Battle of Time Series: SQL Server 2022 vs. ADX vs. InfluxDB vs. TimescaleDB

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AGENDA

1. What is Time Series data?
2. Options on the market
3. The contestants
4. The challenges
5. The winner

What is Time Series data?

Definitions

What is **time series data**?

> *"Time series data (or time-stamped data) is a collection of observations for a single object (entity) at different time intervals."*

What is a **time series database**?

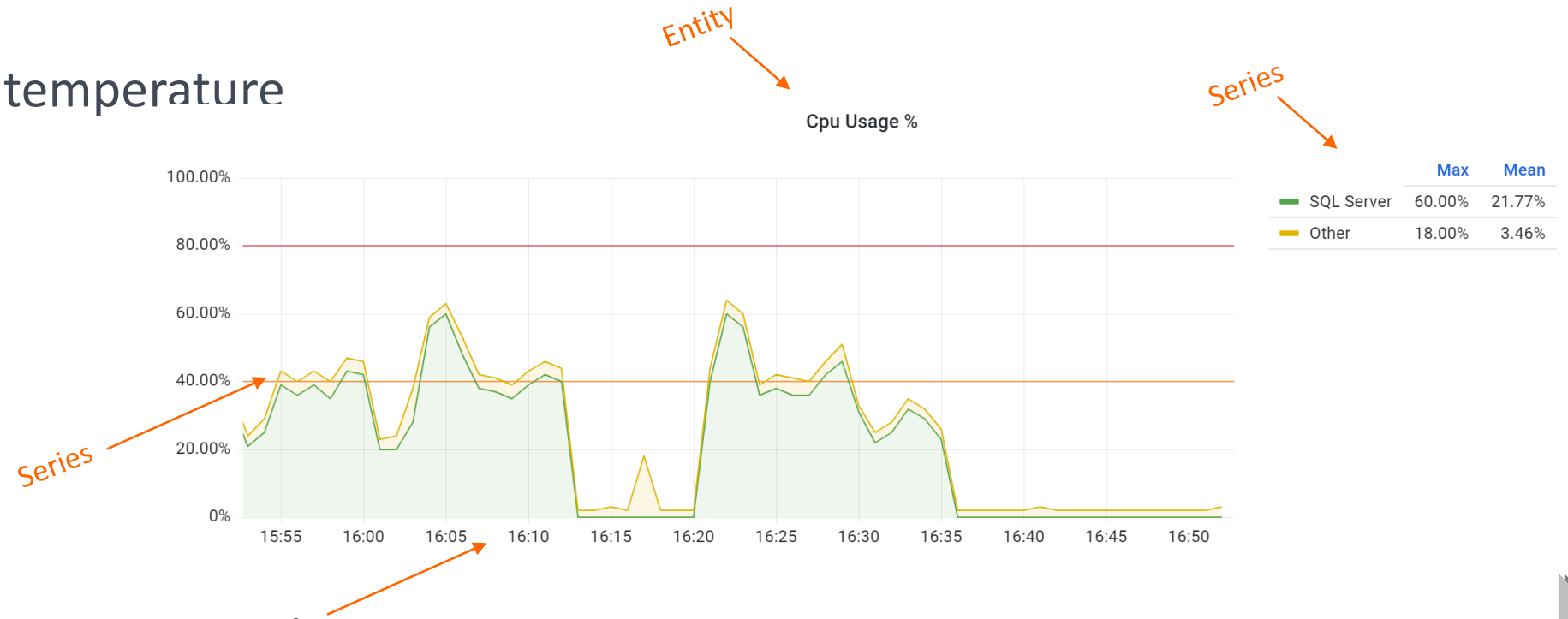
> *"A time series database (TSDB) is a database optimized for **time series data** and for measuring change over time."*

Time Series Data

Time series data is obtained by performing repeated measurements over time

Examples:

- Atmospheric temperature
- Stock prices
- CPU usage %
- Emails/sec
- Sensor data



Time Series Data

How is this different from relational data?

- Continuous Stream of data in time order
- Bulk uploads of large sets of data
- High volume data
- Data is append-only – no updates
- Delete large volumes of data when it goes out of scope
- Downsampling and aggregating high resolution data to save space

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Why does it matter?

Aircraft Engine

10 terabytes every 30 min.

14 million hours of flight in 2018

2 engines

= 560 million TB

2020s

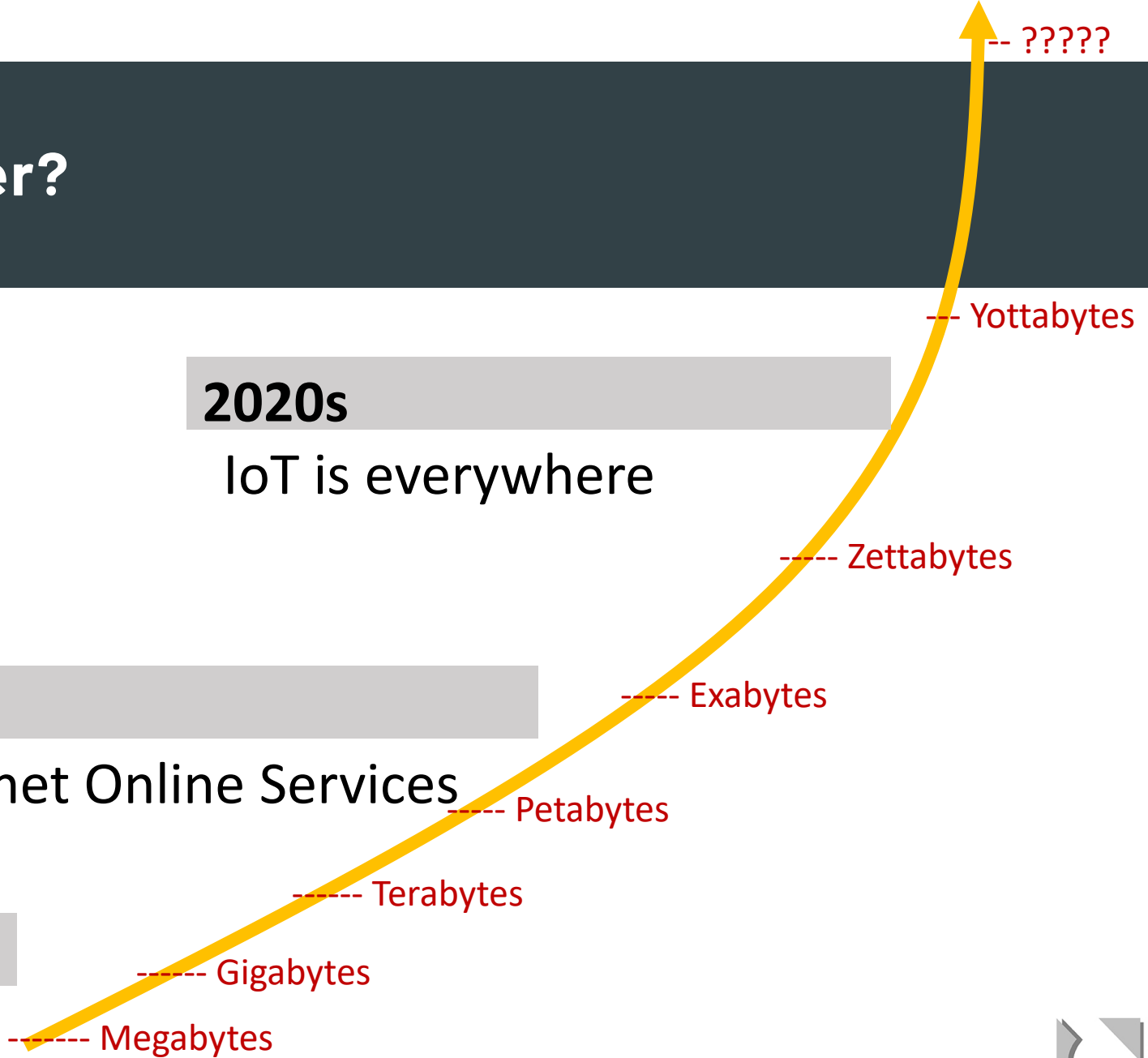
IoT is everywhere

2000s

Internet Online Services

1970s

Early Relational Databases



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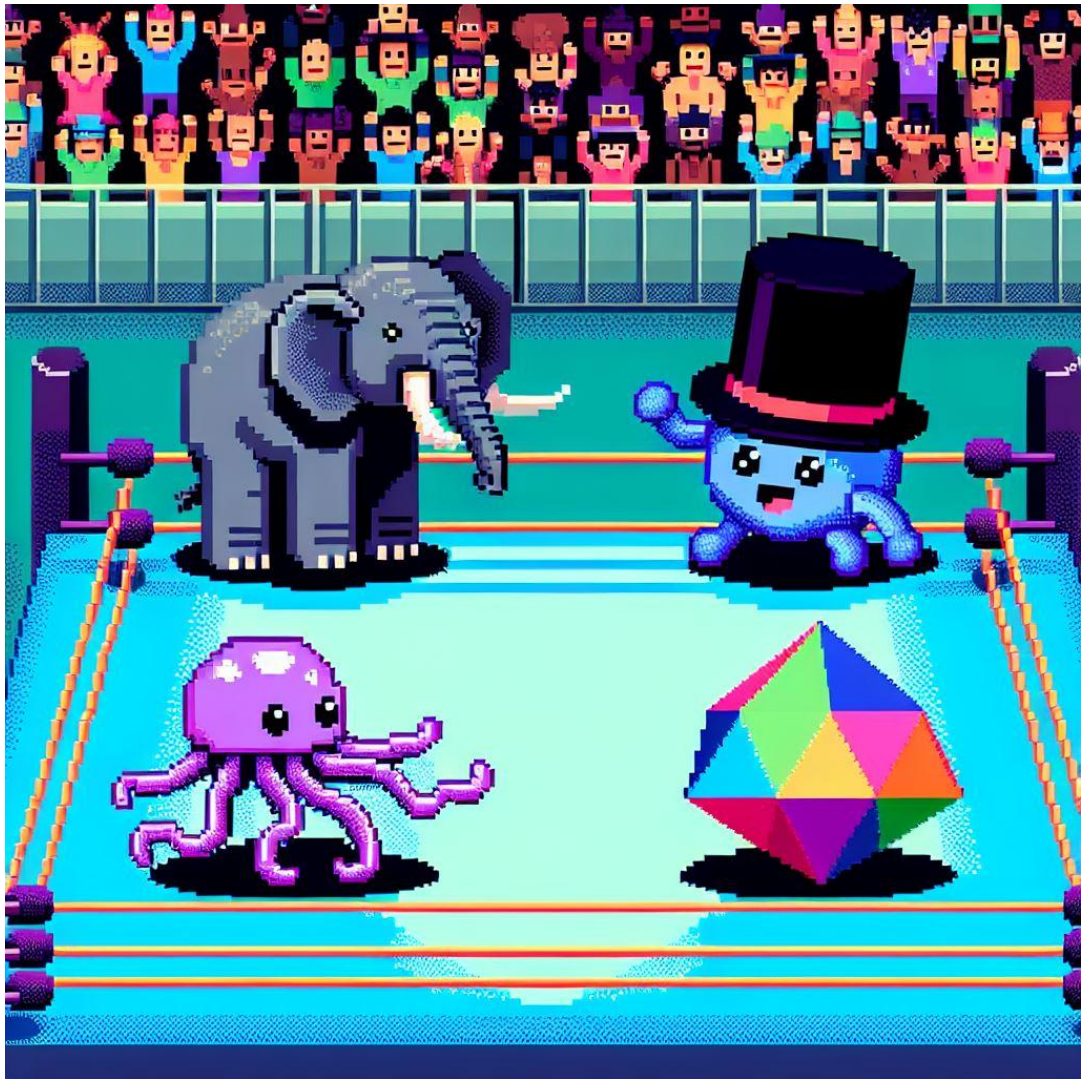
Time Series Database Options

RANK	DBMS	SCORE	
NOV 2024		NOV 2024	24 MONTH
1	InfluxDB	21.47	-8.55
2	KDB+	7.06	-1.72
3	Prometheus	6.92	+0.61
4	Graphite	4.91	-0.45
5	TimescaleDB	3.68	-0.88
6	QuestDB	2.91	+2.01
7	Apache Druid	2.70	-0.48
8	DolphinDB	2.60	+0.98
9	TDEngine	2.27	+1.08
?????	Azure Data Explorer	????	?????

Microsoft SQL Server 2022

Battle of TimeSeries!!!!

Timescale



Microsoft SQL Server

Azure Data Explorer

influxdb

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SQL Server 2022

Microsoft SQL Server

- All-round, enterprise-ready relational database
- Not a time-series database
- Has some of the ingredients
- Has a specialized edition for time-series data called Azure SQL Edge

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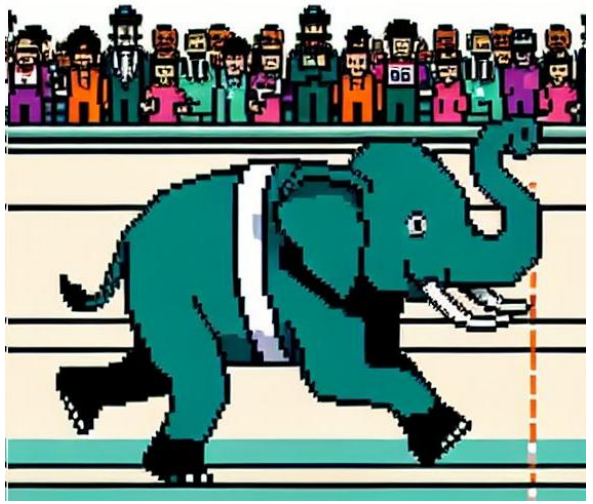
Timescale

- Open Source Time-Series database
- Built on top of PostgreSQL as an extension
- Optimized to ingest, store and query time-series data
- Stores data in «HyperTables», special tables composed of «chunks»
- Time buckets partition data by timestamp
- Allows compression for
- Can also store relational data and all types of data supported by PostgreSQL



Azure Data Explorer

- Fully managed, high performance, big data analytics platform
- Can store and analyze structured, semi-structured and unstructured data
- Uses a «relational» model (tables, columns and rows) with fixed strongly-typed schemas
- Tables are stored in databases
- Clusters contain databases
- Log analytics, IoT, time series data

➔ not strictly a time-series database!

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influxdb

Most popular time series database

Designed and optimized for time series data

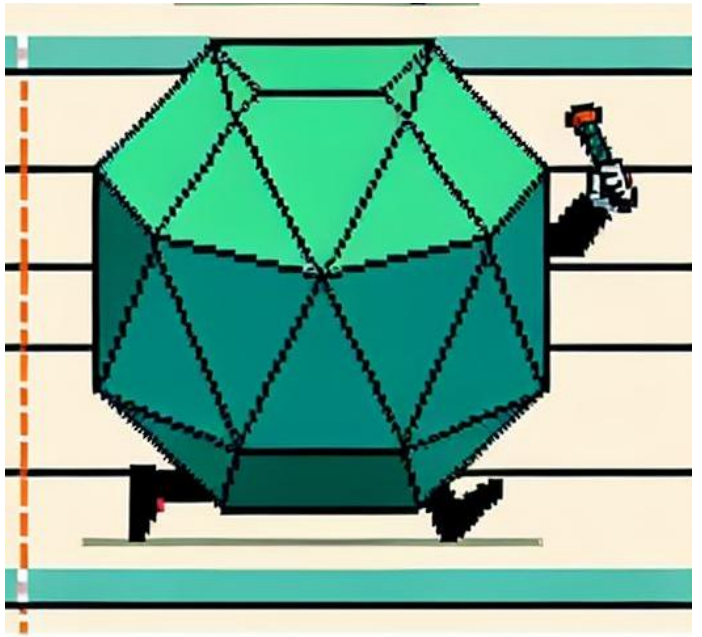
- Uses optimized TSM storage engine with columnar compression
- Built-in retention policies

Open Source with permissive licensing (MIT)

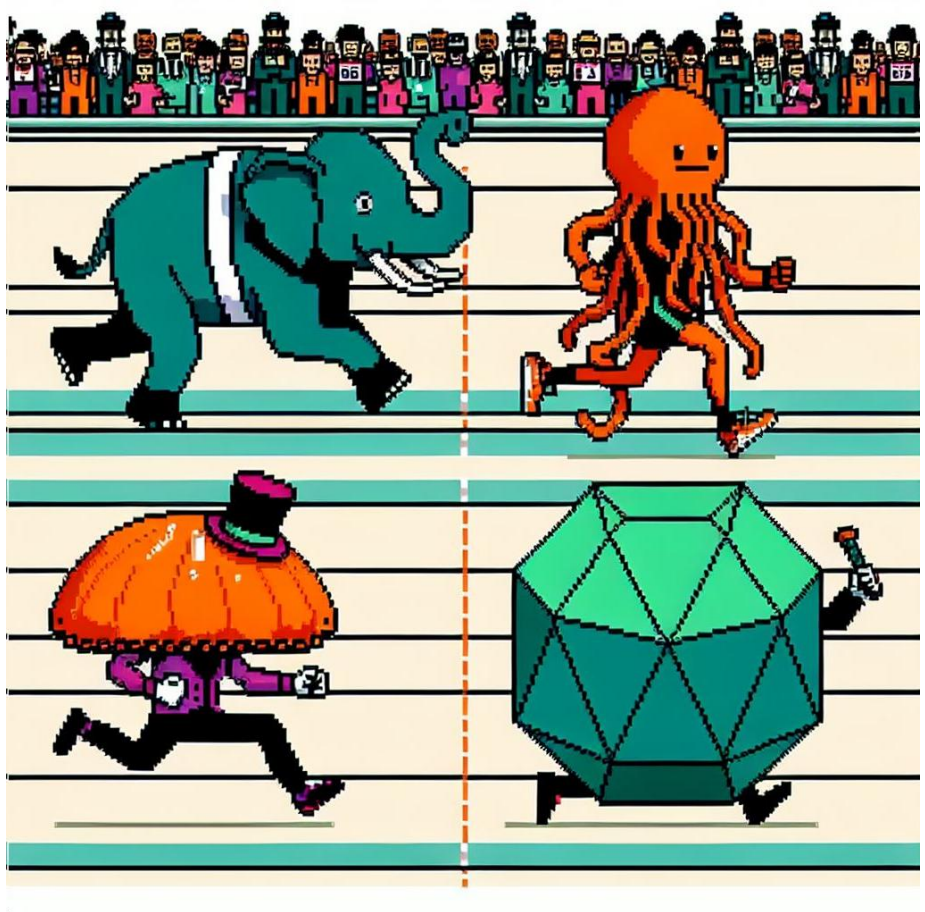
Written in GO

Cross platform:

windows, linux, macOS, docker, kubernetes, raspberryPI



The challenges



1. Licensing
2. Installation
3. Tooling
4. Storage Efficiency
5. Retention Policies and Downsampling
6. Query Capabilities

The rules:

- 0 to 3 points awarded
- I am the sole judge :)

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Licensing

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Licensing

SQL Server

- Commercial Product – public pricing
- Closed Source
- Has cloud option(s) – public pricing
- Has free editions with limitations

2

InfluxDB

- Commercial Product – secret pricing
- Open Source
- Has cloud option – public pricing
- Has extremely limited community edition
- Different versions with different limitations

0

TimescaleDB

- Commercial Product – secret pricing
- Open Source
- Has cloud option – public pricing
- Has free editions with **no** limitations

3

Azure Data Explorer

- Commercial Product – public pricing
- Closed Source
- Only available in the cloud
- Offers a limited free tier

1

Installation

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Installation and setup

SQL Server

- Cross-platform
- Works in containers
- GUI setup – Unattended setup
- Extensive and accurate documentation

3

InfluxDB

- Cross-platform
- Works in containers
- No setup required – single executable
- Nearly non-existent documentation

2

TimescaleDB

- Cross-platform
- Works in containers
- GUI setup – Unattended setup
- Extensive and accurate documentation *with OSS factor*

1

Azure Data Explorer

- No installation required
- Extensive and accurate documentation

1

Tooling

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Tooling

SQL Server

- SSMS
- Azure Data Studio
- Code extension
- Countless alternatives (some OSS)

3

InfluxDB

- Web UI - Chronograf
- CLI (influx.exe)
- Unofficial – unsupported OSS tools

0

TimescaleDB

- pg_admin
- Code extension
- Countless alternatives (some OSS)

2

Azure Data Explorer

- Web UI - dataexplorer.azure.com
- Kusto Explorer
- Azure Data Studio

1

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Storage Efficiency

SQL Server 2022 – Storage Engine

Big Heaps or Clustered Indexes are problematic

- Huge in size
- Hard to query
- Hard to maintain

Alternatives?

- Data compression
- Clustered Columnstore Indexes

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SQL Server 2022 – Columnstore Indexes

- Each column is stored independently
- Compresses data very efficiently
- Suitable when lots of repeating data exists
- Good for bulk operations
- Don’t play well with UPDATEs and DELETEs

DEMO!

InfluxDB - Series

SQL Server CPU usage percent from `sys.dm_os_ring_buffers`

time	SQL Server CPU	Other CPU
08:00	10	3
08:01	15	2
08:02	18	6
08:03	73	1

InfluxDB Series – An Example

This is saved in a **measurement** (let's call it **CPUHistory)** with **two series:**

time	SQL Server CPU	Other CPU
08:00	10	3
08:01	15	2
08:02	18	6
08:03	73	1

[CPUHistory, SQL Server CPU]

time	SQL Server CPU
08:00	10
08:01	15
08:02	18
08:03	73

[CPUHistory, Other CPU]

time	Other CPU
08:00	3
08:01	2
08:02	6
08:03	1

Series – Tags

If we add **tags**, we will get **one series for each tag value:**

time	**ServerName**	SQL Server CPU	Other CPU
08:00	ACCOUNTING	10	3
08:00	CRM	37	7
08:01	ACCOUNTING	15	2
08:01	CRM	48	5
08:02	ACCOUNTING	18	6
08:02	CRM	41	9
08:03	ACCOUNTING	73	1
08:03	CRM	28	7

[CPUHistory, **ACCOUNTING**, SQLServerCPU]

time	SQL Server CPU
08:00	10
08:01	15
08:02	18
08:03	73

[CPUHistory, **ACCOUNTING**, OtherCPU]

time	Other CPU
08:00	3
08:01	2
08:02	6
08:03	1

[CPUHistory, **CRM**, SQLServerCPU]

time	SQL Server CPU
08:00	37
08:01	48
08:02	41
08:03	28

[CPUHistory, **CRM**, OtherCPU]

time	Other CPU
08:00	7
08:01	5
08:02	9
08:03	7

InfluxDB – Storage Engine

Series are stored independently

We get one series for each combination of tag values → **cardinality**

v1 & v2 Storage engine is called **TSM** (Time series Structured Merge tree)

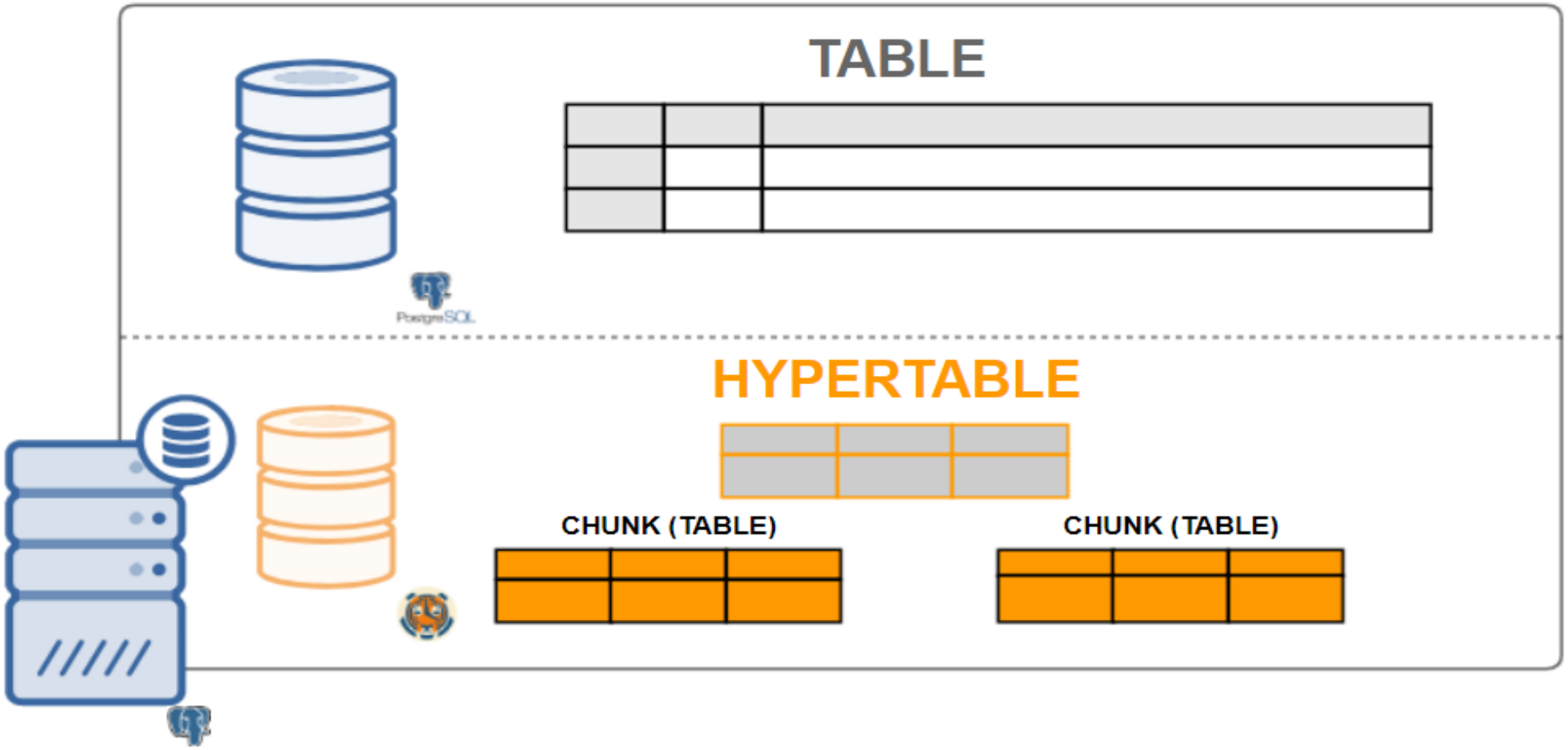
derived from **LSM** (Log-Structured Merge tree) → **Cassandra**

v3 Storage is based on **Parquet**

Available in the InfluxDB cloud

(Soon?) available on-prem

TimescaleDB – Storage Engine

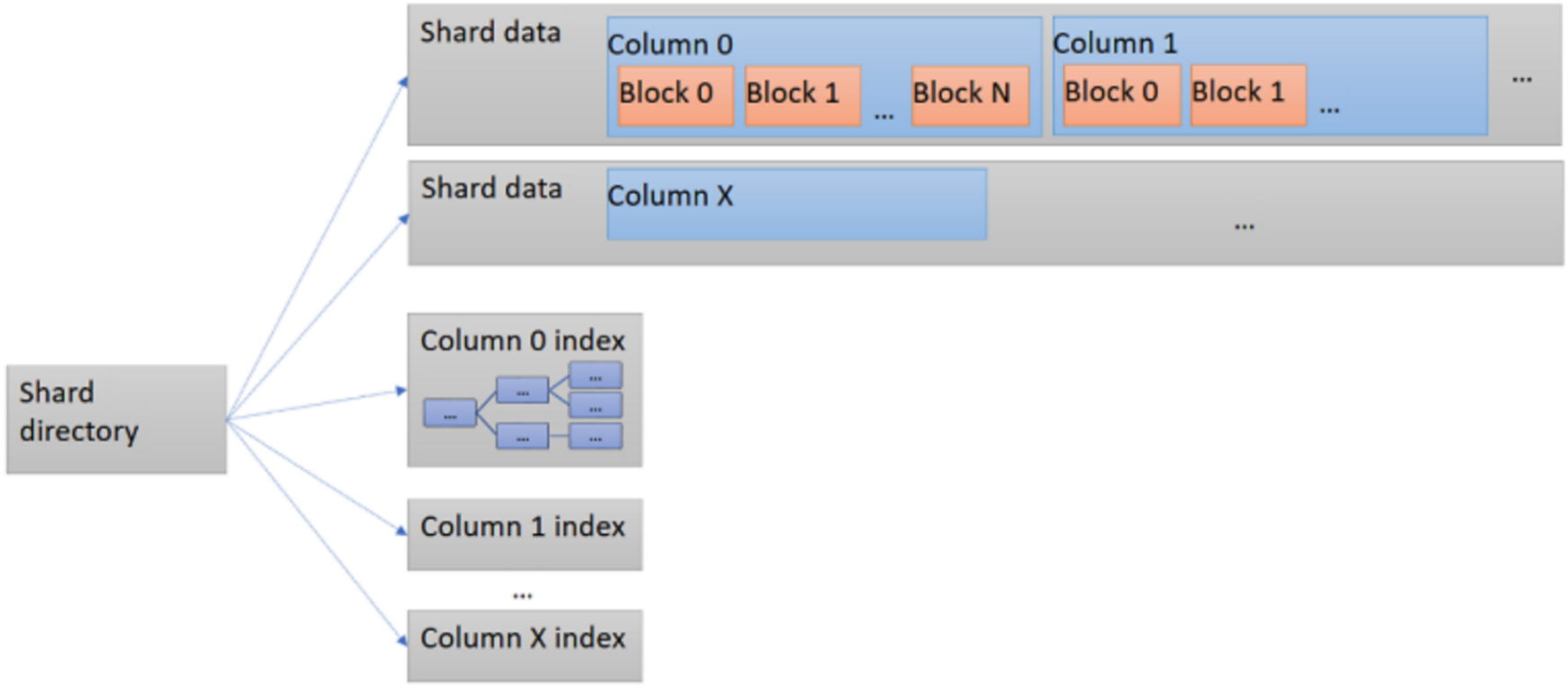


Azure Data Explorer - Internals

- Separates storage and compute resources
- Persistent data resides in Azure Blob Storage
  - Data is stored in **extents** (shards)
  - Extents are spread across cluster nodes
  - Extents are cached in SSD and memory
  - Data is compressed with columnar compression
- Compute uses a cache for persistent storage
- Row store is used when ingesting data (streaming ingestion)

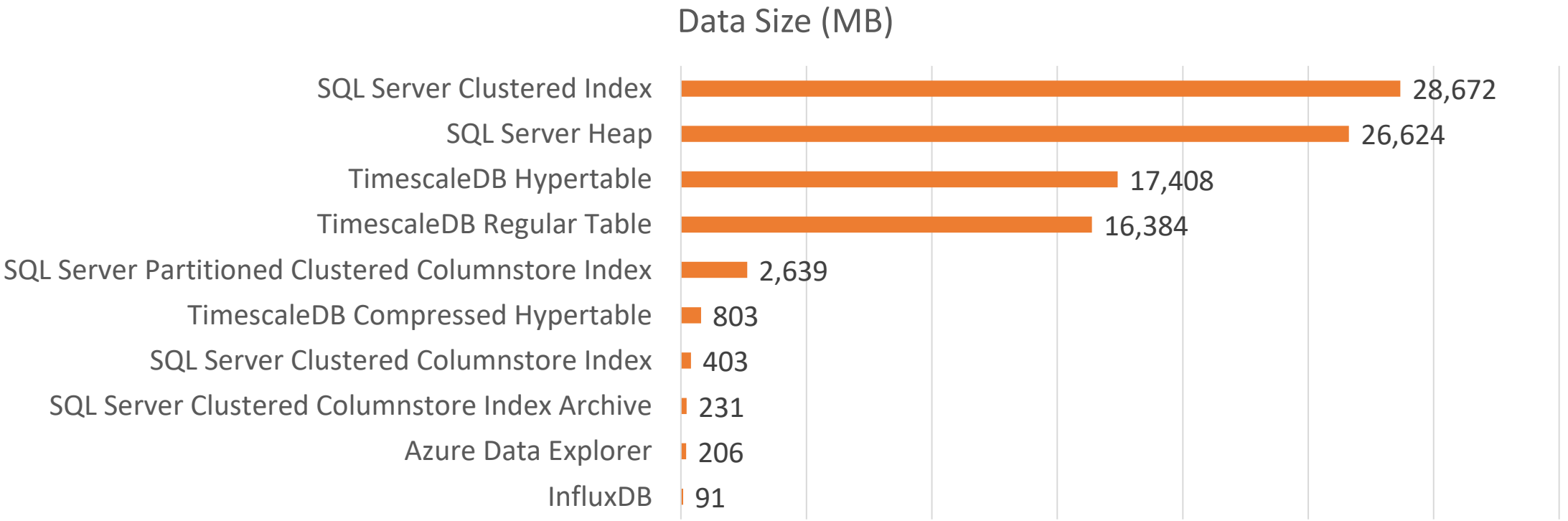
Azure Data Explorer – Shard Format

Compressed column store with free text support and full-text inverted index



Storage Efficiency

Data size for SQL Server performance counters, 2 instances,
15 days of data, 82 million rows



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Storage Efficiency

SQL Server

- Terrible with regular tables
- Better with clustered columnstore
- Partitioning affects efficiency

1

InfluxDB

- Stellar compression ratios
- Unaffected by sharding

3

TimescaleDB

- Terrible with regular tables
- Regular hypertables are just as inefficient
- Compressed hypertables are fine

2

Azure Data Explorer

- Uses an undocumented columnar compression algorithm
- Stores data efficiently

2

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Retention Policies and Downsampling

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Storage Efficiency

SQL Server

- Data needs to be deleted manually
- Partitioning makes it nearly-instantaneous
- Requires scheduling jobs

0

InfluxDB

- Retention policies are built-in
- Downsampling can be achieved with continuous queries in v1 and with jobs in v2 and v3

3

TimescaleDB

- Retention policies are built-in
- Downsampling is implemented with materialized views

3

Azure Data Explorer

- Retention policies are built-in
- Data gets soft-deleted when expired
- Downsampling is implemented with materialized views or with Power Automate
- Not really a time-series database

1

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Query Capabilities

InfluxDB – Query Capabilities

InfluxDB supports 2 query languages:

InfluxQL → similar to SQL, born with version 1, still available in v2

```
SELECT MEAN(SQLServerCPU) AS avg_cpu
FROM CPUHistory
WHERE time > now() -1d
GROUP BY server_name
```

InfluxDB – Query Capabilities

Flux → doesn't look like SQL (more like KQL), default in v2, also available in v1

Supports «advanced» query features like joins…

```
from(bucket:"demo/autogen" )
    |> range(start: -1d)
    |> filter(fn: (r) => r._measurement == "CPUHistory")
    |> filter(fn: (r) => r._field == "SQLServerCPU")
    |> mean()
    |> group(columns: ["server_name"])
    |> yield(name: "avg_cpu")
```

InfluxDB – Query Capabilities

InfluxDB v3 supports SQL

InfluxDB Cloud Serverless uses the **Apache Arrow DataFusion** implementation of SQL

Supports JOINs
Supports CTEs
Supports windowing functions
… Supports everything you would expect from a decent database

GROUP BY TIME

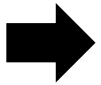
InfluxQL allows grouping by time:

```
SELECT MEAN(value) AS avg_lazy_writes_sec
FROM "sqlserver_performance"
WHERE counter = 'Lazy writes/sec'
    AND sql_instance = 'SQLCSRV04:SQL2017'
    AND time > now() - 1d
GROUP BY time(1h)
```

GROUP BY TIME

… GROUP BY time(1h)

time	lazy_writes_sec	
16-10-2022 10:00:00	398091	
…	…	10:00
16-10-2022 10:59:59	395644	
16-10-2022 11:00:00	432211	
…	…	11:00
16-10-2022 11:59:59	452325	
16-10-2022 12:00:00	456541	
…	…	12:00
16-10-2022 12:59:59	433505	
16-10-2022 13:00:00	456654	
…	…	13:00
16-10-2022 13:59:59	456788	
16-10-2022 14:00:00	417545	
…	…	…



time	avg_lazy_writes_sec
16-10-2022 10:00:00	398,091.00
16-10-2022 11:00:00	400,187.50
16-10-2022 12:00:00	406,095.00
16-10-2022 13:00:00	411,167.76
16-10-2022 14:00:00	417,963.40
16-10-2022 15:00:00	425,683.27
16-10-2022 16:00:00	433,001.40
16-10-2022 17:00:00	441,937.02
16-10-2022 18:00:00	449,937.73
16-10-2022 19:00:00	450,737.81
16-10-2022 20:00:00	453,467.40
16-10-2022 21:00:00	455,703.76
16-10-2022 22:00:00	457,270.19
16-10-2022 23:00:00	458,743.47
17-10-2022 00:00:00	461,533.64
…	…

FILL

InfluxQL allows filling intervals with data:

```
SELECT MEAN(value) AS avg_lazy_writes_sec
FROM "sqlserver_performance"
WHERE counter = 'Lazy writes/sec'
    AND sql_instance = 'SQLCSRV04:SQL2017'
    AND time > now() - 1d
GROUP BY time(1h) FILL(NULL)
```

FILL

… FILL(NULL|VALUE)

time	value
16-10-2022 10:35:45	398091
16-10-2022 10:36:01	398091
16-10-2022 12:16:15	406095
16-10-2022 12:16:30	406095
16-10-2022 13:06:45	411167
16-10-2022 13:07:01	411167

time	avg_lazy_writes_sec
16-10-2022 10:00:00	398,091.00
16-10-2022 11:00:00	NULL
16-10-2022 12:00:00	406,095.00
16-10-2022 13:00:00	411,167.76

SQL Server – Query capabilities

The new DATE_BUCKET function in SQL Server 2022 helps implement GROUP BY TIME

```
SELECT DATE_BUCKET(hour, 1, time) AS time, AVG(value) AS avg_lazy_writes_sec
FROM [dbo].[sqlserver_performance_cci_partitioned]
WHERE time >= '2022-10-01'
    AND time < '2022-10-02'
    AND counter = 'Lazy writes/sec'
    AND sql_instance = 'SQLCSRV04:SQL2017'
GROUP BY DATE_BUCKET(hour, 1, time)
ORDER BY 1
```

SQL Server – Query capabilities

The new GENERATE_SERIES function in SQL Server 2022 helps implement FILL

```
SELECT DATEADD(hour, value, '2022-10-01') AS time
FROM GENERATE_SERIES(0, DATEDIFF(hour, '2022-10-01', '2022-10-02') -1)
```

DEMO!

Azure Data Explorer – Query Capabilities

- ADX supports the Kusto Query Language (KQL)
- It's a brand new language, no similarities with SQL
- SQL is not supported but you can convert SQL to KQL with EXPLAIN
- KQL is simple and powerful
- … but it's not SQL!!!
- SQL support for KQL databases is coming in 2025!!!

```
Perf
| where TimeGenerated >= ago(10m)
| where CounterName == "% Free Space"
| project PerfComputer = Computer
        , CounterName
        , CounterValue
        , PerfTime=TimeGenerated
| join ( InsightsMetrics
        | where TimeGenerated >= ago(10m)
        | project IMComputer = Computer
                , Namespace
                , Name
                , Val
                , IMTime=TimeGenerated
      )
    on $left.PerfComputer == $right.IMComputer
```

DEMO!

TimescaleDB – Query capabilities

PostgreSQL has a rich SQL dialect called PL/pgSQL (or just pgSQL) which handles most queries with ease.

TimescaleDB adds **hyperfunctions** to handle common time-series use cases

GROUP BY TIME is achieved with **time_bucket()**

FILL is achieved with **time_bucket_gapfill()**

Carry over of the last value is implemented with **locf()**

DEMO!

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Query capabilities

SQL Server

- Supports T-SQL
- Has gained (some) time-series capabilities with SQL Server 2022

1

InfluxDB

- Has specific time-series query features
- InfluxQL
- Flux
- SQL

3

TimescaleDB

- Supports pgSQL
- Has specific time-series query features

3

Azure Data Explorer

- Has specific time-series query features
- Supports KQL
- Has a SQL endpoint

2

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And the winner is...

	10		11		14		8

TimescaleDB!

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Resources

Questions? Ask me!

spaghettidba@sqlconsulting.it

Get slides and demos from GitHub:

https://github.com/spaghettidba/CodeSamples