Magical Mystery Tour:

A Roundup of Observability Datastores

Josh Lee • Altinity • Texas Linux Fest • Oct. 4, 2025

"A Developer will never ask you, 'Hey, what filesystem is that?'"

— Patrick McFadin

Josh Lee

Open Source Advocate

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FUEL TRANSFER IN
FLIGHT PROHIBITED
PROPELLER
FEATHERING BUTTONS
HEATER CONTROL PANEL
PRESSURIZATION CONTROL PANEL
GENERATOR LOAD PANEL


HYDRAULIC
PRESSURIZATION
VENTILATION

Observability = Visibility + Understanding

50x

Observability data vs system data

What are we storing?

Metrics, Traces, Logs
Labels/Tags
Resource Metadata
Graphs & Topologies
Snapshots & Deltas
Configuration (e.g. alerts, users, dashboards)

What do we need for observability?

Fast streaming writes
Fast multi-row analytics
Full-text search
Tag/label search

"Anything you can do with a group by, that's what analytics is"

—Peter Marshall

More Requirements

Efficient compression & storage
Time-oriented management
Fast, frequent "last point" reads
Updates?

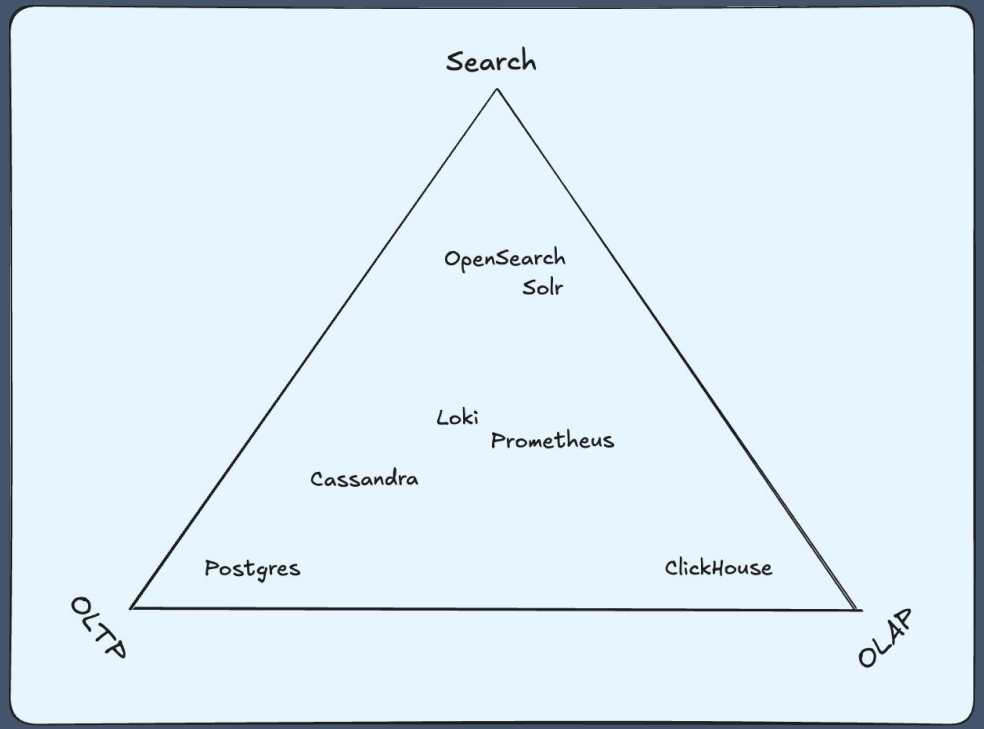
Database Archetypes

OLTP
OLAP
TSDB
Search/Analytics

Introducing the cast of characters

Postgres (OLTP)
Cassandra (OLTP)
OpenSearch (Search & Analytics)
Prometheus (TSDB)
ClickHouse (OLAP)

Taxonomies are challenging



Storage on disk

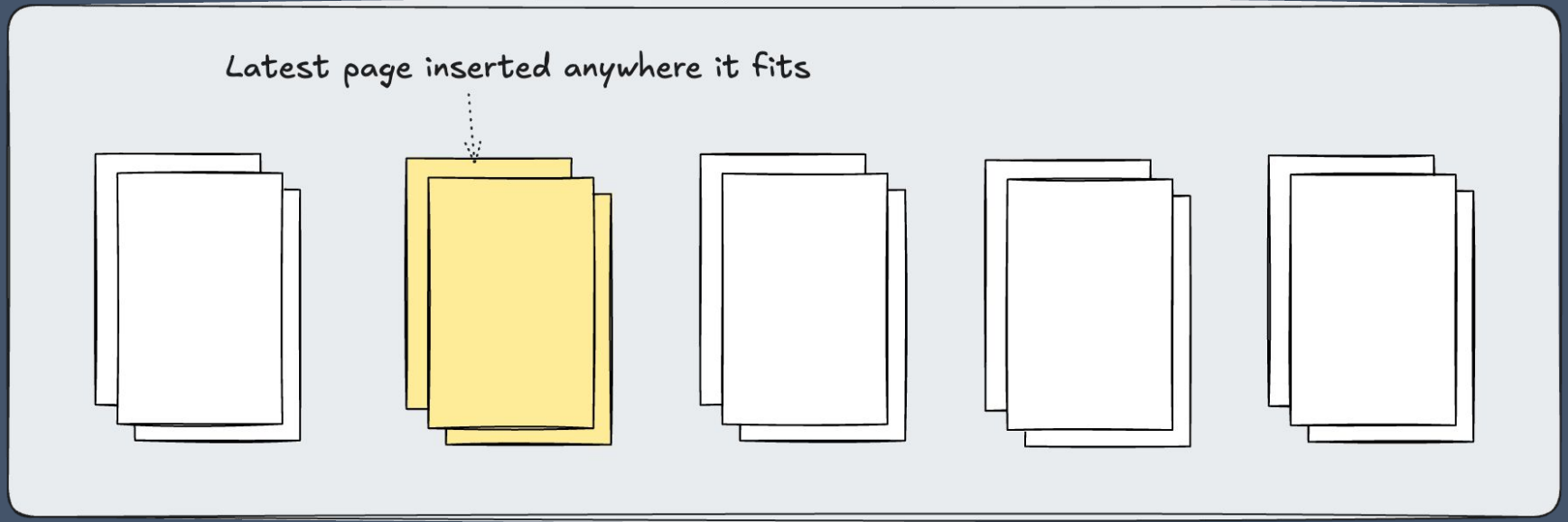
Database Storage Styles

Heap Pages + Commit Log
Time-series Blocks
Parts / Segments

Heap Pages

* the JBOD of storage styles

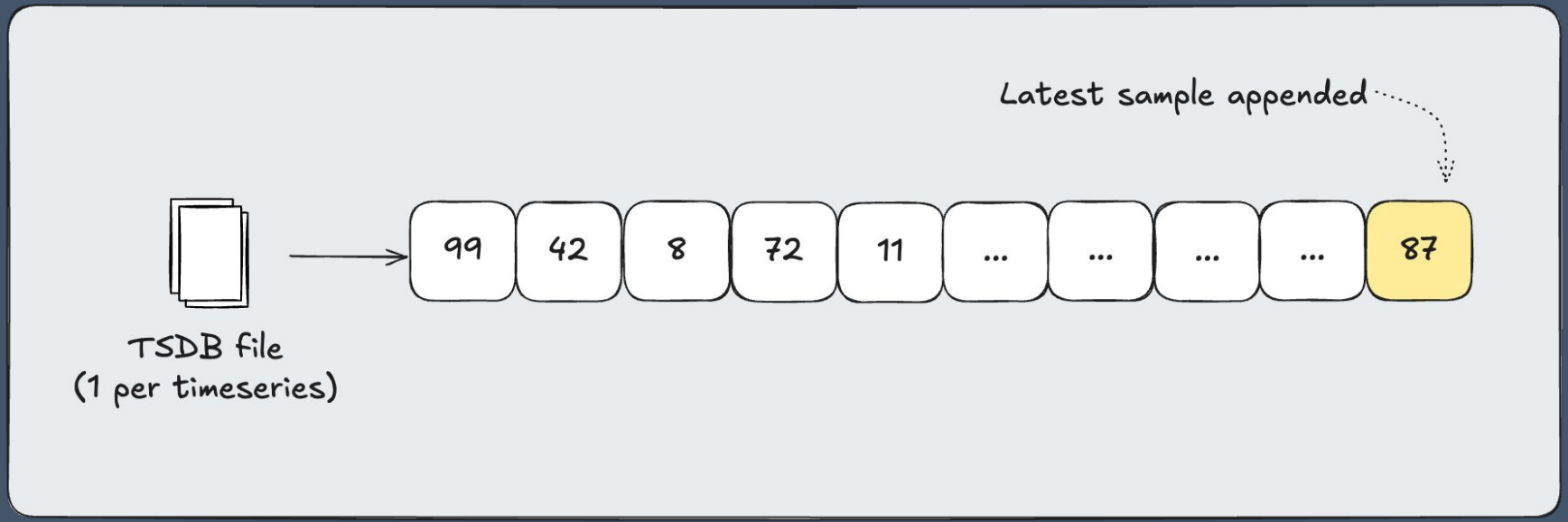
Heap Pages



TSDB Blocks

Append-only

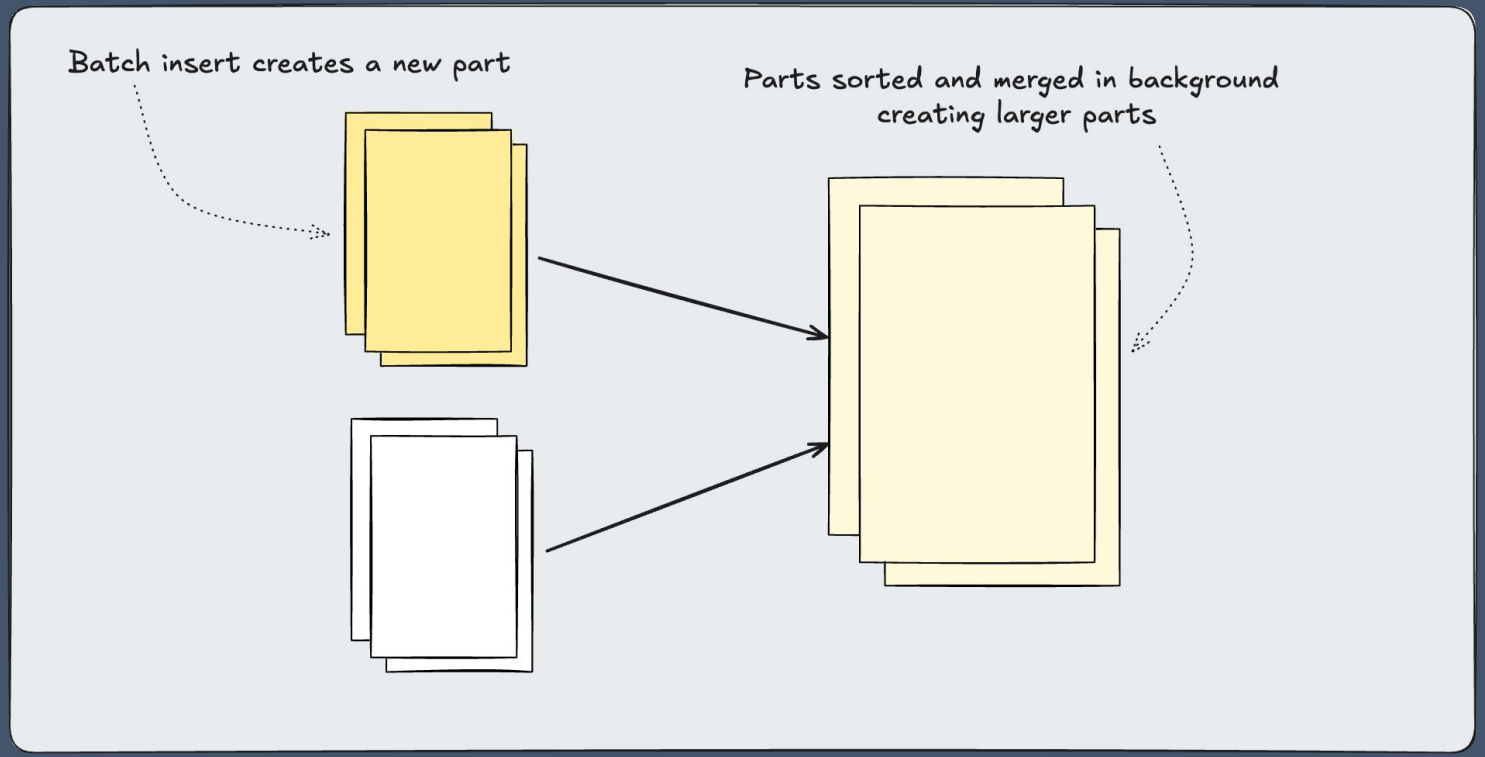
TSDB Blocks


Latest sample appended
99
42
8
72
11
...
...
...
...
87
TSDB file
(1 per timeseries)

Immutable Parts / Segments

w/ Background Compaction

Immutable Parts / Segments



Writing Data

Write Ahead Log (WAL) / Commit Log

Buffered, unordered writes stored on disk

Concurrency Control Strategies

- MVCC + Vacuum
- "Tombstone" deletes
- Last-write wins

Balanced Trees (B-Trees)

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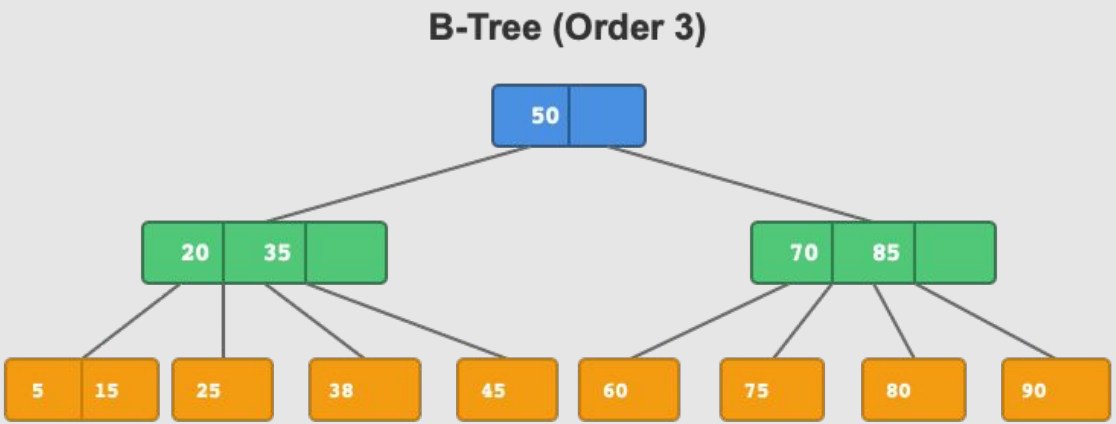


Legend:

- Root Node
- Internal Nodes
- Leaf Nodes

Key Properties:

- All leaf nodes at the same level
- Each node has max 2 keys (order 3)
- Keys in sorted order within nodes
- Self-balancing structure

Now we can build a Postgres

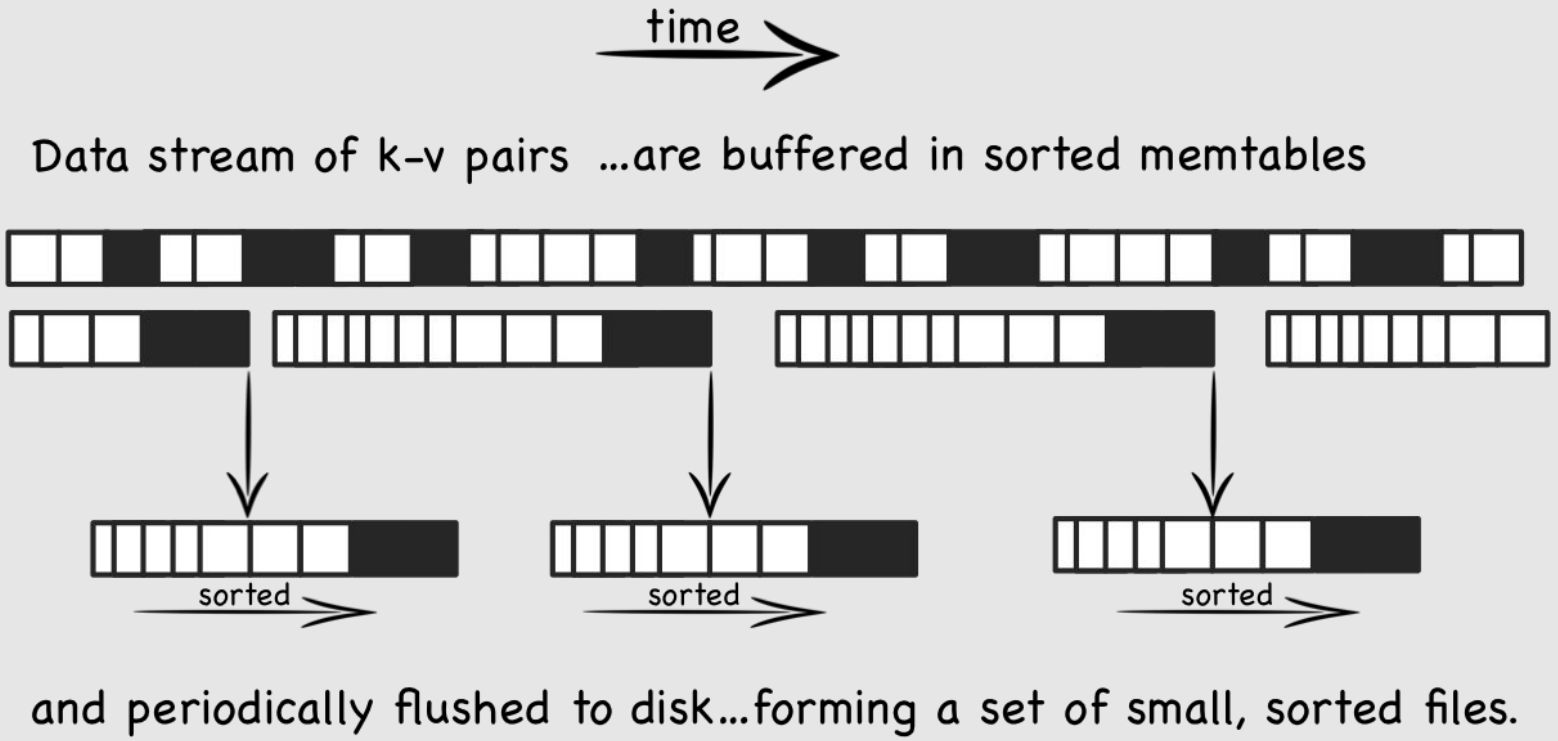
WAL
Heap Pages + MVCC
B-Tree Indexes

Postgres

Optimized for updates/upserts and row-level reads
Strong ACID guarantees
Scaling horizontally is challenging

Analytics & Search Architecture

Log-Structured Merge Tree



http://www.benstopford.com/2015/02/14/log-structured-merge-trees/

Lucene Family:

Cassandra, Elastic/OpenSearch, Apache Solr

A Lucene Query

```
(title:"database systems" OR content:(postgres OR "clickhouse"))
AND timestamp:[2025-01-01 TO 2025-12-31]
AND NOT tags:deprecated
```

Cassandra

Wide-event Scalable OLTP

Vector Engines & Search

Inverted Indexes

Bloom Filters

Approximate Nearest Neighbor (ANN Graph)

Inverted Indexes

```
"cat" → [doc1, doc3, doc7]
"dog" → [doc2, doc5]
"parrot" → [doc1, doc4]
```

Bloom Filters

Call me maybe

Bloom Filters

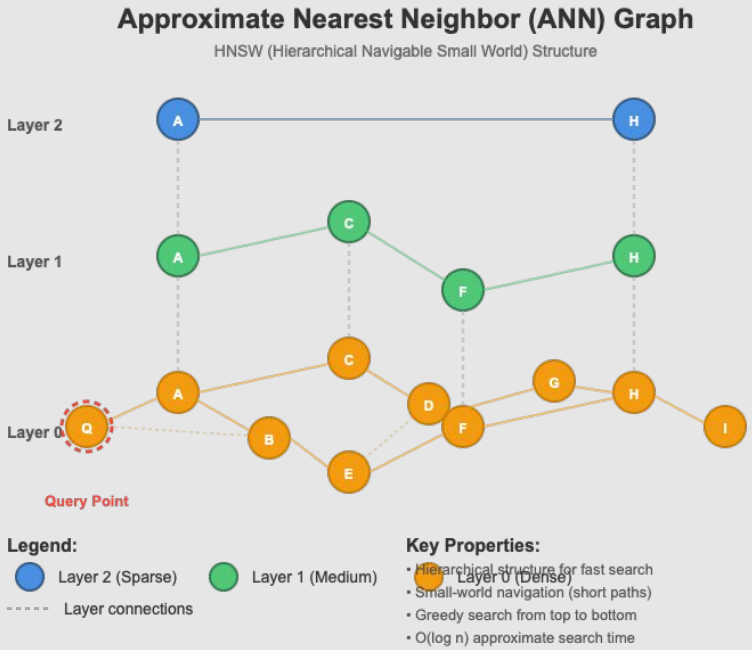
No false negatives

Sparse Indexes

Great for finding parts based on time

Approximate Nearest Neighbor (ANN)

A way to organize and filter vectors

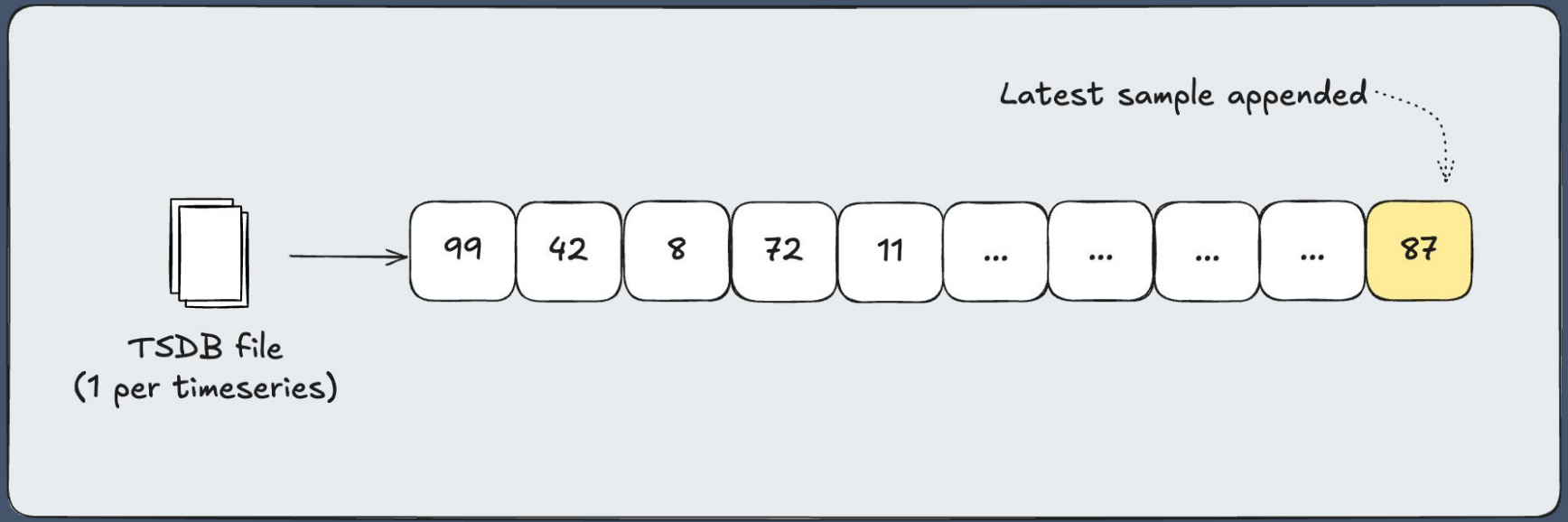


Prometheus (& friends)

Time-series Database

TSDB: Data is naturally ordered by time

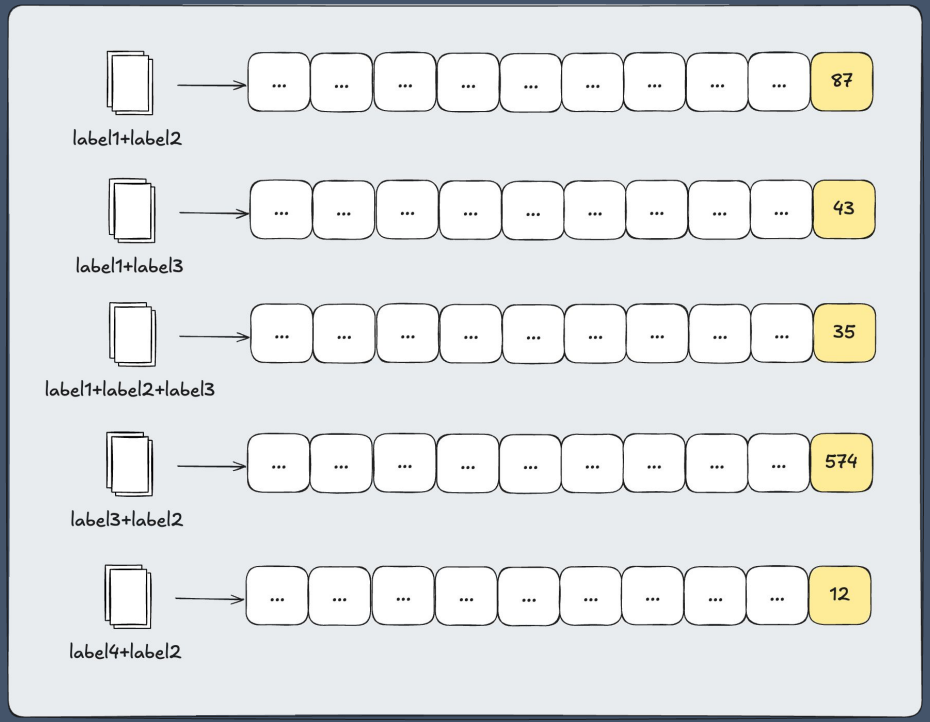
Excellent for frequent reads of last-sample



TSDB

No. of time series = cardinality^dimensionality

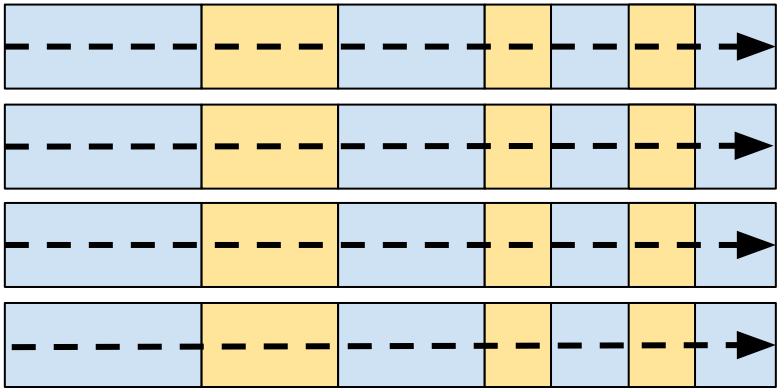
Cardinality Explosions



Row-oriented vs column-oriented storage

Row-oriented Storage

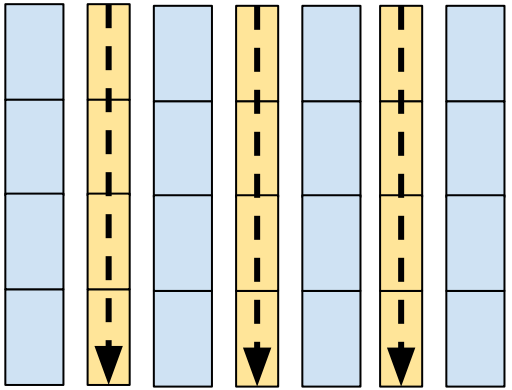
Read all columns in row



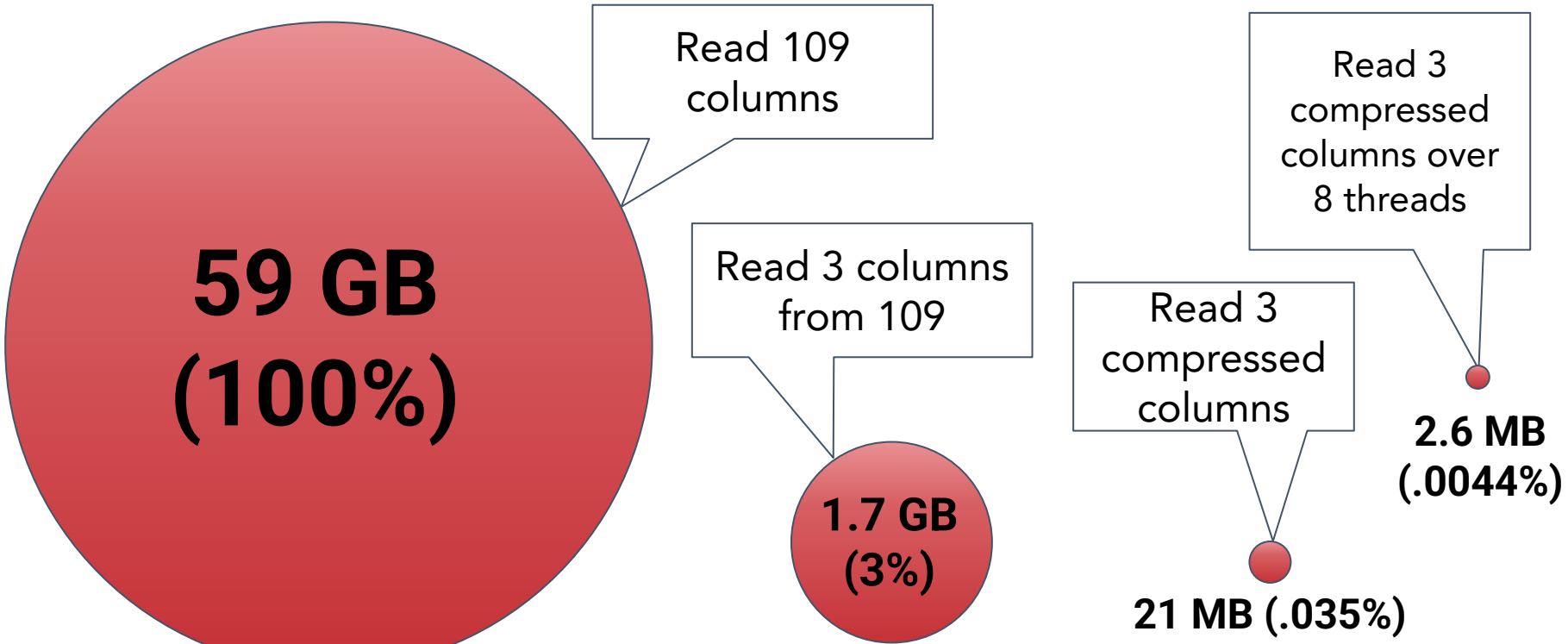
Rows compressed minimally or not at all

Column-oriented

Read only selected columns

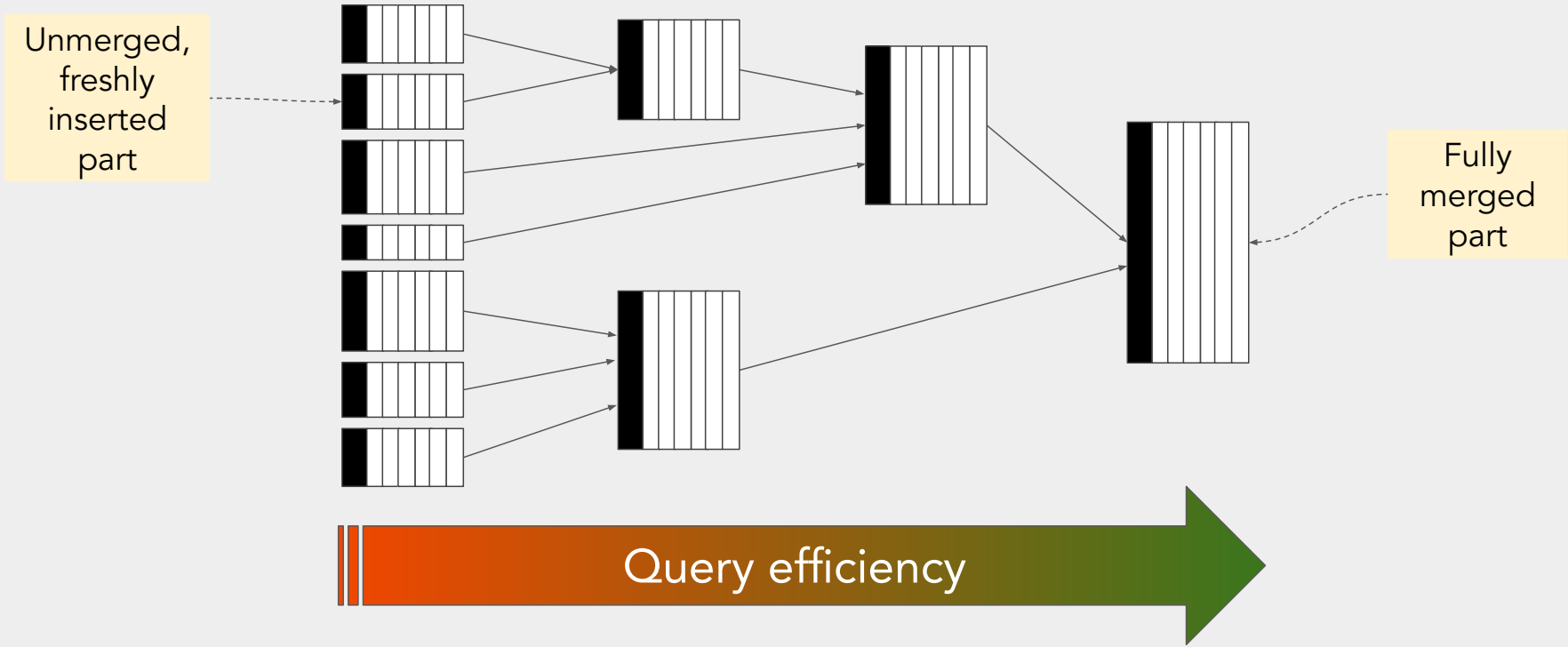


Columns highly compressed


59 GB
(100%)
Read 109
columns
Read 3 columns
from 109
1.7 GB
(3%)
Read 3
compressed
columns
21 MB (.035%)
Read 3
compressed
columns over
8 threads
2.6 MB
(.0044%)

ClickHouse

Column-oriented MergeTree


Unmerged, freshly inserted part
Fully merged part
Query efficiency

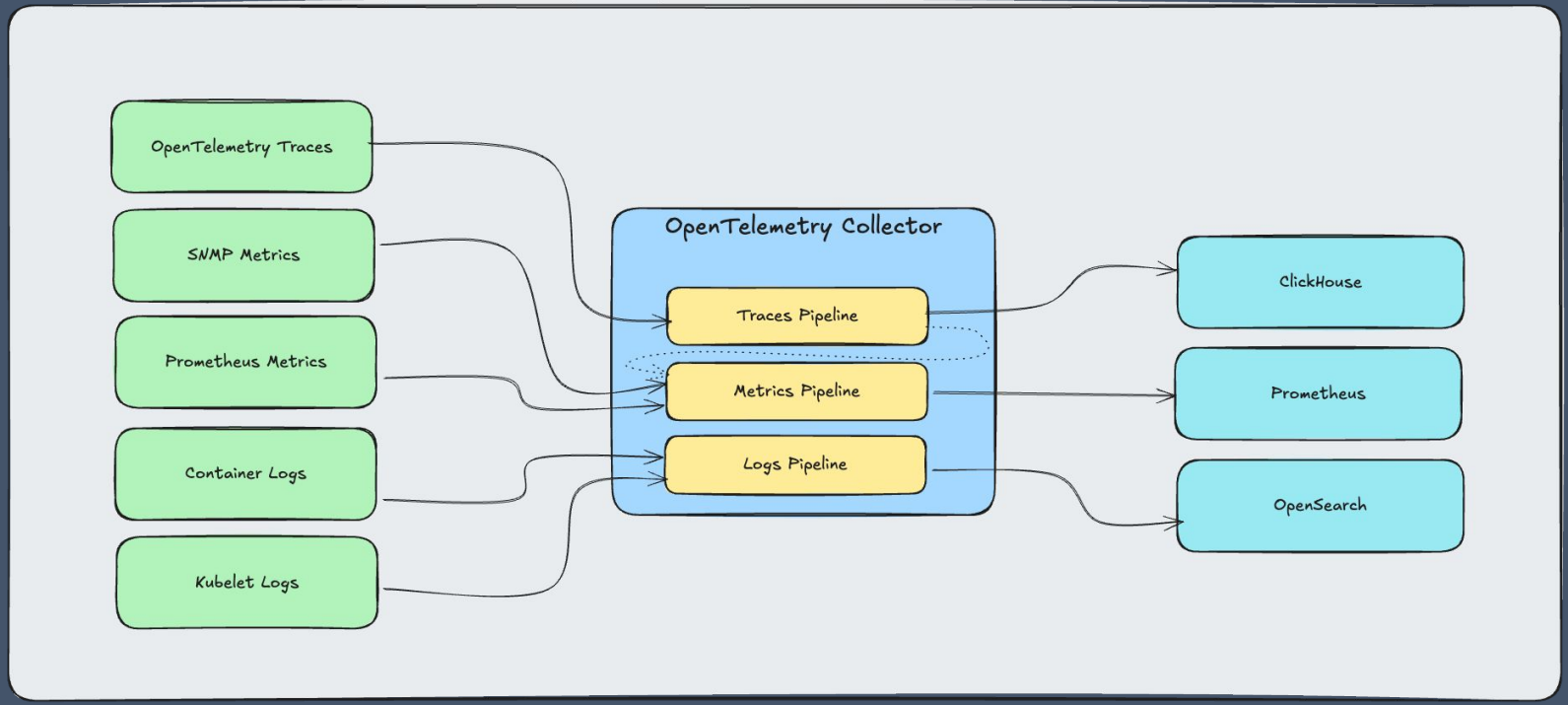
VictoriaMetrics

TSDB meets MergeTree

Honorable Mentions

Loki, Cortex, Thanos, Mimir, TimecaleDB, Solr, Druid...

Which to choose?



At (very) small scale

Just use what you have until it breaks (Postgres)

Hooked-on full-text search

OpenSearch has your back

One database for everything

ClickHouse is pretty cool

Wide-event analytics

ClickHouse is awesome

Filtering heavily before analyzing

OpenSearch is also a good choice here

Lots of "last-sample" reads + alerts

Choose a TSDB like Prometheus or VictoriaMetrics

Wide-events analytics with transactional guarantees

Cassandra or Postgres->ClickHouse

Database	Style/QL	Storage	Indexes	Use Case
Postgres	OLTP/SQL	Heap Pages	B-Tree	Update/Upsert with Guarantees
Cassandra	OLTP/SQL	Lucene Segments	Inverted	Scalable Upserts
Prometheus	TSDB/PromQL	TSDB files	By label	Time-series metrics, alerting
OpenSearch	Search/LuceneQL	Lucene Segments	Inverted, Bloom Filter, ANN	Full-text search, analytics
ClickHouse	OLAP/SQL	MergeTree Parts	Sparse, Inverted, and more…	Wide-event analytics

Thank you and happy querying!

Josh Lee - Altinity

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Connect with me

Resources & slides