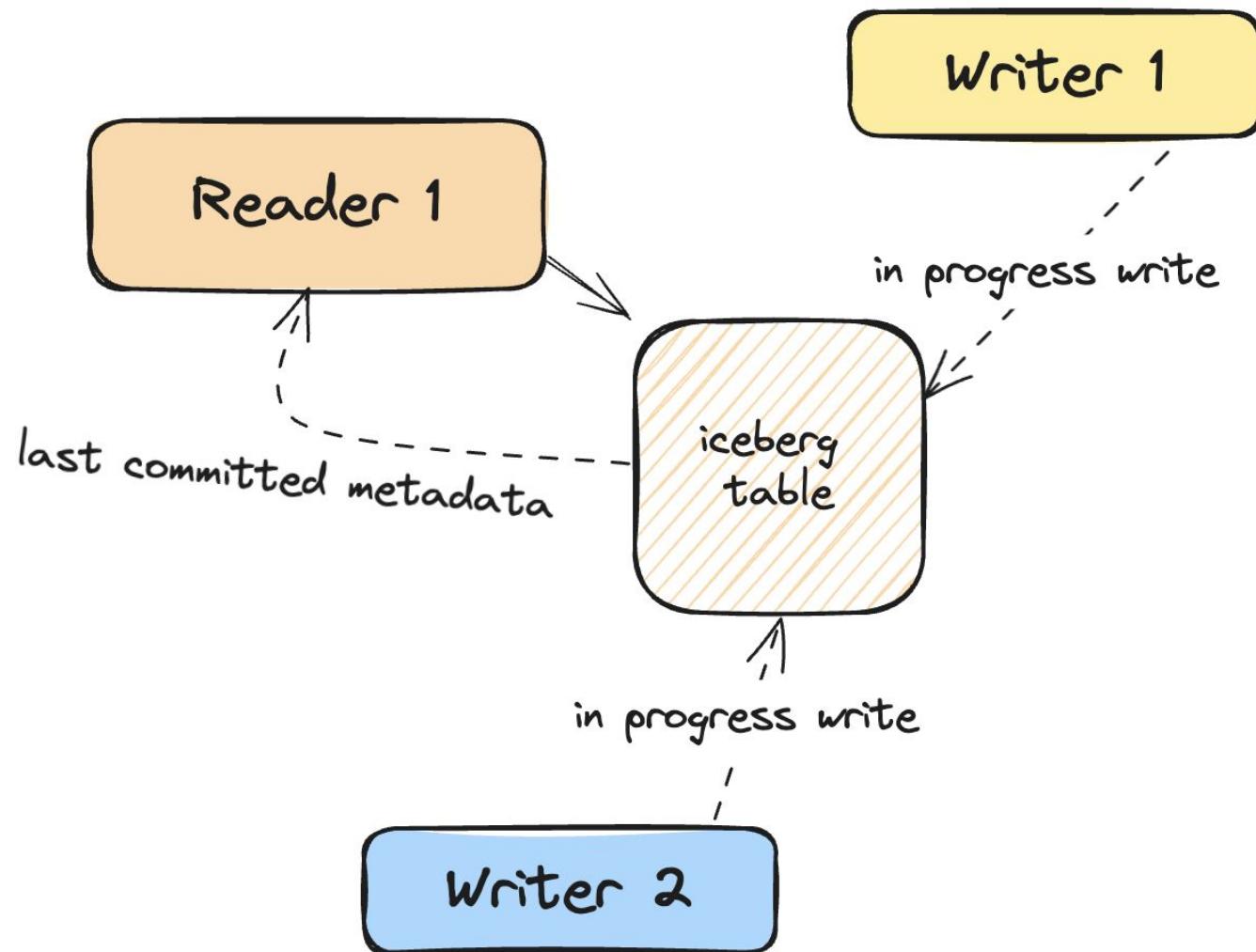
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ALL OR NOTHING



OPTIMISTIC CONCURRENCY ISOLATION



Schema Evolution

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Europython

SESSION_ID
SESSION_NAME
SESSION_TYPE

+ SESSION_DURATION



Europython

SESSION_ID
SESSION_NAME
SESSION_TYPE
SESSION_DURATION

Metadata Only!!

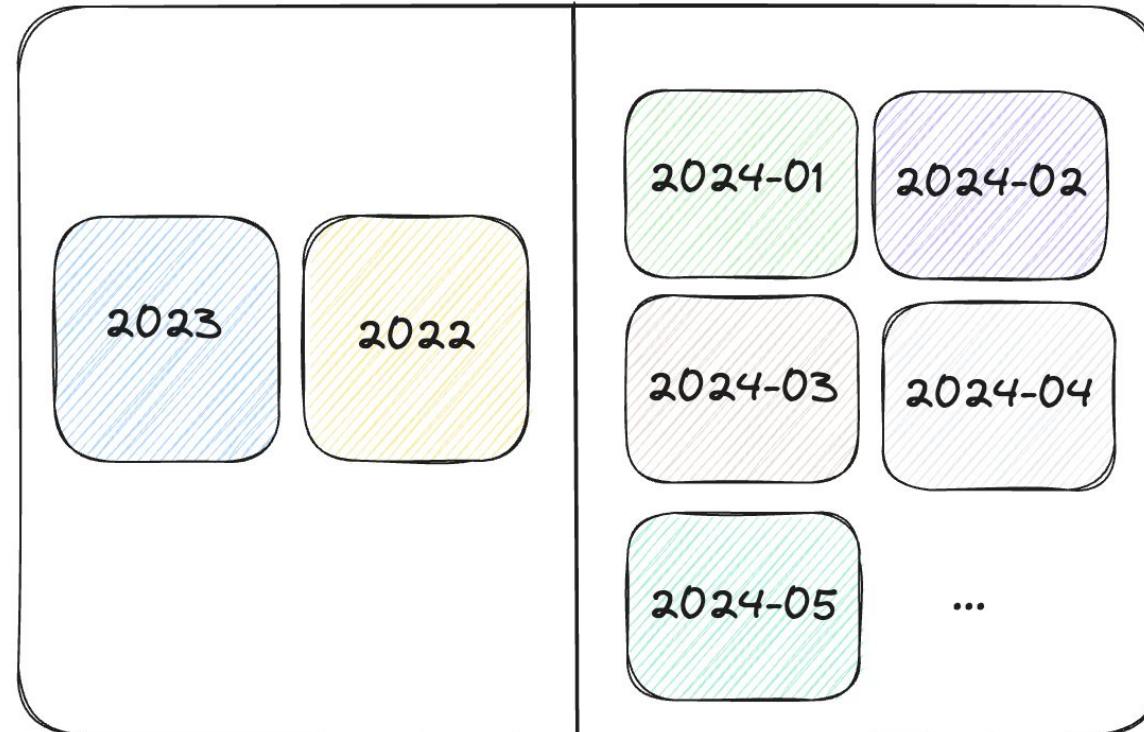
Partition Evolution

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PARTITIONED BY YEAR PARTITIONED BY MONTH

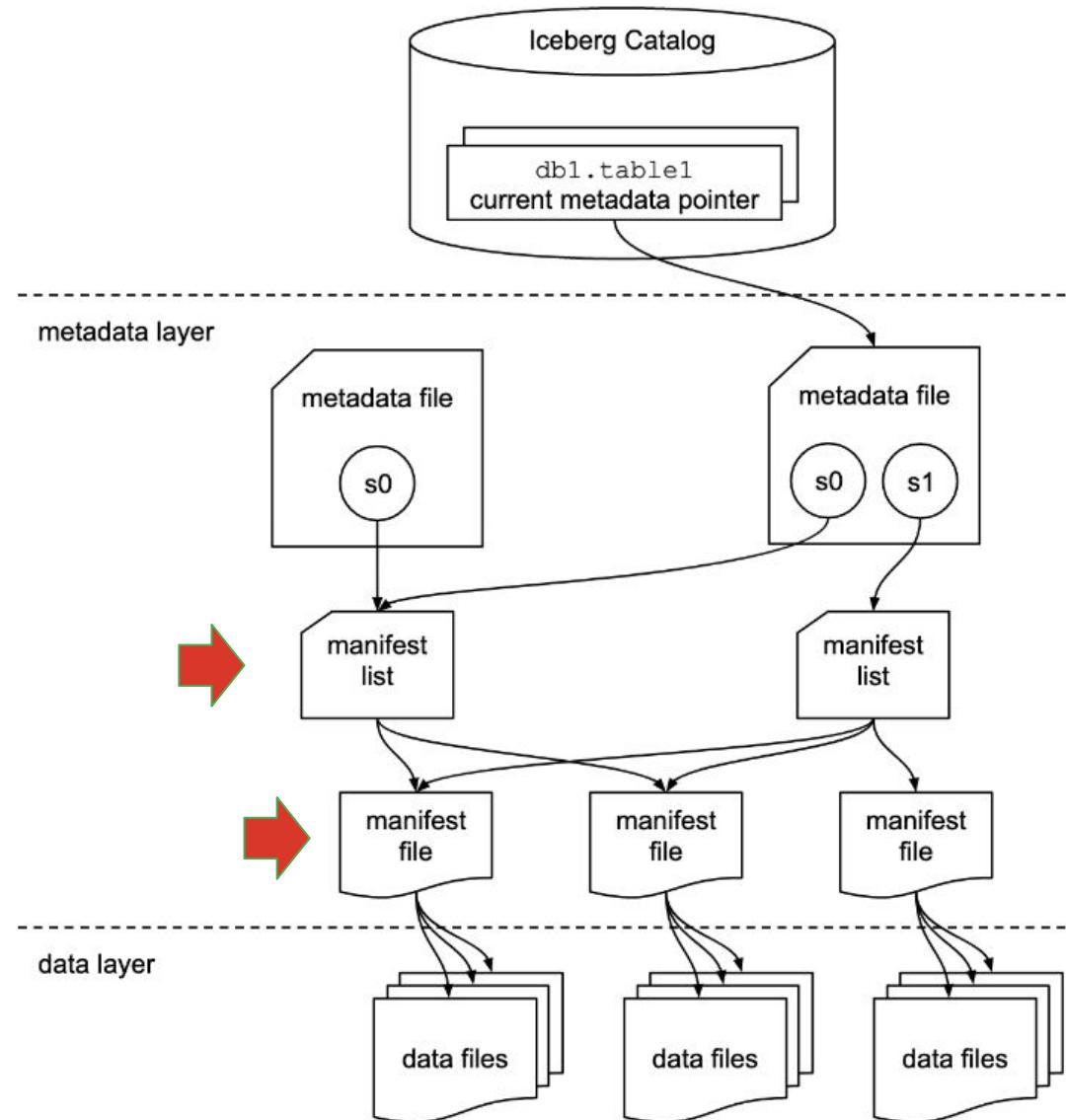


Query Planning

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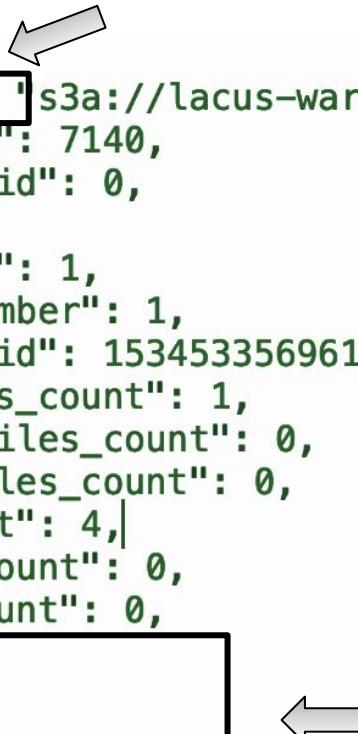


```
[{  
    "status": 1,  
    "snapshot_id": 1534533569610702800,  
    "data_file": {  
        "content": 0,  
        "file_path": "s3a://lacus-warehouse/test/europython/data/  
          SESSION_DATE_year=2024/00000-6-12d78028-5ec4-4080-8f1d-adace111c2a8-00001.parquet",  
        "file_format": "PARQUET",  
        "partition": {  
            "SESSION_DATE_year": 54  
        },  
        "record_count": 4,  
        "file_size_in_bytes": 1395,  
        "column_sizes": [...  
        ],  
        "value_counts": [...  
        ],  
        "null_value_counts": [...  
        ],  
        "nan_value_counts": [],  
        "lower_bounds": [...  
        ],  
        "upper_bounds": [...  
        ],  
        "split_offsets": [  
            4  
        ],  
        "sort_order_id": 0  
    }]  
}]
```

MANIFEST FILE

.AVRO

```
[{"manifest_path": "s3a://lacus-warehouse/test/europython/metadata/8261a1ce-3376-4126-a200-4dbd0e028690-m0.avro",  
 "manifest_length": 7140,  
 "partition_spec_id": 0,  
 "content": 0,  
 "sequence_number": 1,  
 "min_sequence_number": 1,  
 "added_snapshot_id": 1534533569610702800,  
 "added_data_files_count": 1,  
 "existing_data_files_count": 0,  
 "deleted_data_files_count": 0,  
 "added_rows_count": 4,  
 "existing_rows_count": 0,  
 "deleted_rows_count": 0,  
 "partitions": [  
     { ...  
     }  
 ]}]
```



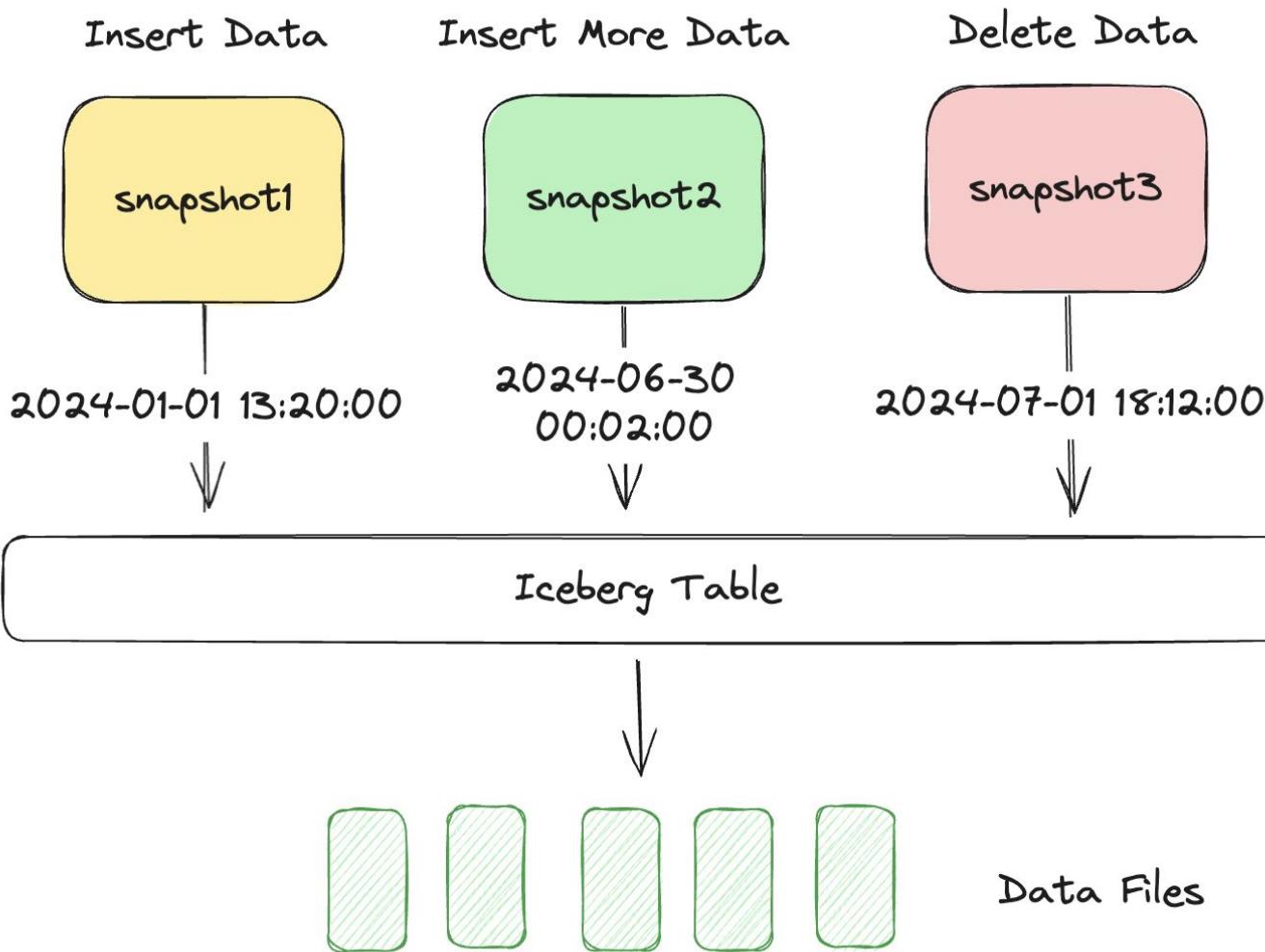
MANIFEST LIST .AVRO

Time Travel

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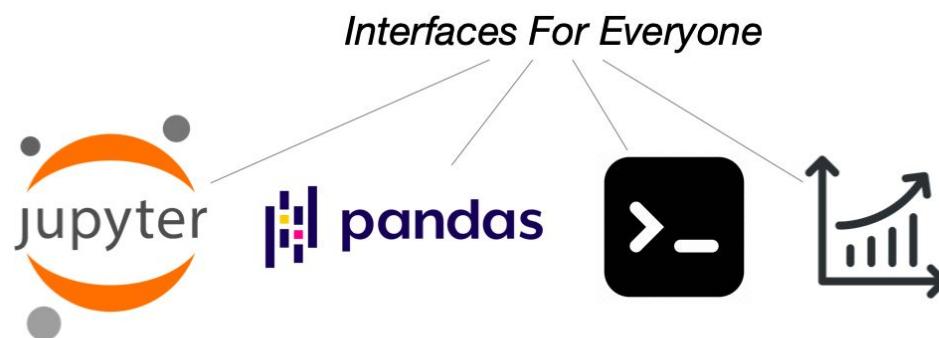
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```
SELECT * FROM TABLE  
WHERE VERSION AS OF  
SNAPSHOT1;
```

ANALYSIS



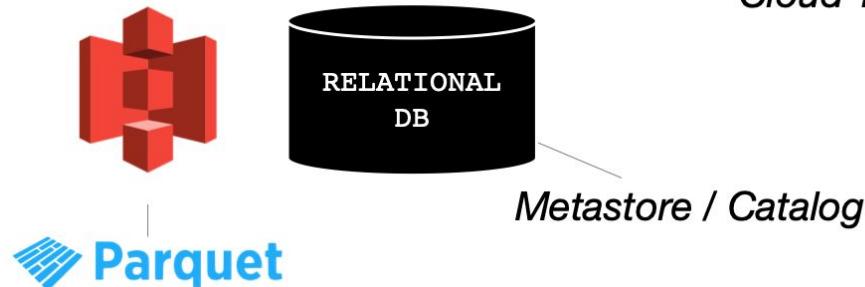
PROCESSING



FORMAT



STORAGE



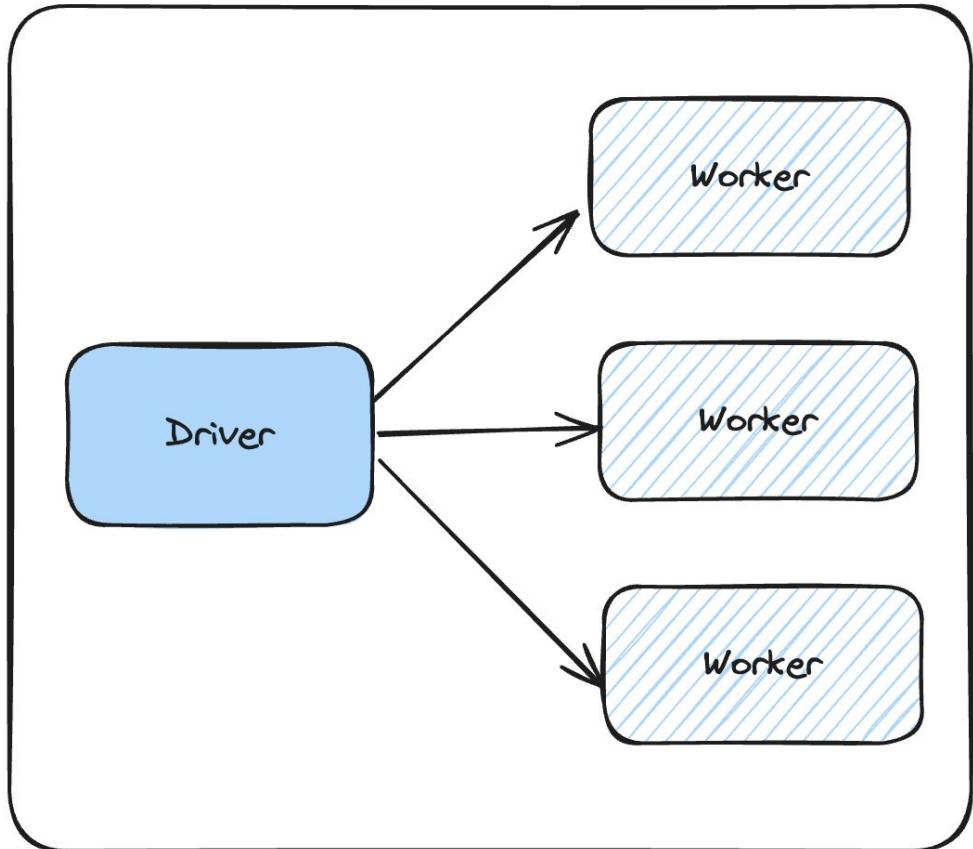
Using Python with Apache Iceberg

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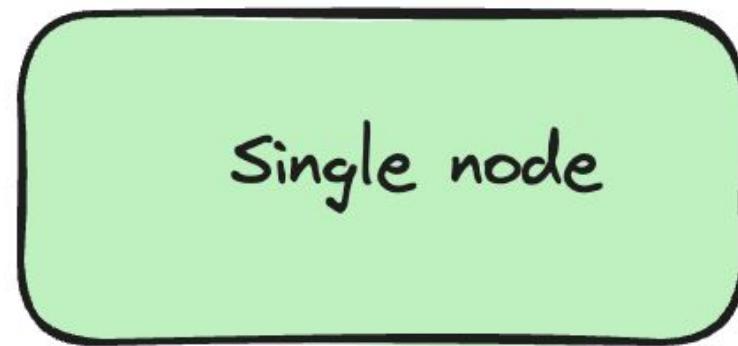
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#1: PySpark



#2: Pylceberg



PySpark

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```
JARS = [  
    "https://xxxxx/root-repos/org/apache/iceberg/iceberg-spark-runtime-3.5_X.XX/X.X.X/iceberg-spark-runtime-3.5_X.XX-X.X.X.jar"] ←  
  
spark = (  
    SparkSession.builder.config(  
        "spark.sql.extensions",  
        "org.apache.iceberg.spark.extensions.IcebergSparkSessionExtensions",  
    )  
.config("spark.sql.catalog.lacus", "org.apache.iceberg.spark.SparkCatalog") ←  
.config("spark.sql.catalog.lacus.warehouse", "s3a://data-warehouse") ←  
.config("spark.sql.catalog.lacus.catalog-impl", "org.apache.iceberg.jdbc.JdbcCatalog") ←  
.config("spark.sql.catalog.lacus.uri", "jdbc://mydb://localhost:3306/iceberg",)  
.config("spark.jars", ",".join(JARS)))  
spark = SparkSession.builder.getOrCreate()
```

```
spark.sql("""
```

catalog namespace table
↓ ↓ ↓

```
    CREATE TABLE IF NOT EXISTS lacus.test.europython USING iceberg  
    TBLPROPERTIES (  
        'format-version' = '2' ←  
    )  
    PARTITIONED BY (year(SESSION_DATE)) ←  
    AS SELECT * FROM df
```

```
""")
```

```
df.show()
```

Last executed at 2024-06-26 15:02:29 in 227ms

SESSION_ID	SESSION_NAME	SESSION_TYPE	SESSION_DATE
1	ICEBERG WALKTHROUGH	TUTORIAL	2024-07-08
2	KEY NOTE	ANNOUNCEMENTS	2024-07-09
3	PYICEBERG TALK (LONG SESSION)	(LONG SESSION)	2024-07-08
4	PYTEST	TALK	2024-07-09

```
spark.sql("""select * from lacus.test.europython""")
```

Last executed at 2024-06-27 16:58:01 in 4.53s

SESSION_ID	SESSION_NAME	SESSION_TYPE	SESSION_DATE
1	ICEBERG WALKTHROUGH	TUTORIAL	2024-07-08
2	KEY NOTE	ANNOUNCEMENTS	2024-07-09
3	PYICEBERG TALK (LONG SESSION)	(LONG SESSION)	2024-07-08
4	PYTEST	TALK	2024-07-09

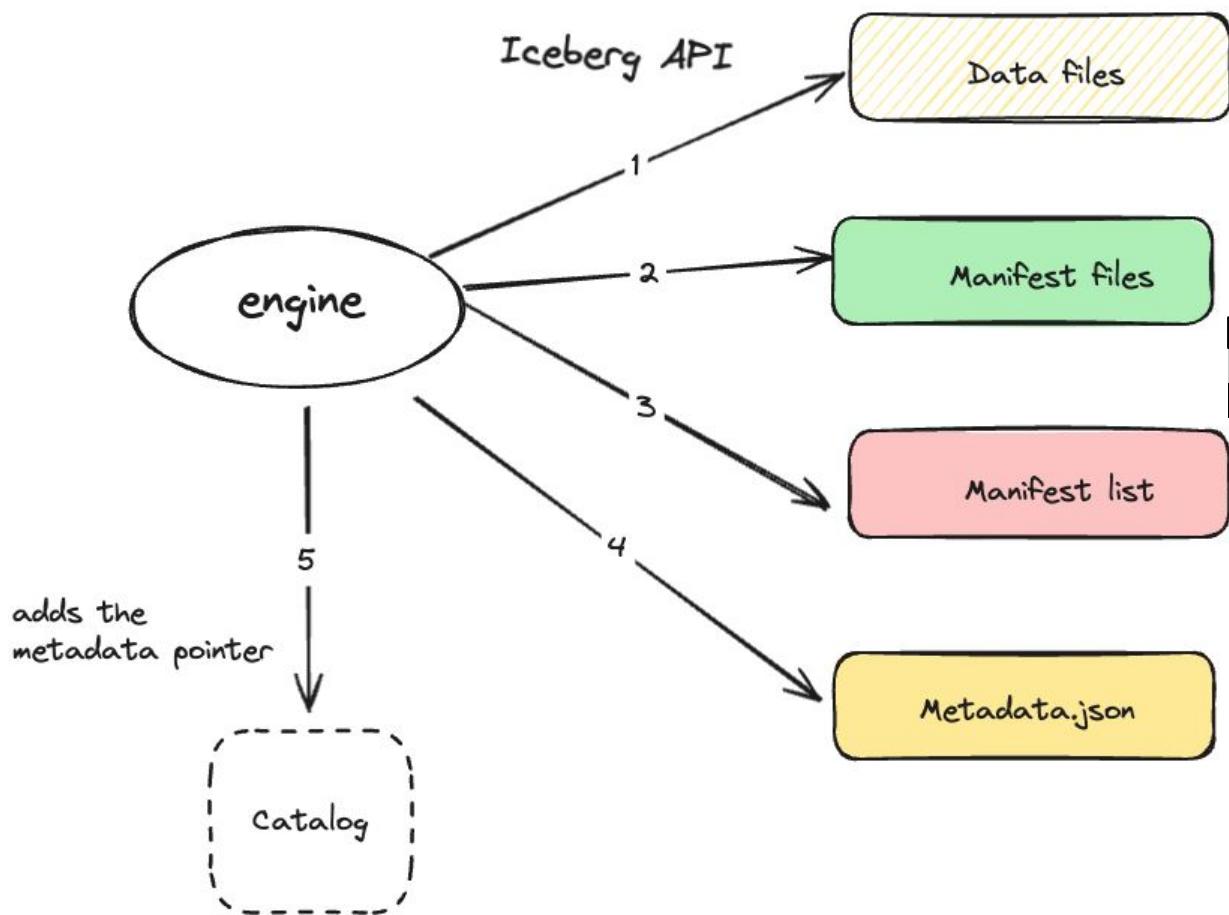
```
{"metadata-location": "s3a://lacus-warehouse/test/europython/metadata/0000-a1249670-2ddf-4734-8620-f3d6d6977c78.metadata.json", "metadata": {"location": "s3a://lacus-warehouse/test/europython", "table-uuid": "f0a46b3c-4be7-4394-891a-e131d919a249", "last-updated-ms": 1719428590109, "last-column-id": 4, "schemas": [{"type": "struct", "fields": [{"id": 1, "name": "SESSION_ID", "type": "int", "required": false}, {"id": 2, "name": "SESSION_NAME", "type": "string", "required": false}, {"id": 3, "name": "SESSION_TYPE", "type": "string", "required": false}, {"id": 4, "name": "SESSION_DATE", "type": "date", "required": false}], "schema-id": 0, "identifier-field-ids": []}, "current-schema-id": 0, "partition-specs": [{"spec-id": 0, "fields": [{"source-id": 4, "field-id": 1000, "transform": "year", "name": "SESSION_DATE_year"}]}], "default-spec-id": 0, "last-partition-id": 1000, "properties": {"owner": "job", "write.metadata.delete-after-commit.enabled": "true", "commit.manifest.target-size-bytes": "8388608", "write.metadata.metrics.default": "full", "write.parquet.compression-codec": "zstd"}, "current-snapshot-id": 1534533569610702955, "snapshots": [{"snapshot-id": 1534533569610702955, "sequence-number": 1, "timestamp-ms": 1719428590109, "manifest-list": "s3a://lacus-warehouse/test/europython/metadata/snap-1534533569610702955-1-8261a1ce-3376-4126-a200-4dbd0e028690.avro", "summary": {"operation": "append", "spark.app.id": "spark-application-1719426812731", "added-data-files": "1", "added-records": "4", "added-files-size": "1395", "changed-partition-count": "1", "total-records": "4", "total-files-size": "1395", "total-data-files": "1", "total-delete-files": "0", "total-position-deletes": "0", "total-equality-deletes": "0"}, "schema-id": 0}], "snapshot-log": [{"snapshot-id": 1534533569610702955, "timestamp-ms": 1719428590109}], "metadata-log": [], "sort-orders": [{"order-id": 0, "fields": []}], "default-sort-order-id": 0, "refs": {"main": {"snapshot-id": 1534533569610702955, "type": "branch"}}, "format-version": 2, "last-sequence-number": 1, "config": {}}
```

```
{  
    "metadata-location": "s3a://lacus-warehouse/test/europython/metadata/  
        00000-a1249670-2ddf-4734-8620-f3d6d6977c78.metadata.json",  
    "metadata": {  
        "location": "s3a://lacus-warehouse/test/europython",  
        "table-uuid": "f0a46b3c-4be7-4394-891a-e131d919a249",  
        "last-updated-ms": 1719428590109,  
        "last-column-id": 4,  
        "schemas": [...]  
    },  
    "current-schema-id": 0,  
    "partition-specs": [...]  
},  
    "default-spec-id": 0,  
    "last-partition-id": 1000,  
    "properties": {  
        "owner": "job",  
        "write.metadata.delete-after-commit.enabled": "true",  
        "commit.manifest.target-size-bytes": "8388608",  
        "write.metadata.metrics.default": "full",  
        "write.parquet.compression-codec": "zstd"  
    },  
    "current-snapshot-id": 1534533569610702800,  
    "snapshots": [...]  
},  
    "snapshot-log": [...]  
},  
    "metadata-log": [],  
    "sort-orders": [...]  
},  
    "default-sort-order-id": 0,  
    "refs": {...}  
},  
    "format-version": 2,  
    "last-sequence-number": 1  
},  
    "config": {}  
}
```

lacus-warehouse/test/europython -----

20.435Ki [#####] /metadata

1.362Ki [#] /data



```

lacus-warehouse/test/europython/data -----
1.362Ki [#####] /SESSION_DATE_year=2024
:lacus-warehouse/test/europython/data/SESSION_DATE_year=2024 -----
1.362Ki [#####] 00000-6-12d78028-5ec4-4080-8f1d-adace111c2a8-00001.parquet

lacus-warehouse/test/europython/metadata -----
6.973Ki [#####] 8261a1ce-3376-4126-a200-4dbd0e028690-m0.avro
4.170Ki [#####] snap-1534533569610702955-1-8261a1ce-3376-4126-a200-4dbd0e028690.avro

00000-a1249670-2ddf-4734-8620-f3d6d6977c78.metadata.json
snapshot_id - 1534533569610702955

```

```
-- status: integer (nullable = true)
-- snapshot_id: long (nullable = true)
-- sequence_number: long (nullable = true)
-- file_sequence_number: long (nullable = true)
-- data_file: struct (nullable = true)
  -- content: integer (nullable = true)
  -- file_path: string (nullable = true)
  -- file_format: string (nullable = true)
  -- partition: struct (nullable = true)
    -- SESSION_DATE_year: integer (nullable = true)
-- record_count: long (nullable = true)
-- file_size_in_bytes: long (nullable = true)
-- column_sizes: array (nullable = true)
  -- element: struct (containsNull = true)
    -- key: integer (nullable = true)
    -- value: long (nullable = true)
-- value_counts: array (nullable = true)
  -- element: struct (containsNull = true)
    -- key: integer (nullable = true)
    -- value: long (nullable = true)
-- null_value_counts: array (nullable = true)
  -- element: struct (containsNull = true)
    -- key: integer (nullable = true)
    -- value: long (nullable = true)
-- nan_value_counts: array (nullable = true)
  -- element: struct (containsNull = true)
    -- key: integer (nullable = true)
    -- value: long (nullable = true)
-- lower_bounds: array (nullable = true)
  -- element: struct (containsNull = true)
    -- key: integer (nullable = true)
    -- value: binary (nullable = true)
-- upper_bounds: array (nullable = true)
  -- element: struct (containsNull = true)
    -- key: integer (nullable = true)
    -- value: binary (nullable = true)
-- key_metadata: binary (nullable = true)
-- split_offsets: array (nullable = true)
  -- element: long (containsNull = true)
-- equality_ids: array (nullable = true)
  -- element: integer (containsNull = true)
-- sort_order_id: integer (nullable = true)
```

```
root
  -- manifest_path: string (nullable = true)
  -- manifest_length: long (nullable = true)
  -- partition_spec_id: integer (nullable = true)
  -- content: integer (nullable = true)
  -- sequence_number: long (nullable = true)
  -- min_sequence_number: long (nullable = true)
  -- added_snapshot_id: long (nullable = true)
  -- added_data_files_count: integer (nullable = true)
  -- existing_data_files_count: integer (nullable = true)
  -- deleted_data_files_count: integer (nullable = true)
  -- added_rows_count: long (nullable = true)
  -- existing_rows_count: long (nullable = true)
  -- deleted_rows_count: long (nullable = true)
  -- partitions: array (nullable = true)
    -- element: struct (containsNull = true)
      -- contains_null: boolean (nullable = true)
      -- contains_nan: boolean (nullable = true)
      -- lower_bound: binary (nullable = true)
      -- upper_bound: binary (nullable = true)
```

Schema evolution - metadata only!!!

```
spark.sql("ALTER TABLE lacus.test.europython ADD COLUMNS (SESSION_DURATION_MINS int)")
```

```
spark.sql("""select * from lacus.test.europython""")
```

Last executed at 2024-06-27 16:58:01 in 4.53s

SESSION_ID	SESSION_NAME	SESSION_TYPE	SESSION_DATE	SESSION_DURATION_MINS
1	ICEBERG WALKTHROUGH	TUTORIAL	2024-07-08	NULL
2	KEY NOTE	ANNOUNCEMENTS	2024-07-09	NULL
3	PYICEBERG TALK (LONG SESSION)	TALK	2024-07-08	NULL
4	PYTEST	TALK	2024-07-09	NULL



Updated Schema in metadata.json

```
"schemas": [{"type": "struct", "fields": [{"id": 1, "name": "SESSION_ID", "type": "int", "required": false}, {"id": 2, "name": "SESSION_NAME", "type": "string", "required": false}, {"id": 3, "name": "SESSION_TYPE", "type": "string", "required": false}, {"id": 4, "name": "SESSION_DATE", "type": "date", "required": false}], "schema-id": 0, "identifier-field-ids": []},  
  
{"type": "struct", "fields": [{"id": 1, "name": "SESSION_ID", "type": "int", "required": false}, {"id": 2, "name": "SESSION_NAME", "type": "string", "required": false}, {"id": 3, "name": "SESSION_TYPE", "type": "string", "required": false}, {"id": 4, "name": "SESSION_DATE", "type": "date", "required": false}, {"id": 5, "name": "SESSION_DURATION_MINS", "type": "int", "required": false}], "schema-id": 1, "identifier-field-ids": []}],  
  
"current-schema-id": 1
```



```
"schemas": [  
  {  
    "type": "struct",  
    "fields": [  
      {  
        "id": 1,  
        "name": "SESSION_ID",  
        "type": "int",  
        "required": false  
      },  
      {  
        "id": 2,  
        "name": "SESSION_NAME",  
        "type": "string",  
        "required": false  
      },  
      {  
        "id": 3,  
        "name": "SESSION_TYPE",  
        "type": "string",  
        "required": false  
      },  
      {  
        "id": 4,  
        "name": "SESSION_DATE",  
        "type": "date",  
        "required": false  
      }  
    ]  
  },  
  {  
    "type": "array",  
    "elementType": "string",  
    "size": 10  
  }  
]
```

```
spark.sql("SELECT SESSION_ID, SESSION_NAME FROM  
LACUS.TEST.EUROPYTHON;")
```

**Columns are selected from
data files using field IDs**

Pylceberg API

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```
>>> pip install "pyiceberg[sql-sqlite]"
```

```
1  from pyiceberg.catalog.sql import SqlCatalog
2
3  warehouse_path = "/tmp/warehouse"
4  catalog = SqlCatalog(
5      "default",
6      **{
7          "uri": f"sqlite:///{warehouse_path}/pyiceberg_catalog.db",
8          "warehouse": f"file://{warehouse_path}",
9      },
10 )
11 catalog.create_namespace("test")
```

```
>>> pip install pyarrow
```

```
import pyarrow.parquet as pq
data = pq.read_table("s3://test/insert_europython.parquet")
```

```
pyarrow.Table
```

```
SESSION_ID: int64
```

```
SESSION_NAME: string
```

```
SESSION_TYPE: string
```

```
SESSION_DATE: string
```

```
DURATION_MINS: int64
```

```
----
```

```
SESSION_ID: [[5, 6]]
```

```
SESSION_NAME: [[ "Airflow and Python", "Python modules in Rust" ]]
```

```
SESSION_TYPE: [[ "TALK", "TALK" ]]
```

```
SESSION_DATE: [[ "2023-07-07", "2023-07-08" ]]
```

```
DURATION_MINS: [[30, 45]]
```

```
tbl = catalog.create_table("test.europython_pyiceberg", schema=data.schema)
tbl.append(data)
```

```
/tmp/warehouse/  
/tmp/warehouse//pyiceberg_catalog.db  
/tmp/warehouse//test.db  
/tmp/warehouse//test.db/europython_pyiceberg  
/tmp/warehouse//test.db/europython_pyiceberg/data  
/tmp/warehouse//test.db/europython_pyiceberg/data/00000-0-ee45bb2f-6c80-4272-a2e9-0dc45a826b  
1c.parquet  
/tmp/warehouse//test.db/europython_pyiceberg/metadata  
/tmp/warehouse//test.db/europython_pyiceberg/metadata/00001-384de88c-d052-4148-9e43-d77a4630  
3de1.metadata.json  
/tmp/warehouse//test.db/europython_pyiceberg/metadata/e95cd1f9-5fc6-4535-991c-ee90212ba3a2-m  
0.avro  
/tmp/warehouse//test.db/europython_pyiceberg/metadata/00000-356f91ad-6777-409f-a4fb-0f052f31  
fa1f.metadata.json  
/tmp/warehouse//test.db/europython_pyiceberg/metadata/snap-1181746681384757451-0-e95cd1f9-5f  
c6-4535-991c-ee90212ba3a2.avro
```

```
from pyiceberg.expressions import GreaterThanOrEqual

scan = tbl.scan(
    row_filter=GreaterThanOrEqual("DURATION_MINS", 35),
    selected_fields=("SESSION_NAME", "SESSION_DATE"),
    limit=10,
)

file_paths = [task.file.file_path for task in scan.plan_files()]

['file:///tmp/warehouse/test.db/europython_pyiceberg/data/00000-0-ee45bb
2f-6c80-4272-a2e9-0dc45a826b1c.parquet']
```

```
scan.to_arrow()  
scan.to_pandas()
```

pyarrow.Table

SESSION_NAME: string

SESSION_DATE: string

SESSION_NAME: [["Python modules in Rust"]]

SESSION_DATE: [["2023-07-08"]]

Pylceberg 0.7.0

The main objective of 0.7.0 is to have partitioned writes (non-exhaustive list :)

- Support for merge-into / upsert: [Merge into / Upsert #402](#)
 - Support partitioned appends: [Support Appends with TimeTransform Partitions #784](#)
 - Support partial deletes: [Support partial deletes #569](#)
- Support for parallelizing writes: [Parallel Table.append #428](#) [Faster ingestion from Parquet #346](#)
 - Support parallelized writes: [Bin-pack Writes Operation into multiple parquet files, and parallelize writing WriteTasks #444](#)
- Support `table_exists` on catalog: [check if table exist #406](#) [Add `table_exists` method to the Catalog #507](#), fixed in [Add `table_exists` method to Catalog #512](#)
- Metadata tables:
 - Files assigned to [@Gowthami03B](#), PR in [Add Files metadata table #614](#)
 - Snapshots assigned to [@Fokko](#) in [Add Snapshots table metadata #524](#)
 - History assigned to [@ndrluis](#) in [Add history inspect table #828](#)
 - Metadata log entries [@kevinjqliu](#) (issue in [feat request\] Add `metadata_log_entries` metadata table #594](#)):
 - [Metadata Log Entries metadata table #667](#)
 - Manifests [@geruh](#): PR in [Add manifests metadata table #717](#)
 - Partitions assigned to [@syun64](#) (issue in [Support get partition table with filter #24](#)): [Add Partitions Metadata Table #603](#)
 - References assigned to [@geruh](#) in [Add Refs metadata table #602](#)
 - Entries assigned to [@Fokko](#) in [Add entries metadata table #551](#)
- Manifest read/write improvements:
 - Implement rolling writes: [Implement rolling manifest-writers #596](#) [feat: add RollingManifestWriter #650](#)
 - Caching of manifests: [Implement caching of manifest-files #595](#)
- Incremental append scan: [Incremental Append Scan #533](#)

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Contributions to the Pylceberg community

Support partitioned writes #208

[Open](#) [4 tasks](#) Fokko opened this issue on Dec 12, 2023 · 26 comments

apache / iceberg-python

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add_files support partitioned tables #531

Merged Fokko merged 5 commits into apache:main from syun64:add-files-partitioned on Mar 21

Conversation 20 Commits 5 Checks 7 Files changed 6

syun64 commented on Mar 18 · edited

As a follow up to #506, this PR introduces the support for adding files as DataFiles to partitioned tables.

allow override env-variables in load_catalog #45

Merged Fokko merged 2 commits into apache:main from bdilday:bf-config-rhs-override on Oct 13, 2023

Conversation 3 Commits 2 Checks 6 Files changed 4

bdilday commented on Oct 6, 2023

Partitioned Append on Identity Transform #555

Merged Fokko merged 20 commits into apache:main from jquin61:identity-partitioned-append on Apr 5

Conversation 42 Commits 20 Checks 7 Files changed 11

jquin61 commented on Mar 28 · edited

Change Append/Overwrite API to accept snapshot properties #419

Merged Fokko merged 13 commits into apache:main from Gowthami03B:snapshot-properties on Mar 19

Conversation 15 Commits 13 Checks 7 Files changed 3

Gowthami03B commented on Feb 12

No description provided.

Retry with new Access Token on 419 response #340

Merged Fokko merged 10 commits into apache:main from anupam-saini:as-token-refresh on Feb 20

Conversation 6 Commits 10 Checks 6 Files changed 4

anupam-saini commented on Jan 31

Closes #234

- Attempts to retry 2 more times if the initial call fails.
- The retry is only triggered for AuthorizationExpiredError response.

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