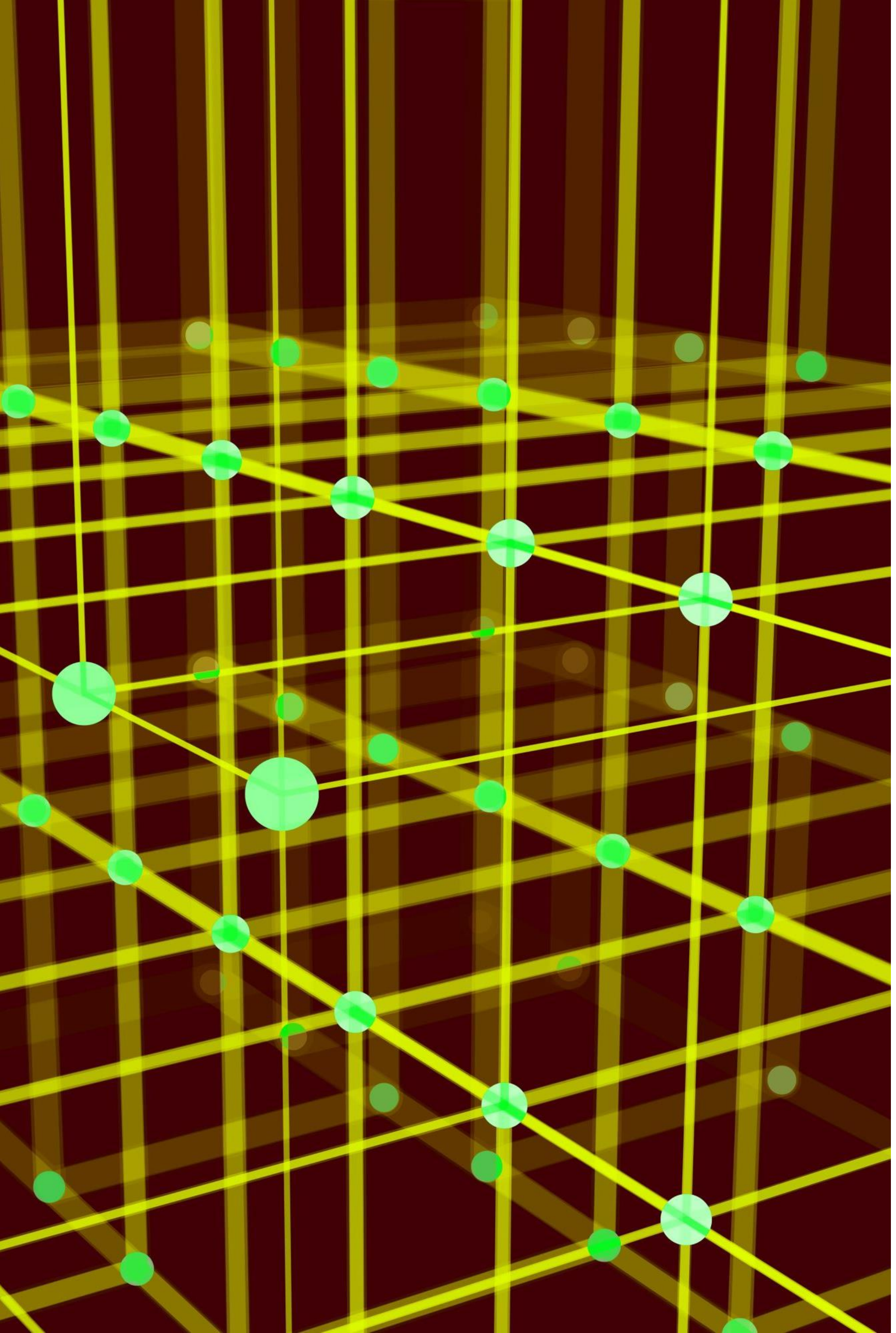

ΟΙΚΟΝΟΜΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ ATHENS UNIVERSITY OF ECONOMICS AND BUSINESS

Time series databases: Study & Benchmarking

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This presentation is part of my BSc Thesis in Time Series Databases
Important part of the research was held in ISDB lab.

Contents

What is time series data?

Time series data

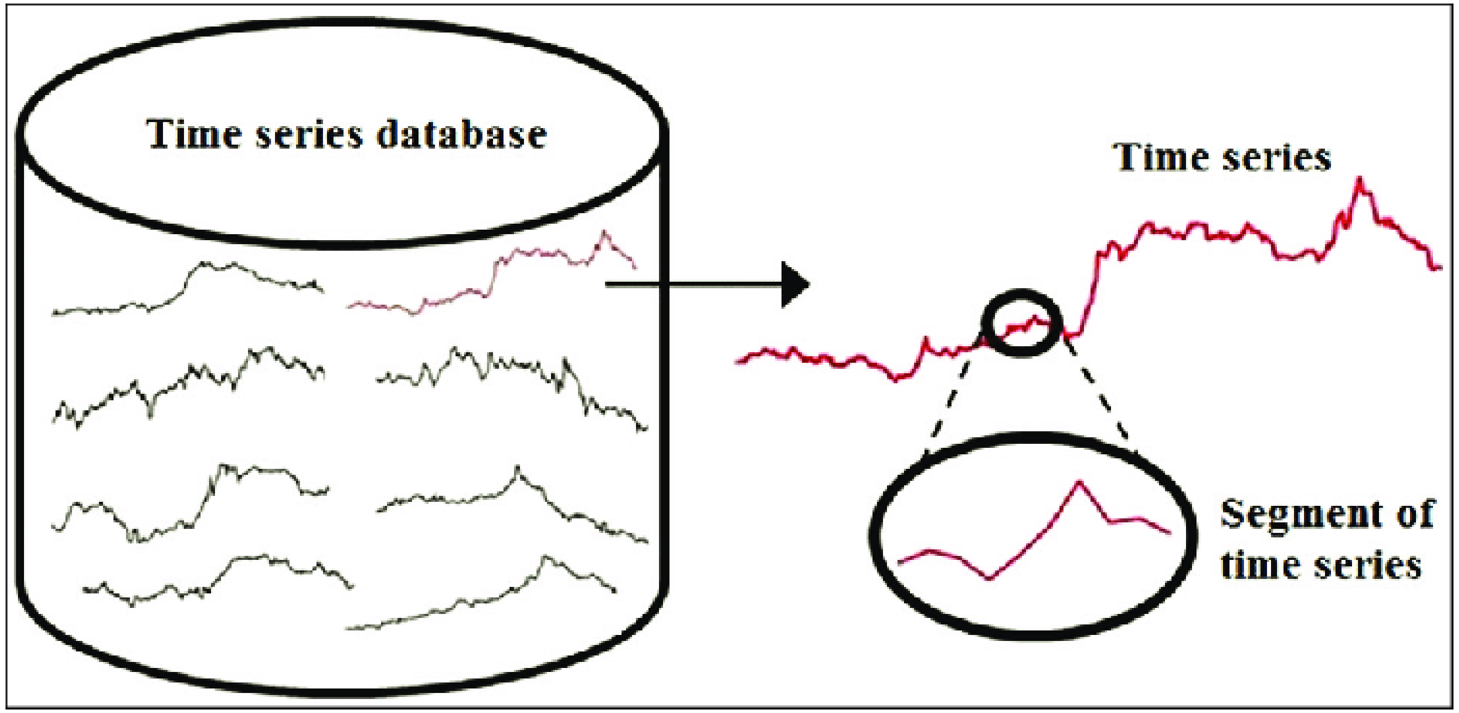
Observations obtained through time (e.g. health metrics)

Can be distinguished in univariate (single observations over time) and multivariate (2+ variables)

Used in forecasting, clustering/classification, signal detection/estimation

TSDBs

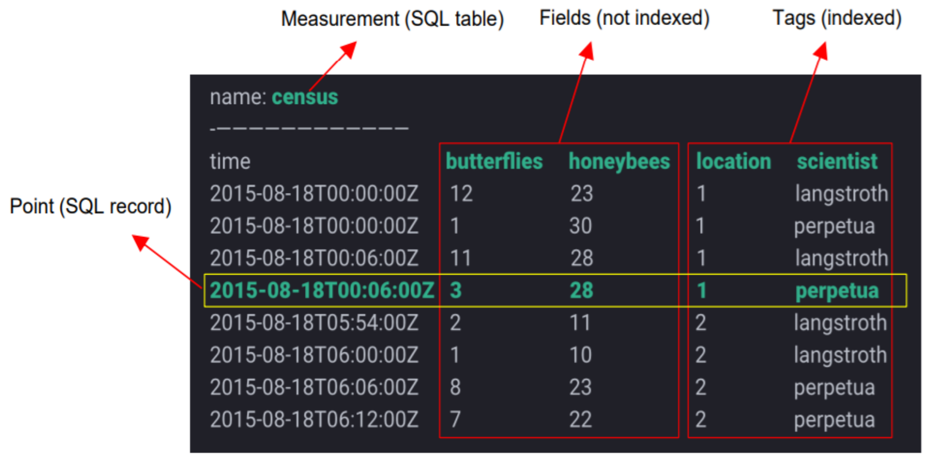
- Time series databases
- Time is treated as a first-class citizen (and not an extra field)
- Use of continuous queries, retention policies etc.
- These databases aim to maximize performance and query capabilities for time series data



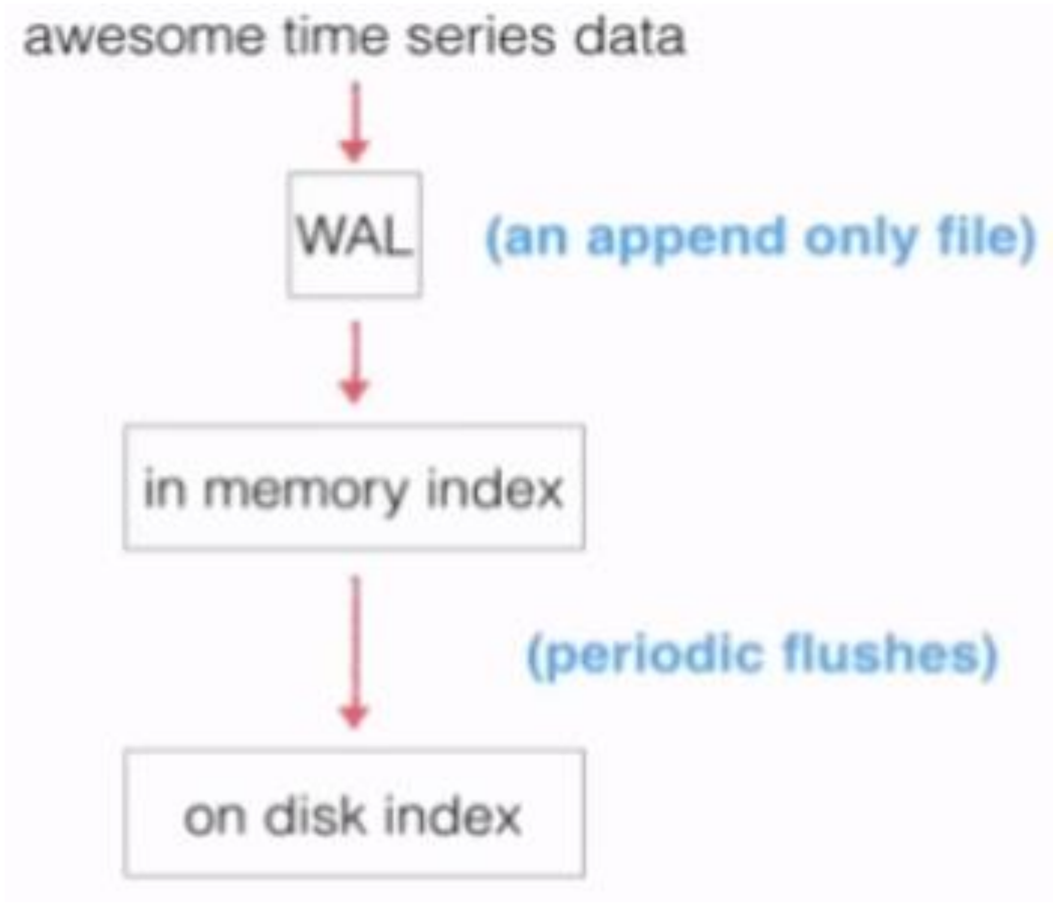
Studying TSDBs

InfluxDB (1/3)

- Open - source time series database
- Written in Go
- Supports the InfluxLineProtocol
- Two query languages: InfluxQL (SQL-like), Flux
- Data elements: Timestamp, Measurement, Fields, Tags, Point
- <u>Downsampling</u>: Reduce disk usage, improve query performance. Achieved by continuous queries



```
name: census
-------------
time                  butterflies  honeybees  location  scientist
2015-08-18T00:00:00Z  12           23         1         langstroth
2015-08-18T00:00:00Z  1            30         1         perpetua
2015-08-18T00:06:00Z  11           28         1         langstroth
2015-08-18T00:06:00Z  3            28         1         perpetua
2015-08-18T05:54:00Z  2            11         2         langstroth
2015-08-18T06:00:00Z  1            10         2         langstroth
2015-08-18T06:06:00Z  8            23         2         perpetua
2015-08-18T06:12:00Z  7            22         2         perpetua
```



InfluxDB storage system

InfluxDB (3/3)

- Strong read/write throughputs (+)
- SQL-like query language (+)
- Connection with Grafana (+)
- Support of multiple programming languages (Java, R, Python, Ruby, Scala etc.) (+)
- Scalability offered as a close-source feature (-)
- Not a CRUD database, more like CR-ud (-)

TimescaleDB (1/2)

- Open – source time series database
- Constructed on PostgreSQL, supports SQL
- Wide-column based
- A group of chunks makes a hypertable
- When partitioning, rows with the same hour timestamp are placed on the same chunk
- Chunks created automatically when adding new rows

TimescaleDB (2/2)

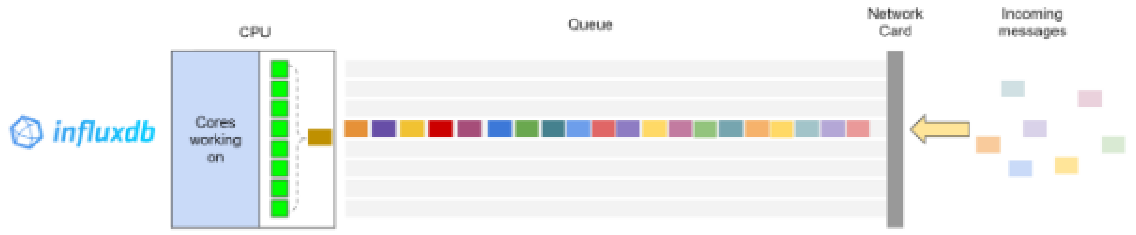
- Continuous aggregates help boost performance, similarly to InfluxQL's continuous queries
- Retention policies
- Data model: wide-table (used also in relational databases), narrow-table (each metric combination used as an individual time series)

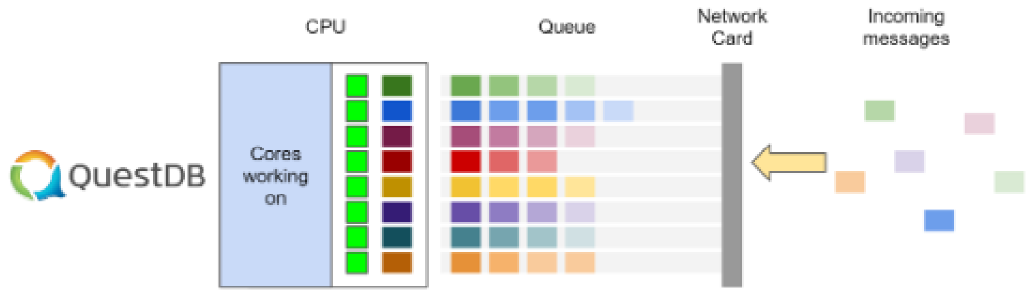
QuestDB (1/3)

- Open – source time series database
- Includes the InfluxDB line protocol
- Implemented with SQL
- Supports partitioning, indexing
- Reported to be the fastest time series database

QuestDB – InfluxLineProtocol (2/3)

- QuestDB can ingest data through the InfluxLineProtocol (ILP) to take advantage of SQL to query Influx data but keeping at the same time the flexibility of ILP.
- InfluxDB faces problems , cannibalizing the CPU when dealing with big cardinality rates.
- QuestDB maximizes the utilization of the CPU, while it does not stay idle.
- QuestDB can work in parallel, InfluxDB is limited to single receiver throughput.





QuestDB - Schemaless ingestion (3/3)

- QuestDB uses the InfluxLineProtocol (ILP) to ingest data without having to worry about updating the schema when needing to insert new tags and values from the measurements.
- InfluxDB uses the ILP in the same way to benefit from schemaless ingestion.
- However, this feature is not present in TimescaleDB and most other time series databases.

Prometheus

- Open - source monitoring & alerting system
- Multi-dimensional data model
- Time series collection achieved through a pull model over HTTP
- PromQL as the query language
- Alerting services (similar to triggers in vanilla SQL but more extended)

Benchmarking TSDBs

Time Series Benchmark Suite (TSBS)

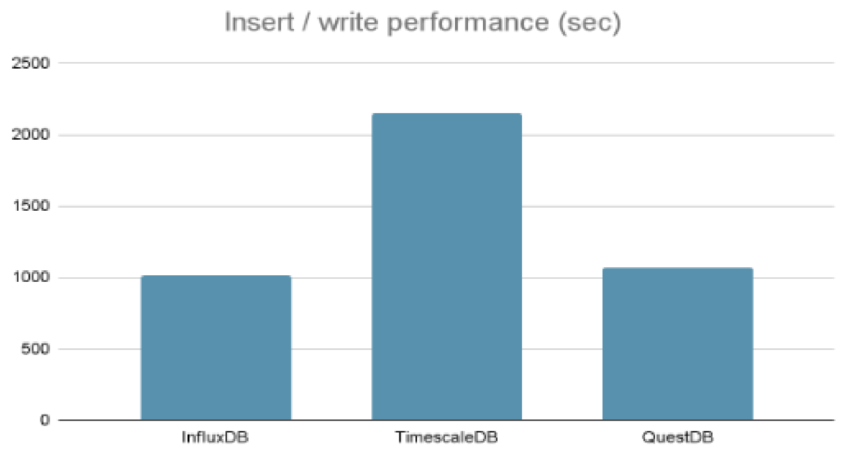
- Open-source benchmarking tool.
- Two kinds of loads: DevOps and IoT data.
- IoT data is closer to real life, containing missing & out-of-order entries.
- Data randomly generated, and then will be tested in load and query execution performance.
- *scale* flag: adjusts the number of hosts (DevOps data) or the number of trucks trucked (IoT data).

DevOps vs IoT

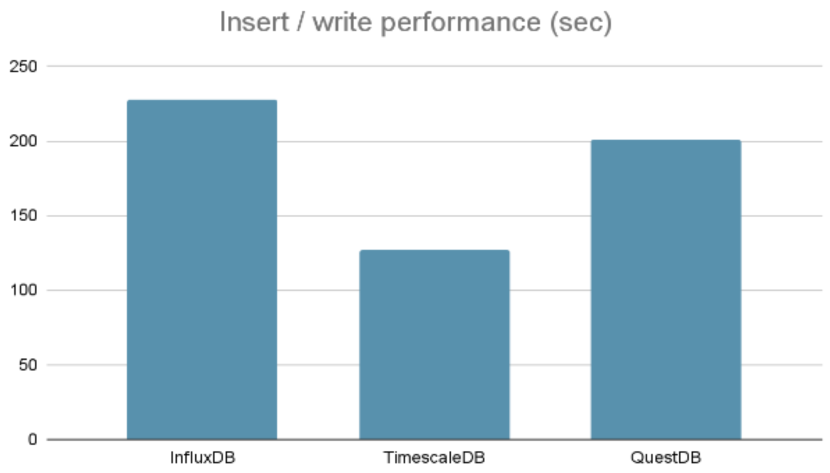
DEVOPS: GENERATE, INSERT DATA FROM 9 SYSTEMS. THE SYSTEMS GENERATE 100 METRICS PER READING INTERVAL.

IOT: SIMULATES DATA STREAMING FROM A SET OF TRUCKS.

Ingestion performance



DevOps data

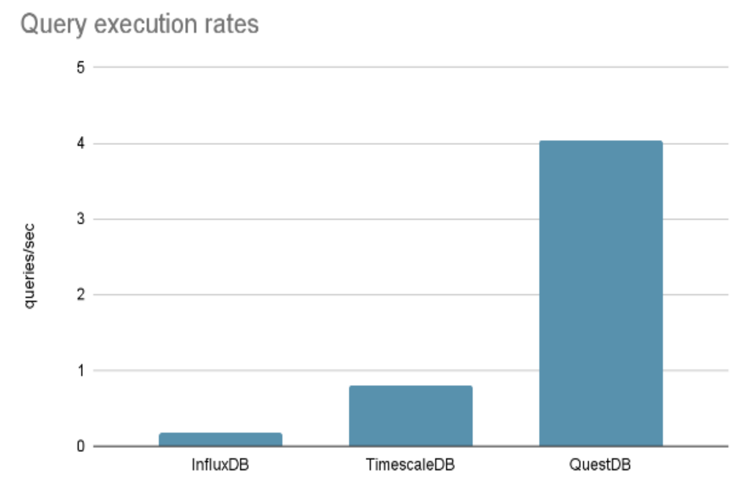


IoT data

Query execution performance (1/2)

Testing the execution performance of the databases based on specific queries:

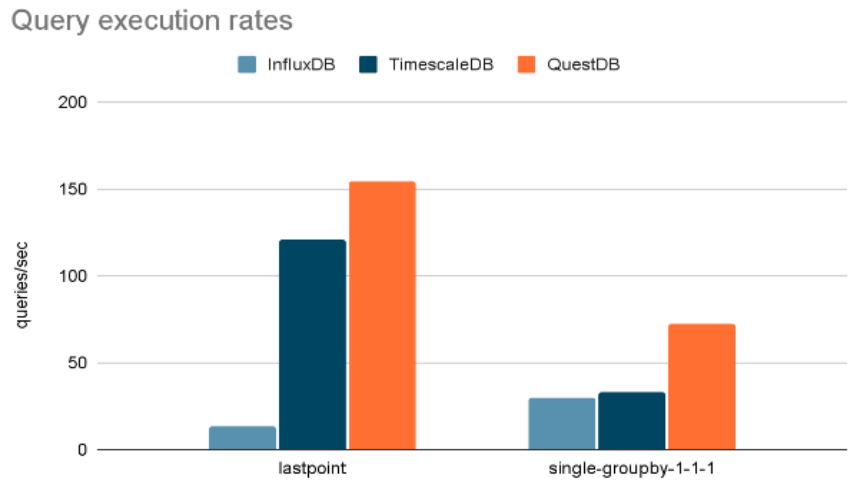
1. Query type “high-cpu-all”: Returns all the readings where one metric is above a threshold across all hosts.



Query execution performance (2/2)

Testing the execution performance of the databases based on specific queries:

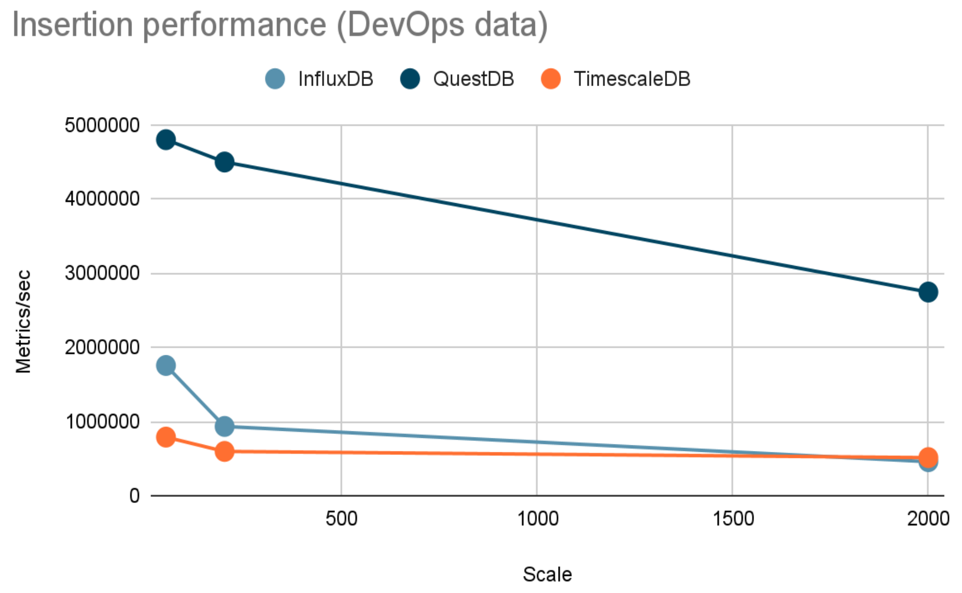
2. Query type “lastpoint” : returns the last reading for each host.
3. Query type “Single-groupby-1-1-1” : a simple aggregation (MAX) on one metric for one host every five minutes for an hour.



Cardinality impact (1/2)

High cardinality: Each indexed column in a table has many unique values.

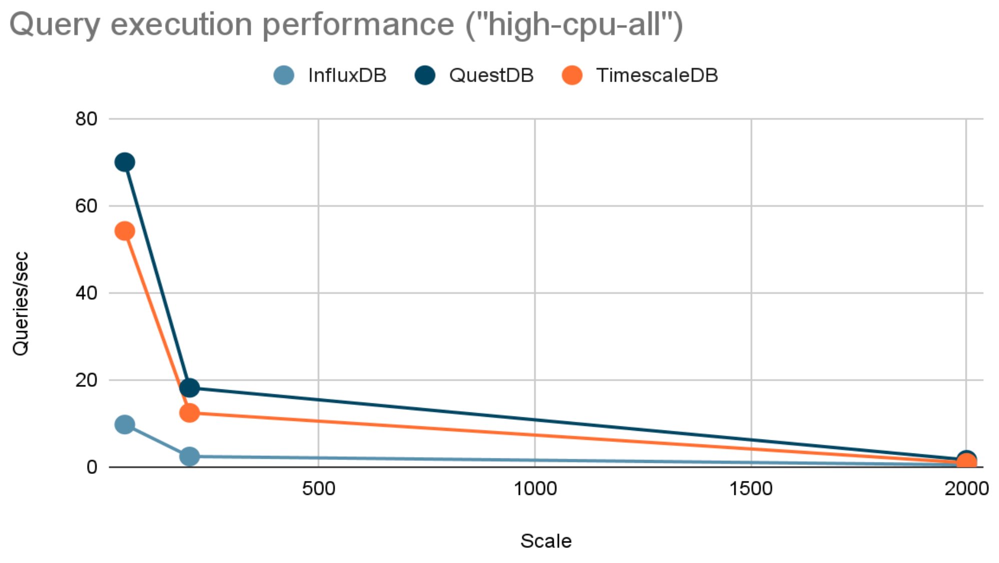
I. Impact on ingestion rates



Cardinality impact (2/2)

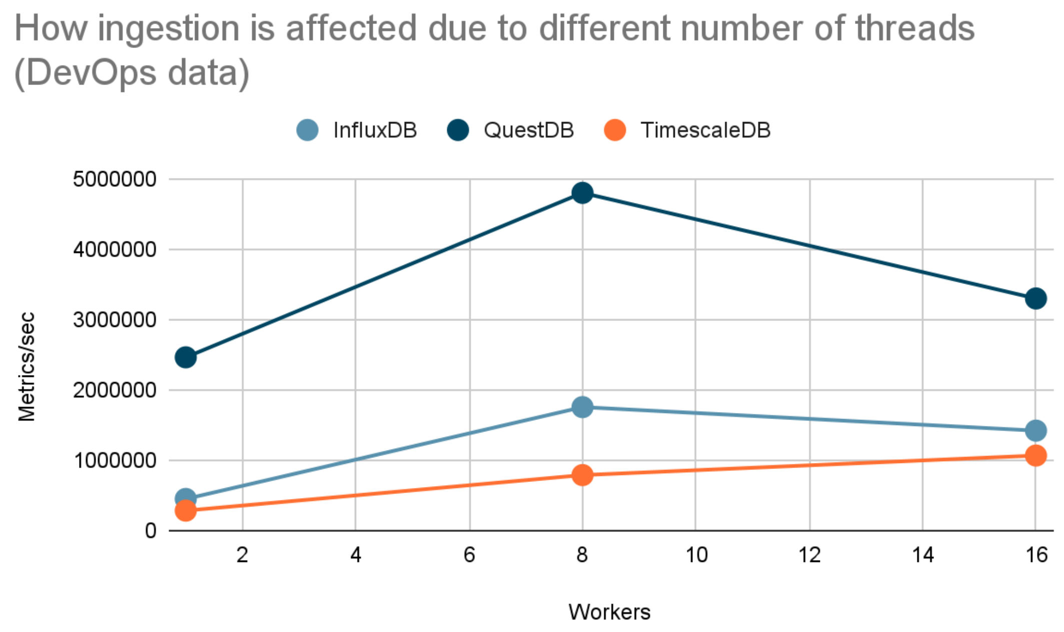
High cardinality: Each indexed column in a table has many unique values.

II. Impact on query execution rates



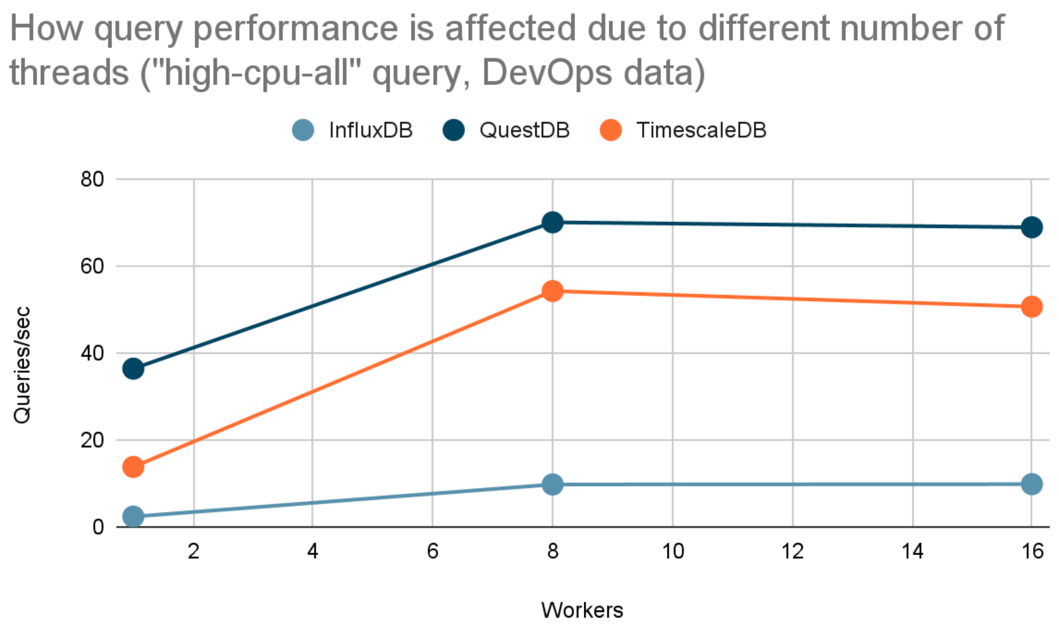
Multi-threading impact (1/2)

I. Impact on ingestion rates



Multi-threading impact (2/2)

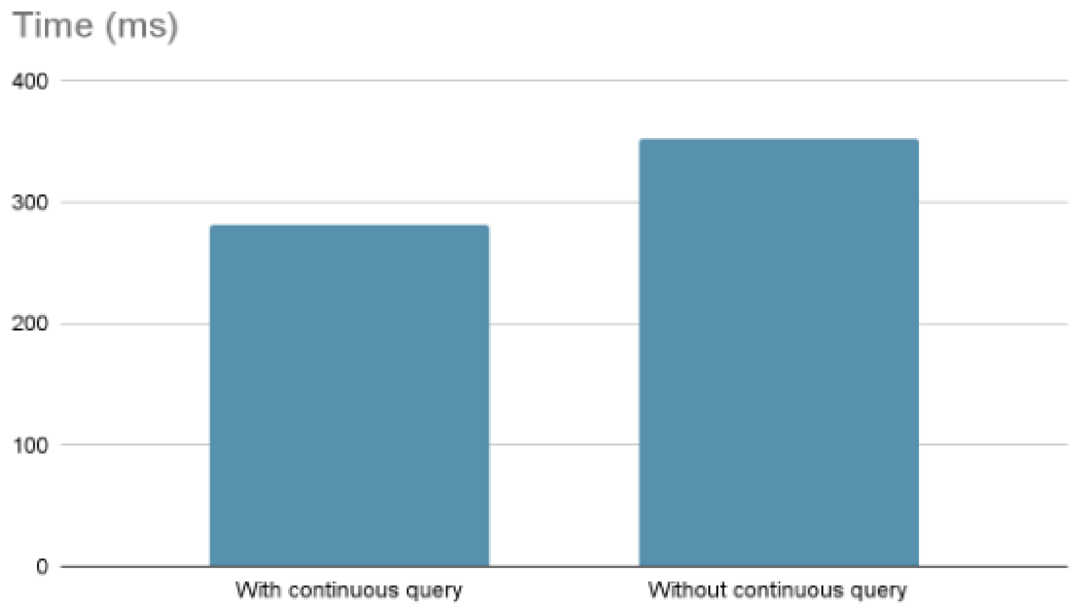
II. Impact on query execution rates



Materialized views (1/3)

- In TSDBs, downsampling is supported by continuous aggregates (InfluxDB) and continuous queries (TimescaleDB).
- We will test performance on aggregate and join queries. (InfluxQL though does not support joins)

InfluxDB performance on an aggregate query is shown on the right.



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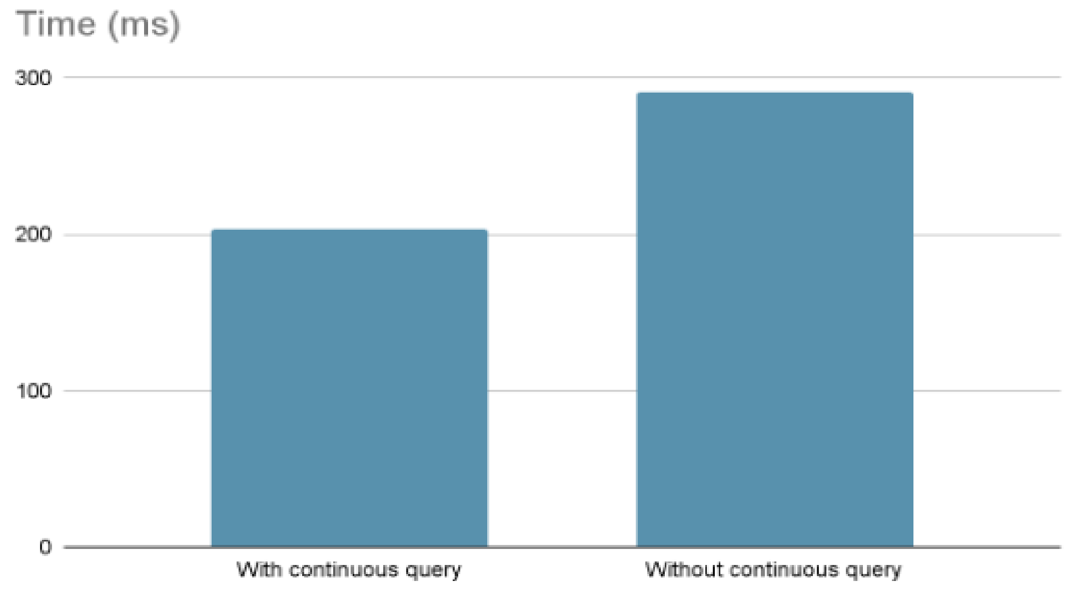
Reduced size: ~4 MB (~ -20%)

Materialized views (2/3)

- In TSDBs, downsampling is supported by continuous aggregates (InfluxDB) and continuous queries (TimescaleDB).
- We will test performance on aggregate and join queries. (InfluxQL though does not support joins)

TimescaleDB performance on an aggregate query is shown on the right.



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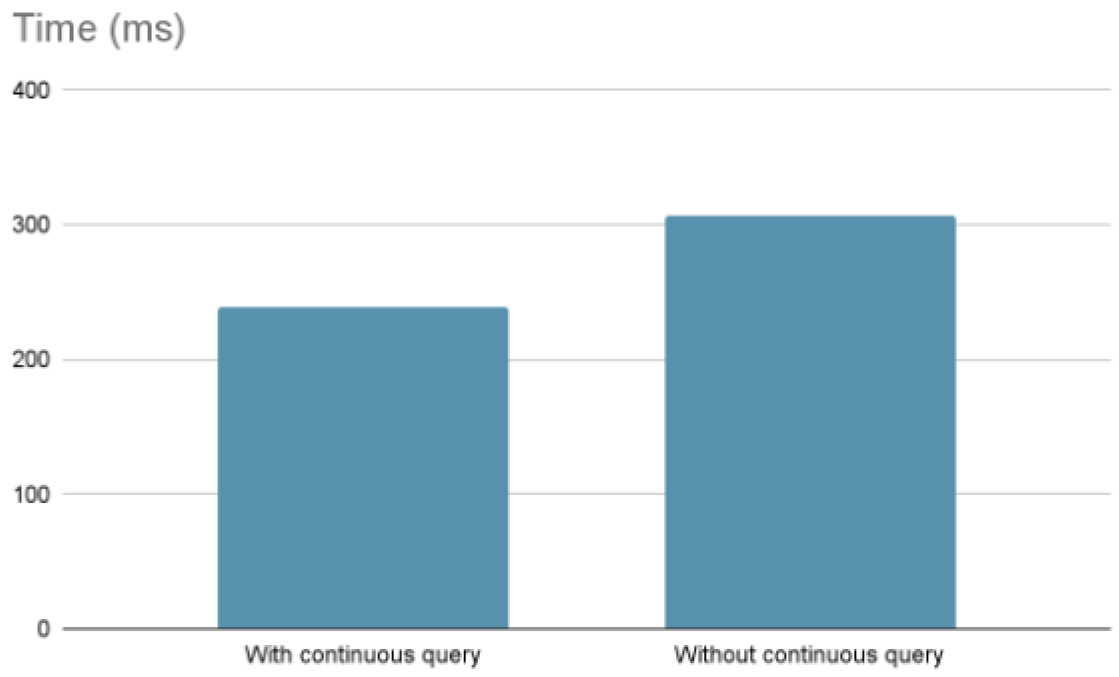
Reduced size: ~3.5 MB (~ -30%)

Materialized views (3/3)

- In TSDBs, downsampling is supported by continuous aggregates (InfluxDB) and continuous queries (TimescaleDB).
- We will test performance on aggregate and join queries. (InfluxQL though does not support joins)

TimescaleDB performance on a join query is shown on the right.



Original size: 5 MB
Reduced size: ~3.77 MB (~ -24.5%)

Thank you!

References

1. https://thecustomizewindows.com/2019/10/what-is-time-series-database-tsdb/

2. https://github.com/questdb/questdb