***Abstract***

A time series database (TSDB) is a database optimized for time-stamped or time series data. Time series data are simply measurements or events that are tracked, monitored, down sampled, and aggregated over time. With a time series database, it is common to request a summary of data over a large time period. This could be server metrics, application performance monitoring, network data, sensor data, events, clicks, trades in a market, and many other types of analytics data. This requires going over a range of data points to perform some computation. InfluxDB is one of such time series databases. InfluxDB was built from the ground up to be a purpose-built time series database. To help provide a better understanding of how to get the best performance out of InfluxDB, this report contains few tips for improving both write and query performance with InfluxDB.

1. **Introduction**

A time series database is built specifically for handling metrics and events or measurements that are time-stamped. A TSDB is optimized for measuring change over time. Properties that make time series data very different than other data workloads are data lifecycle management, summarization, and large range scans of many records.

Time series databases have key architectural design properties that make them very different from other databases. These include time-stamp data storage and compression, data lifecycle management, data summarization, ability to handle large time series dependent scans of many records, and time series aware queries.

What makes InfluxDB time series database unique?

InfluxDB is part of a comprehensive platform that supports the collection, storage, monitoring, visualization and alerting of time series data. It’s much more than just a time series database and InfluxDB data model is quite different from other time series solutions like Graphite, RRD, or OpenTSDB. InfluxDB has a line protocol for sending time series data which takes the following form: measurement-name tag-set field-set timestamp. The measurement name is a string, the tag set is a collection of key/value pairs where all values are strings, and the field set is a collection of key/value pairs where the values can be int64, float64, bool, or string. The measurement name and tag sets are kept in an inverted index which make lookups for specific series very fast.

1. **Properties**

* **Data Location**: It co-locates chucks of data within the same time range on the same physical part of the database cluster and hence enables quick access for faster, more efficient analysis
* **Fast, easy range queries**: Co-related data together it ensures that the range queries are fast.
* **High write performance**: TSDBs should ensure high availability and high performance for both read and write operations during peak loads because they are usually designed to stay available even under the most demanding conditions. Time series data is usually being recorded every second or even less than that, so write operations need to be fast.
* **Data compression**: As time-series data is mostly recorded per second or even with less granularity, they usually need a better data compression technique. And as the data grows older granularity becomes less important, so TSDBs should provide functionality to perform roll-ups in such scenarios for data compaction.
* **Scalability**: time series databases are designed to take care of scale by introducing functionalities that are only possible when we treat time as our first concern. This can result in performance improvements, including higher insertion rates, faster queries at scale, and better data compression.
* **Usability**: TSDBs typically include functions and operations that are common to time series data analysis. For example, they utilize data retention policies, continuous queries, flexible time aggregations, range queries etc. So, this increases the usability by improving the user experience in case of dealing with time related analysis.

Below graph represents popularity changes of DB-engines scored by database category for the last 24 months. This graph clearly shows us where time series database stands among other DB-engines.

![A close up of a map

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Source: <https://www.influxdata.com/>

InfluxDB key features are:

* The TSM engine allows for high ingest speed and data compression
* Simple, high performing write and query HTTP APIs.
* Tags allow series to be indexed for fast and efficient queries.
* Retention policies efficiently auto-expire stale data.
* Continuous queries automatically compute aggregate data to make frequent queries more efficient.

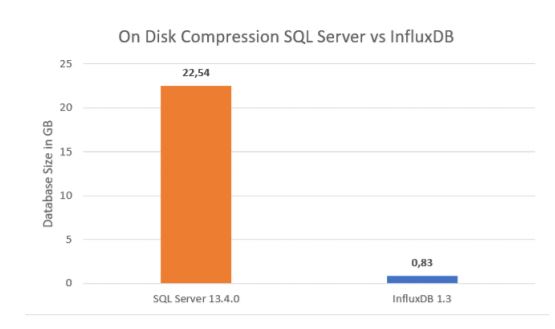
1. **Understanding InfluxDB in terms of SQL**

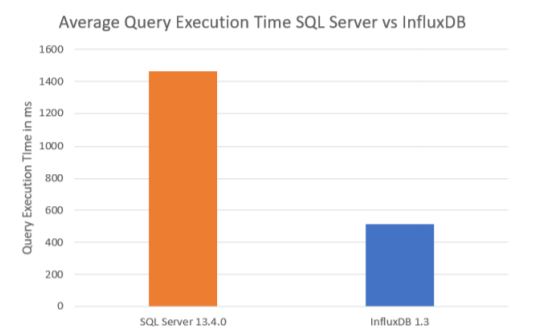
* In InfluxDB, a timestamp identifies a single point in any given data series. This is like an SQL database table where the primary key is pre-set by the system and is always time.
* An InfluxDB measurement is similar to an SQL database table.
* InfluxDB tags are like indexed columns in an SQL database.
* InfluxDB fields are like unindexed columns in an SQL database.
* InfluxDB points are similar to SQL rows.
* InfluxDB continuous queries and retention policies are similar to stored procedures in an SQL database.

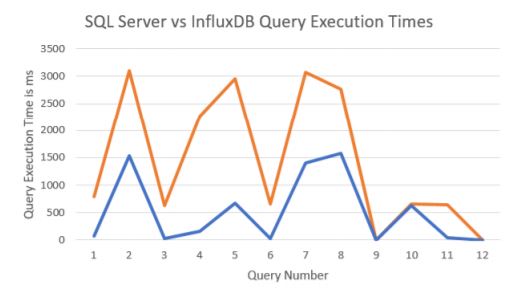
InfluxQL is an SQL-like query language provided by InfluxDB, which provides statements for data and schema exploration, database management, continuous queries, mathematical and aggregation function and authentication and authorization.

For Data Exploration, InfluxQL supports basic SELECT statement, as well as clauses, such as WHERE, GROUP BY, INTO, ORDER BY, LIMIT and OFFSET. Moreover, InfluxQL provides subqueries functionality as an alternative to SQL’s HAVING clause. InfluxQL also provides a TIMEZONE clause (tz()) which returns the UTC offset for the specified time zone. Regarding Database Management statements like DROP/CREATE database, DROP series, DROP measurement, DROP shard and DROP/ALTER/CREATE retention policy are provided and are self-explanatory. However, when authorization is enabled these commands are only available to admin users. Moreover the database can be backed up using the command .\influxd backup -database [database name] -retention [retention policy] -since [start date for backup] [destination folder] and restored using first the command influxdb restore -metadir [path to InfluxDB metadata folder] [backup path] for restoring the metadata and the command influxd restore -database [database name] -datadir [path to InfluxDB data folder] [backup path] for actually restoring the database. InfluxDB provides support for Continues Queries, namely queries that run automatically and periodically on real-time data and store query results in a specified measurement. This is extremely important when it comes to time series and real time analysis.

[1] Below graphs represents the compression ratio on disk and query execution time for SQL server and InfluxDB.







1. **InfluxDB design and tradeoff**

Schema design goal is to minimize Cardinality, Information-encoding, key lengths and to maximize write performance, query performance and readability.

For the time series, we assume that if the same data is sent multiple times, it is the exact same data that a client just sent several times. Pro: Simplified conflict resolution increases write performance. Con: Cannot store duplicate data; may overwrite data in rare circumstances.

Deletes are a rare occurrence. When they do occur, it is almost always against large ranges of old data that are cold for writes. Pro: Restricting access to deletes allows for increased query and write performance. Con: Delete functionality is significantly restricted. Time series data is predominantly new data that is never updated. Pro: Restricting access to updates allows for increased query and write performance. Con: Update functionality is significantly restricted.

The vast majority of writes are for data with very recent timestamps and the data is added in time ascending order. Pro: Adding data in time ascending order is significantly more performant. Con: Writing points with random times or with time not in ascending order is significantly less performant.

Scale is critical. The database must be able to handle a high volume of reads and writes. Pro: The database can handle a high volume of reads and writes. Con: The influxDB development team was forced to make tradeoffs to increase performance.

Being able to write and query the data is more important than having a strongly consistent view. Pro: Writing and querying the database can be done by multiple clients and at high loads. Con: Query returns may not include the most recent points if database is under heavy load.

Many time series are ephemeral. There are often time series that appear only for a few hours and then go away, e.g. a new host that gets started and reports for a while and then gets shut down. Pro: InfluxDB is good at managing discontinuous data. Con: Schema-less design means that some database functions are not supported e.g. there are no cross table joins.

No one point is too important. Pro: InfluxDB has very powerful tools to deal with aggregate data and large data sets. Con: Points don’t have IDs in the traditional sense, they are differentiated by timestamp and series.

1. **Recommended schema design**

Encode meta data in tags: Tags are indexed, and fields are not indexed. This means that queries on tags are more performant than those on fields. Queries should guide what gets stored as a tag and what gets stored as a field:

* Store commonly queried meta data in tags
* Store data in tags if we plan to use them with the InfluxQL GROUP BY clause
* Store data in fields if we plan to use them with an InfluxQL function
* Store numeric values as fields (tag values only support string values)

Avoid too many series: Tags containing highly variable information like UUIDs, hashes, and random strings lead to many series in the database, also known as high series cardinality. High series cardinality is a primary driver of high memory usage for many database workloads.

Avoid the same name for a tag and a field: This often results in unexpected behavior when querying data.

Avoid encoding data in measurement names: InfluxDB queries merge data that falls within the same measurement; it’s better to differentiate data with tags than with detailed measurement names. If we encode data in a measurement name, we must use a regular expression to query the data, making some queries more complicated or impossible.

Avoid putting more than one piece of information in one tag: Splitting a single tag with multiple pieces into separate tags simplifies our queries and reduces the need for regular expressions.

1. **InfluxDB performance improvement**

*Use fields for high-cardinality values*: InfluxDB stores the index of each series in memory. In-memory representation is relatively compact, and size of this index has direct query performance implications. use fields for high-cardinality values, values we need to perform math on (mean, derivative, etc), or values that we need to store as a specific type (boolean, int, float, etc.). Use tags for values we need to use in GROUP BY, or that we frequently reference in the WHERE clause. For example, response time of the website should be stored in InfluxDB as a field and HTTP response code is stored as a tag.

Because fields are not being indexed at all, on every query where InfluxDB is asked to find a specified field, it needs to sequentially scan every value of the field column. This behavior is generally not preferred as it can increase response times significantly, especially on larger data sets. Workloads like this can be parallelized by the use of seek and limit operations on the client side. It is however more beneficial to rearrange the database schema and simply specify those fields as tags, getting constant access.

*Down-sample the data using Retention policies and Continuous queries*: Retention policies determine how long database will store the data. Continuous queries are a query that runs automatically over sampled data from 1 retention policy to another.

*Put similar data into the same measurement and separate un-similar data into different databases*: Data is stored in columnar format. Heavier the points, more data can be compressed and queried at once. Separate un-similar data into different databases to gain large performance gains in the long run.

InfluxDB offers new features for query management, in the style of “fail fast” approach. Administrators can now use these functions and specify hard limits to guarantee a certain level of throughput, effectively enforcing clients to retry in case of timeouts, instead of completely hogging the system.

*Optimizing reads*:

Caching repeat response data: Meta queries (SHOW MEASUREMENTS, SHOW TAG KEYS, SHOW SHARDS, etc.) often return unchanging or infrequently changing data but can be somewhat expensive in certain use cases. We can implement caching layers to reduce load on Influx and reduce “hangtime” of said queries.

A time series database is not only optimized for time series writes but also time series queries. Time-bounding, selecting specific fields, and WHERE filtering by series if possible:

Columnar storage expects to be hit with columnar style queries; queries that SELECT (or filter) for specific columns. This contrasts with the common SQL query, SELECT \* FROM.

Filtering: Filtering by time is the most obvious form of filtering a query but is overlooked by a lot of users that are new to the time series database world.

Filtering by metric/asset/series is similarly important. Time series databases (columnar stores) aren’t optimized for reading out data from every single “column” like a relational database might be. This means it’s important to — if possible — SELECT only the fields we want data from and to WHERE filter our Tags so that only the series keys that contain the information, we want are scanned by the query engine.

Aggregates are much faster to compute than queries that return raw, unprocessed data.

Batch functions require reading all data into memory before processing whereas streaming functions do not:

Batch: percentile(), holt\_winters(), median(), mode(), spread(), stddev()

Stream: mean(), min(), max(), first(), last(), top(), sum(), elapsed(), moving\_average()

Increase shard duration (comes with write performance and storage/compaction trade-offs)

When a query is searching through storage to retrieve data, it must allocate new memory for each shard. Many shards mean more memory usage.

A cursor is created to reference each series per shard. If we run a query evaluating a single field for 1,000 series across 3 shards, 3,000 cursors will be generated at a minimum which has CPU and memory implications. For the most part, “high query load” is defined by number of shards accessed, whether it’s one query that accesses many or many queries that each access one unique shard.

*Shard durations*:

Longer:

* Better overall read and write performance due to active/”hot” shards (the longer a shard duration, the longer a shard will be “hot” or uncompressed and more optimal for query)
* More efficient compactions
* Fewer compactions

Shorter:

* Less expensive compactions
* More manageable

*Precise precision*: Should not choose a precision that is smaller than the collection interval. Regularly spaced points can lead to larger compression benefits. There is only one process writing to a shard at any given time, so the more we can separate our shards out (by splitting them into different databases) the more writes that can occur simultaneously. For example, if we are collecting and storing metrics every 100 seconds, then use seconds precision. Choosing a precision smaller than seconds will lead to wasted space and a larger overhead in performance.

1. **Conclusion**

InfluxDB is one of the most powerful time series databases and it entails some tradeoffs, primarily to increase performance at the cost of functionality. This report provides InfluxDB concepts, general guidelines to follow and pitfalls to avoid when designing the schema. In the later part, summarized few tips to provide a better understanding of how to get the best performance out of InfluxDB such as using fields for high-cardinality values, down-sample the data using retention policies and continuous queries, keeping similar data in the same measurement and un-similar data in the different databases, caching repeat response data, filtering, shard durations, and precise precision. By using all these performance matrices, we should be able to achieve a significant query performance in InfluxDB.

**VIII. References:**

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