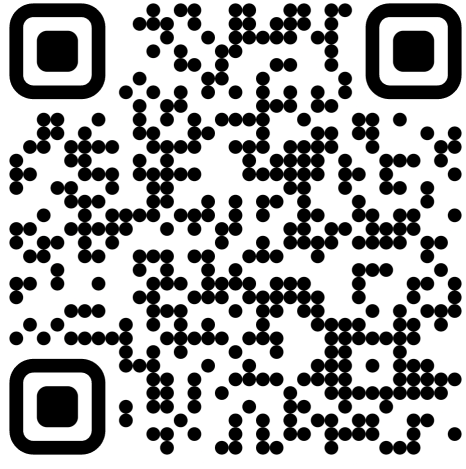
Optimizing Apache HoraeDB for High-Cardinality Metrics at AntGroup



Jiacai Liu（刘家财）

Senior Engineer @ Ant Group

Community Over Code NA, October 2024

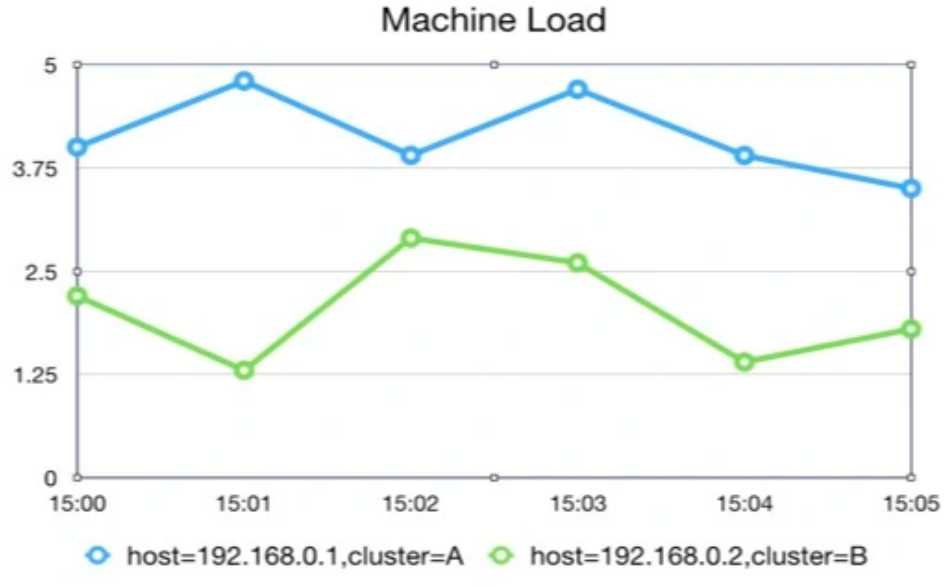
About ME

- Senior Engineer @ Ant Group
- Apache HoraeDB PPMC Member
- Programming language enthusiast
  - Rust: 70K loc
  - Zig: 10K loc
- Misc
  - Emacser since 2016
  - Podcast(Chinese): RustTalk, EmacsTalk
  - github.com/jiacai2050

Agenda

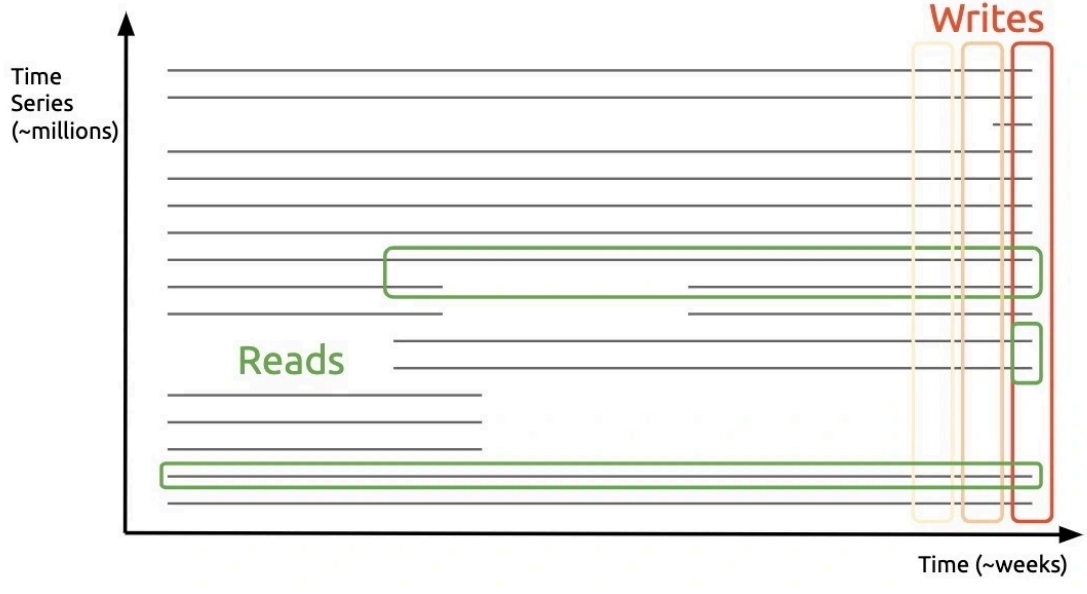
1. What's time series
2. What's Apache HoraeDB
    1. Core design
3. Write path optimization
4. Query path optimization
5. Looking Forward

1. What's time series



- A collection of time-based data points that can be connected into (time) lines.
- Use tags to differentiate between lines

Characteristics



- Vertical writes, horizontal(-ish) reads

Scenarios

- IoT
- APM (Application Performance Monitoring)
- Weather Forecasting
- Stock Market Analysis

Time series database

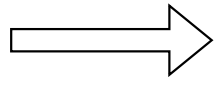
Specialized database that efficiently stores and retrieves time-stamped data

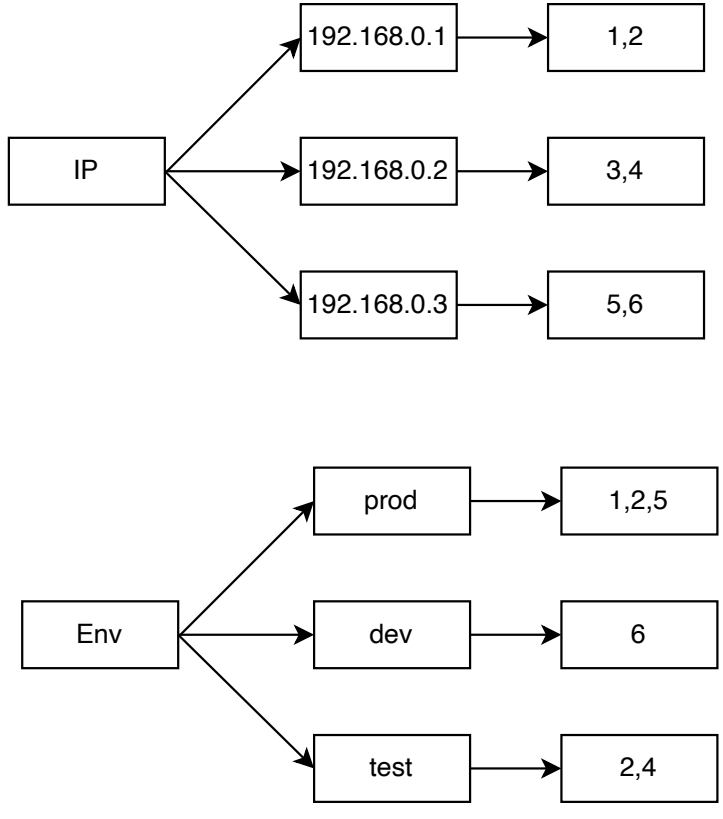
- Prometheus
- InfluxDB
- TimescaleDB
- Apache HoraeDB
- ……

Challenge

- High write throughput
- High-Cardinality tags, lead to BIG index
- Real-time OLAP like query pattern

TSID	Time	IP	Env	Value
1	10:00	192.168.0.1	prod	50.1
2	10:00	192.168.0.1	test	10.2
3	10:00	192.168.0.2	prod	29.5
4	10:00	192.168.0.2	test	4.5
5	10:00	192.168.0.3	prod	43.1
6	10:00	192.168.0.3	dev	20.2





Inverted Index

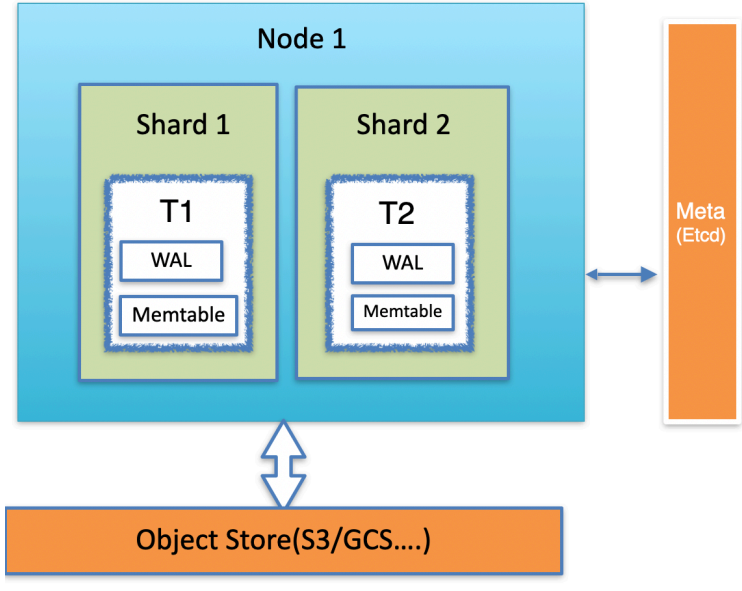
2. What's Apache HoraeDB

Distributed, cloud native time-series database

2.1. Core design

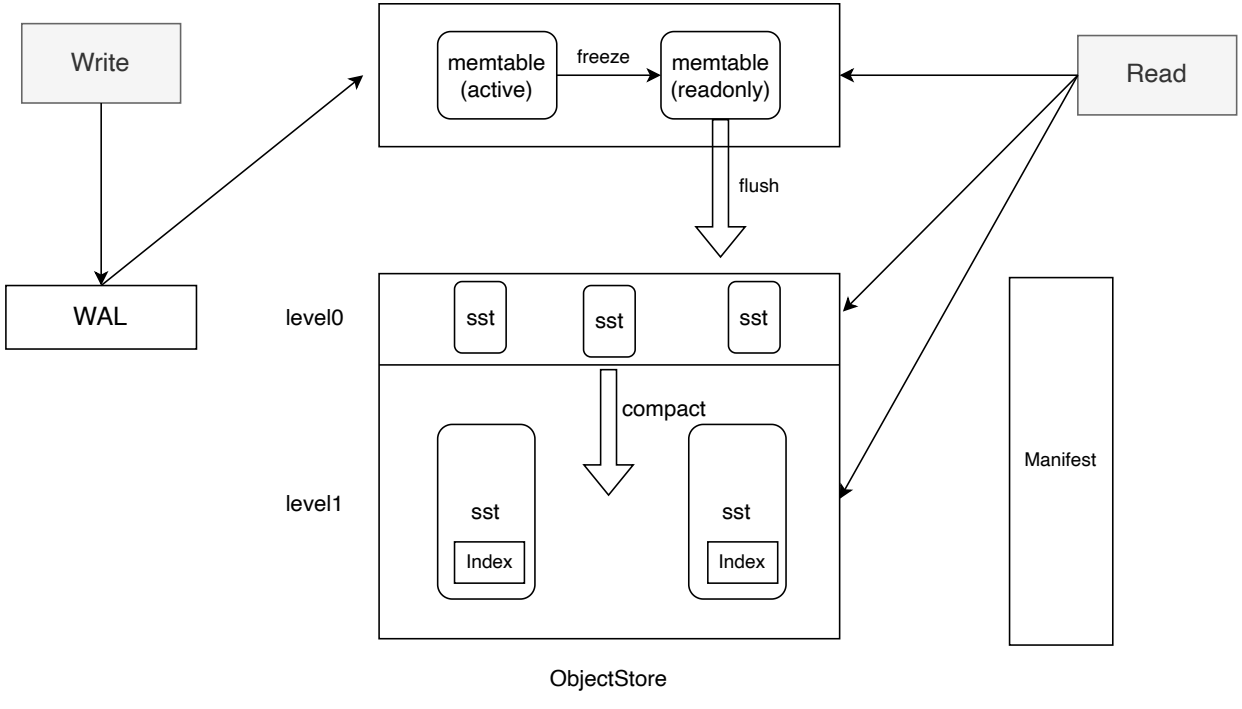
- Separating compute from storage with object storage
- FDAP stack
- BRIN(Block range index)
    - Min/Max Index
    - Xor Filters(faster, smaller than bloom filter)

Storage-Compute Separation



- Table data are distributed in shards(also known as tablets)
- Each node has N shards
- Mapping of table/shard/node are stored in horaemeta

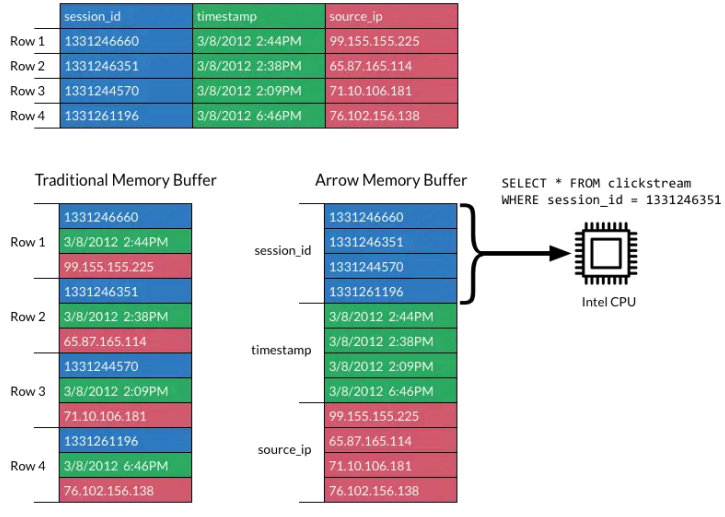
LSM-like engine



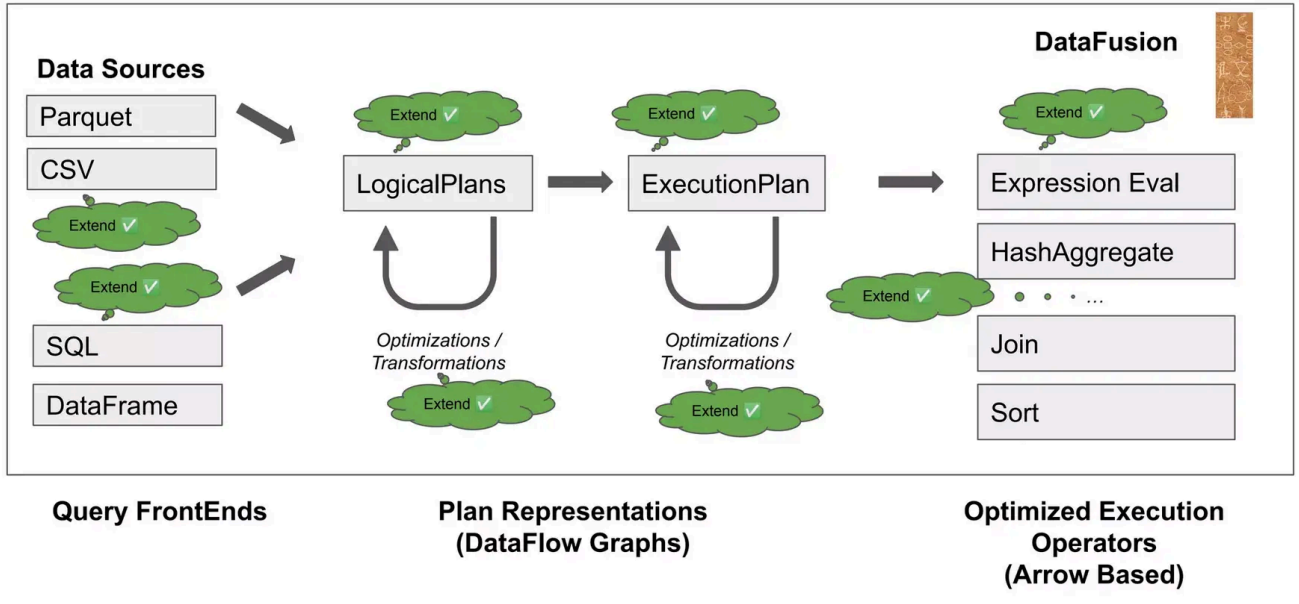
FDAP stack

- (Arrow) Flight, RPC framework based on Arrow data
- DataFusion, Query engine
- Arrow, Memory format
- Parquet, Storage format

How it works for time series



Arrow: columnar memory format for flat and hierarchical data



DataFusion: LLVM-like Infrastructure for Databases

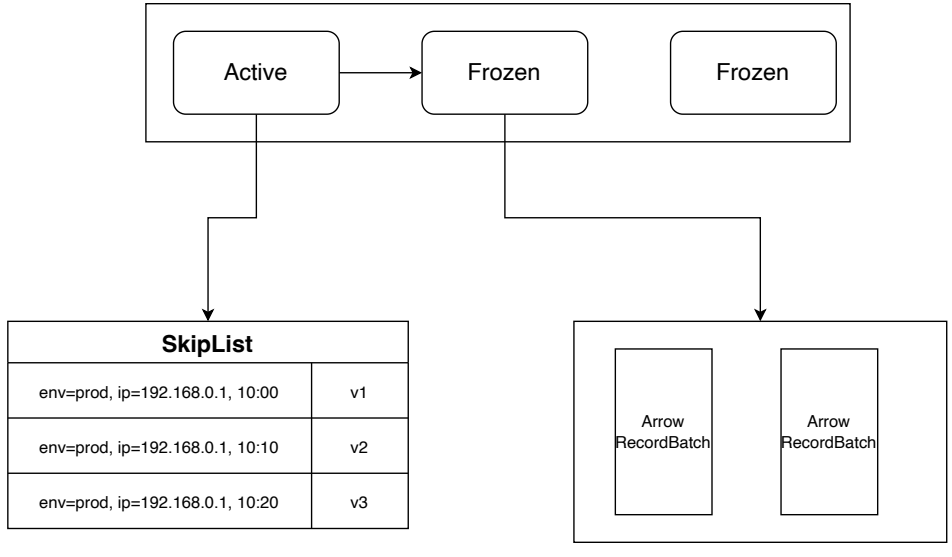
3. Write path optimization

- Metrics are sharded with partitioned table
  - Hash
  - Range
  - Round-robin
- Reduce IO as possible as we can
  - Group commit for WAL
  - Skip building the index for recently-written metrics

4. Query path optimization

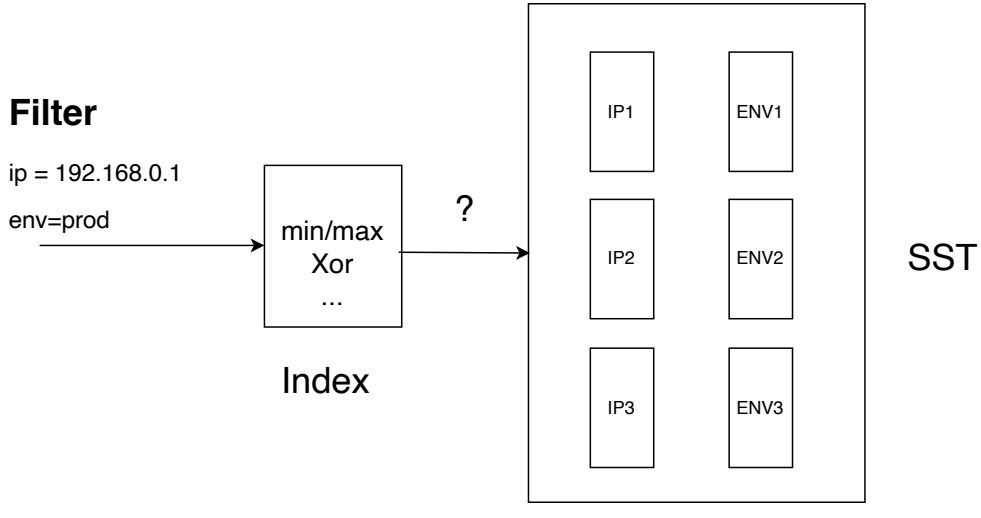
- Reduced IO without inverted index
  - Memtable
  - SST
- Distributed query
  - Partitioned table routing
  - Distributed execution

Reduced IO – Memtable

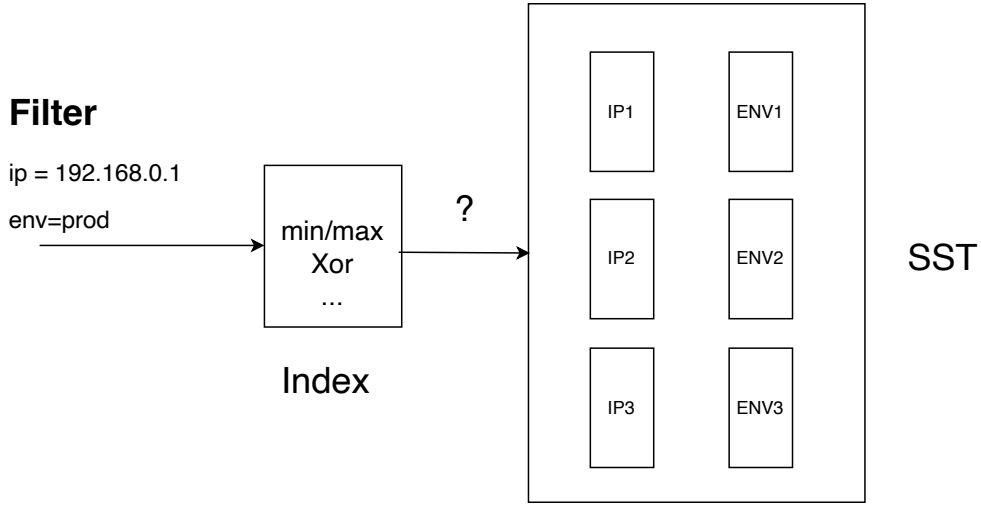


- Active: Write optimized
- Frozen: Read optimized

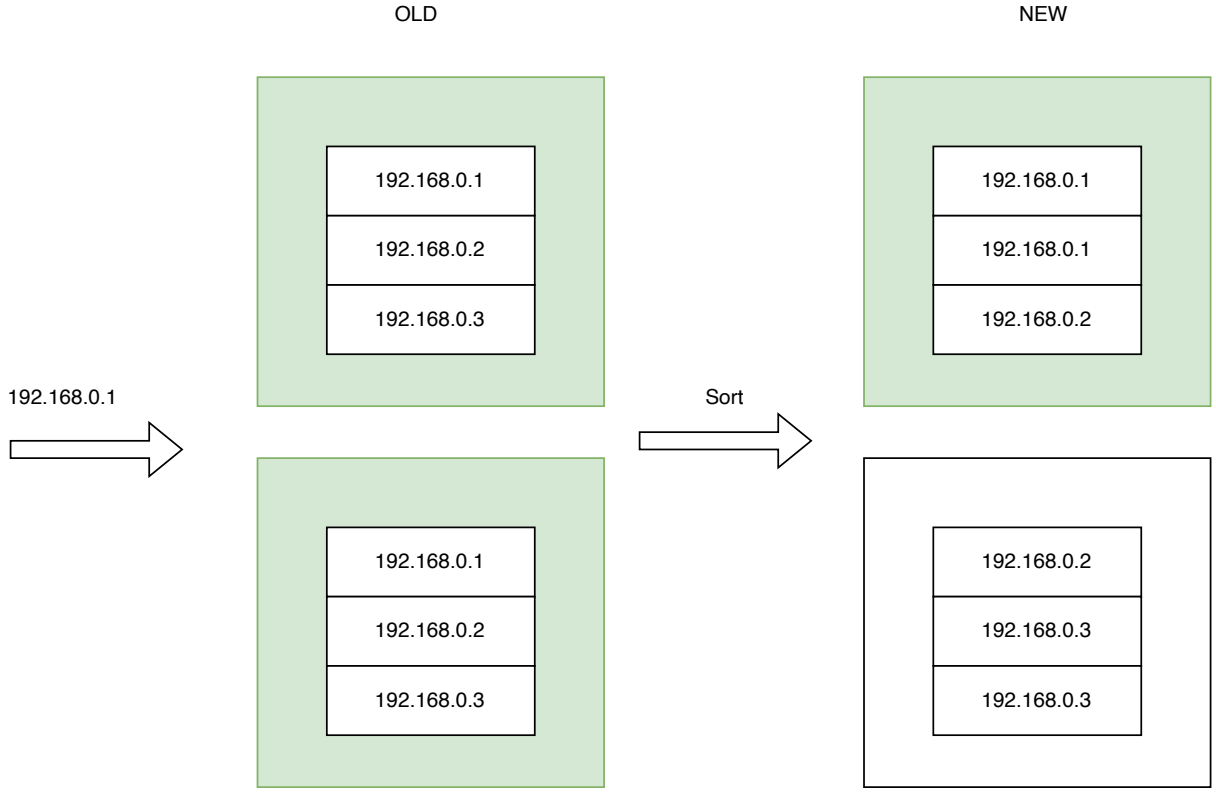
Reduced IO – SST



Reduced IO – SST

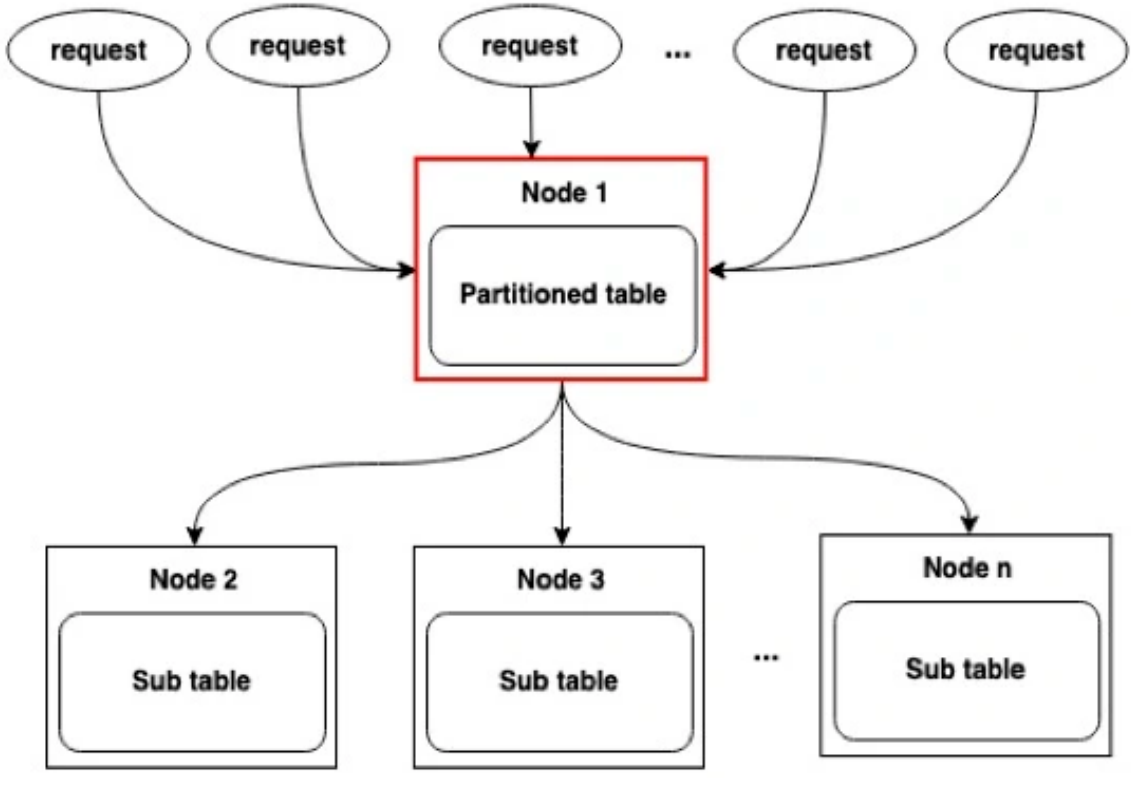


Order is important!

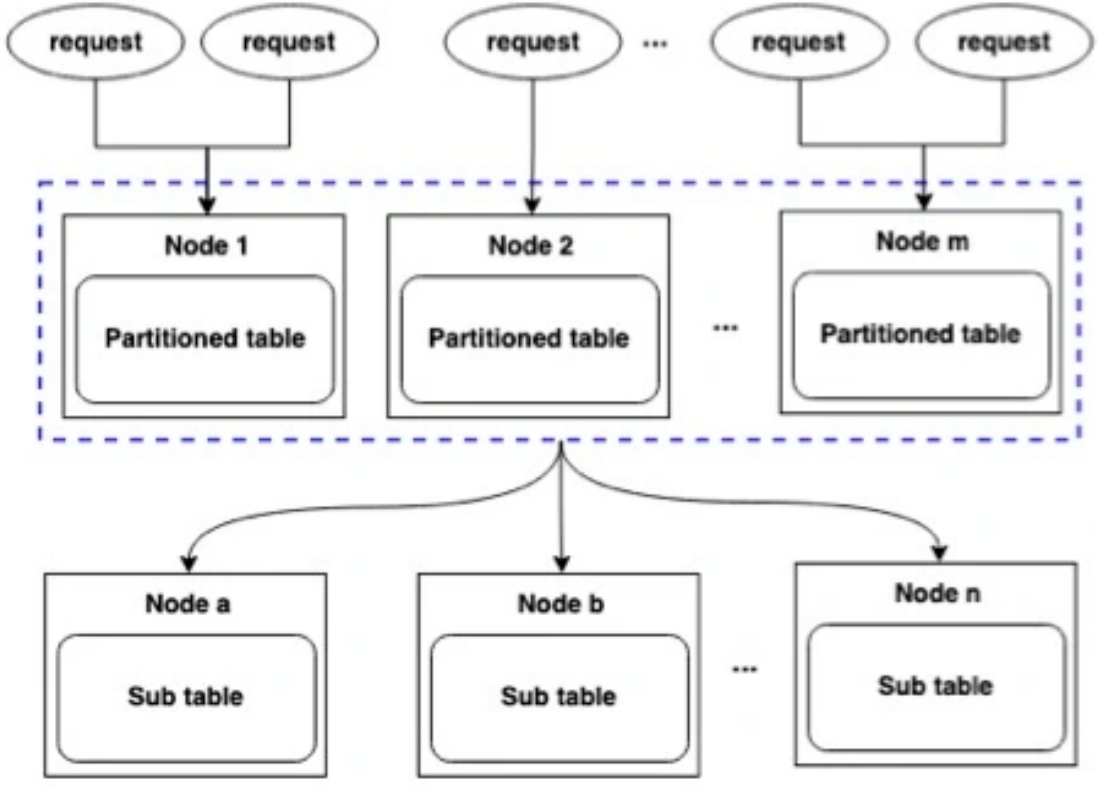


Automatic clustering based on history queries

Distributed



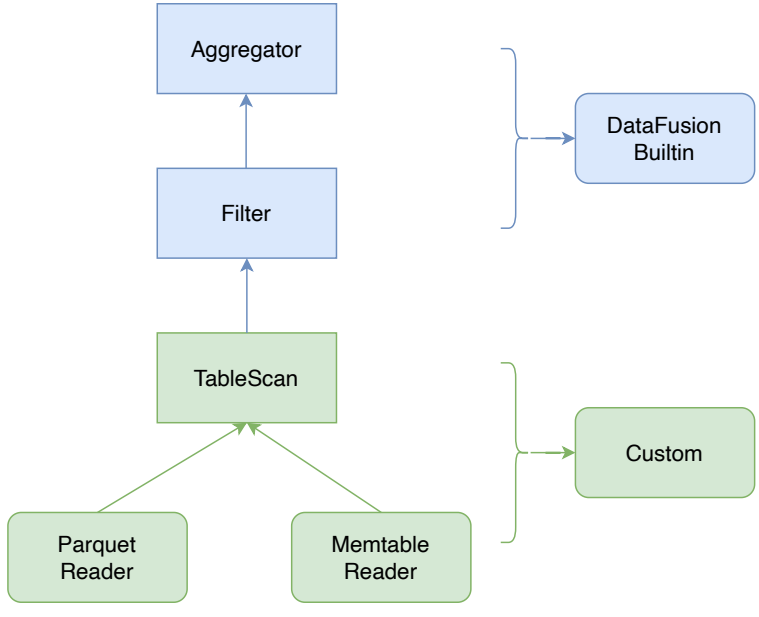
Open as a "normal" table (single point hotspot)



Open as a "virtual" table

Aggregation Pushdown

```
SELECT
    time_bucket(`timestamp`, '5 min') AS `timestamp`,
    SUM(`value`) AS `value_sum`
FROM
    `table`
WHERE
    `timestamp` >= '2023-12-15 07:17:00'
    AND `timestamp` < '2023-12-14 08:17:00'
    AND ((`col2` IN ('T')))
GROUP BY
    time_bucket (`timestamp`, '5 min')
```



Simplified physical plan

```
pub enum AggregateMode {
    /// Partial aggregate that can be applied in parallel across input part
    Partial,
    /// Final aggregate that produces a single partition of output
    Final,
    ....
}
```

AggregateMode

```
ProjectionExec:
 AggregateExec: mode=FinalPartitioned, gby=[..], aggr=[SUM(value)],
  CoalesceBatchesExec:
   RepartitionExec:
     AggregateExec: mode=Partial, gby=[..], aggr=[SUM(value)]
       ProjectionExec:
         ScanTable: table=my_table, filters=[..]
```

Pushdown

5. Looking Forward

- Build inverted index based on query histories
- Teach query engine aware of data distribution patterns(TSID)
- Release more ASF-compliant versions, growing community

Thanks

- https://horaedb.apache.org
- https://github.com/apache/horaedb