Database Benchmarking

Benchmarking is used for comparing/analysing databases and database management systems (DBMS) as a tool for comparing solutions to problems, and ultimately deciding which solution is the best to use. This is because not all databases or DBMS are suitable for every application.

Benchmarking Concept

Older benchmarking methods include SWOT analysis and potential analysis, and would often be presented as a portfolio or a diagram. The general steps for benchmarking include:

1. A model definition – setting goal, process and constraints for the analysis
2. Identify all the related entities, resources, artefacts and data
3. Measure and calculate all analysis options
4. Compare the results of the analysis with the benchmark

General Database Benchmarking

The workload - defined as a 'sequence of operations issued on a database' which 'defines the variance of operations as well as access patterns' (benchANT, no date) that is applied by a benchmark – differs depending on which CRUD operation you are doing, and thus this will also change the benchmark results. They can either be processed by time or sequence. The workload can either be based on trace-based/real-world or synthetic data and will often be categorised into Online Transaction Processing (OLTP), Hybrid Transactional/Analytical Processing (HTAP) or Online Analytical Processing (OLAP). Other synthetic benchmarks include (TPC-C) and Transaction Processing Council Ad-hoc/decision support (TPC-H).

Benchmark Type Definitions

OLTP is defined as 'a type of data processing that consists of executing a number of transactions occurring concurrently' which are often 'economic or financial transactions, recorded and secured so that an enterprise can access the information anytime for accounting or reporting purposes.' (Oracle, no date) It is a synthetic benchmark.

J. Biscobing (no date) describes OLAP as 'a computing method that enables users to easily and selectively extract and query data in order to analyse it from different points of view' which is

used for 'trends analysis, financial reporting, sales forecasting, budgeting and other planning purposes.'

The main difference between OLTP and OLAP is that OLTP is used for real-time execution of many transactions by many people and OLAP is instead used for querying the transactions in the database for analysis, which companies then use for reviewing and decision-making later.

HLAP is a data architecture which connects OLTP and OLAP workloads, allowing an organisation to use one database for both types. This type of system was developed as it was much faster than running two separate databases, and the data could stay up-to-date while it was being analysed, unlike before.

TPC (no date) describes the TPC-C benchmark as a simulation of 'a complete computing environment where a population of users executes transactions against a database' which is 'centred around the principal activities (transactions) of an order-entry environment' such as delivering orders, recording payments or managing stock levels. The benchmark can represent any organisation which manages, sells, or distributes a product.

Alternatively, TPC-H is used for decision support through 'business-oriented ad-hoc queries and concurrent data modifications' (TPC, no date). It is particularly useful for processing large complex sets of data. It compares the database size against query volume, query processing power and query output against number of concurrent users.

Cloud Database Benchmarking

As cloud computing becomes more popular, companies have started to use cloud-based technologies for benchmarking as they are more flexible and can handle very intensive data. Other advantages include However, the results can vary depending on the provider and configuration of the cloud, database and benchmark used. Because of this, using cloud database benchmarking is often more complex and the classic benchmarking methods cannot be used for it. It is also currently not possible to guess the reliability of a particular setup, and must be tested through trial-and-error.

Database Benchmarking Process

After deciding on a database to benchmark, there is an outline of steps that can be taken to achieve helpful results.

Design

In the Design phase, the organisation will determine what aspects of the database need to be measured - such as performance, scalability, availability, elasticity or cost – and how to

measure them. After this, the organisation will choose an appropriate benchmark and workload.

Lastly, test runs of the benchmarking process will occur in several iterations to obtain an idea on what reliable results should look like.

Execution

The execution of the database benchmarking is entirely dependent on what was planned and agreed upon during the Design phase. To obtain fair results, you need to use different resources and software to the database you are benchmarking.

Analysis

The Analysis stage takes place after the Execution stage, where the results are measured and statistically processed. They are then compared with each other to see which configuration yields the best.

The data often needs to be visualised, and comparable KPIs are calculated. The amount of analysis required is dependent on the original problem statement, the number of results and the distribution of the results.

Differences Between Cloud and Non-Cloud

The process is slightly different depending on whether you are using cloud or non-cloud resources, but each stage is the same.

Non-Cloud	Cloud
You can only test a few physical servers at a time	You can test several servers at the same time
You need to purchase servers based on the specifications given by the manufacturer	You can create servers with custom specifications
The process is much simpler due to the limited choice surrounding physical servers	The process is far more complex due to the flexibility of cloud services
The scalability and cost are determined by what is available	You have too much choice – a lot of options to trial and error
You can make estimations on the performance, power, cost and availability of the server	You need more experience and domain knowledge to work with cloud database benchmarking
The installation and setup of the servers and databases must be done manually, through	The setup of the servers and database require accounts, credit card information and API keys. The installation can be done

the command line. Tools are available that can assist this	through a user interface or templates. Wiring components is very complicated to manage due to being dynamic
It is recommended to try and automate some of the measurement and data preparation to obtain reliable/reproducible results	It is mandatory to have some automation to changing IPs and the multitude of combinations
The analysis is usually much easier due to fewer measurement configurations, fewer fluctuations in the infrastructure and a one-dimensional target variable	The data is often large and multi-dimensional, therefore requiring multiple experienced analysts using modern data science techniques
Viewing results in a two-dimensional program causes no issues	Multidimensional visualisation and complex scoring system mandatory
	There are a lot of fluctuating outliers in the results

Difficulties and Challenges

While the overview of benchmarking is relatively simple, there are many challenges surrounding database benchmarking – especially in the cloud. The largest challenge is the multiple different combinations of configurations, and the only way reliable results can be achieved in any considerable time-period is by narrowing down the options – by educated guessing. However even after this is done, there is still a large number of possible configurations and it is still impossible to test them all. After the test runs, the options of possible configurations must be narrowed down further and the ideal option can only be selected after the final iteration.

A rigorous amount of research into databases, cloud services and software implementation must be completed before setting up the first database benchmark configuration. Then, the cloud or physical resources must be set up either by the organisation or the cloud provider and this can be difficult and time-consuming.

The objective of the benchmarking process must be clear from the start, and the data must be statistically processed and prepared for efficient comparison, and this is not easy to do, especially if the data is time-series data and it is often not the field of expertise for most IT team members. It is imperative that the data is displayed visually so that everyone can understand them.

During the process, the database or cloud computing technologies could change as the industry changes, and therefore it is important to keep up with these changes. Changing versions of software can also dramatically change the results – often negatively.

Lastly, the data, software and other resources used must be free from bias – otherwise the results will be affected. Measurements using the same configuration must also be done more than once in case outliers were produced.

References:

1. benchANT (no date) *What is Database Benchmarking?* Available from: https://benchant.com/blog/database-benchmarking [Assessed 12/02/2024]

2. ScyllaDB (no date) *Database Benchmark* Available from: https://www.scylladb.com/glossary/database-benchmark/ [Assessed 12/02/2024]

3. Oracle (no date) *What is OLTP?* https://www.oracle.com/uk/database/what-is-oltp/ [Assessed 14/02/2024]

4. J. Biscobing (no date) *OLAP (online analytical processing)* https://www.techtarget.com/searchdatamanagement/definition/OLAP [Assessed 14/02/2024]

5. M. Zweben and S. Ferragut (2020) *How To Benchmark an HTAP Database* https://www.techtarget.com/searchdatamanagement/definition/OLAP [Assessed 14/02/2024]

6. Snowflake (no date) *HTAP: HYBRID TRANSACTIONAL AND ANALYTICAL PROCESSING* https://www.snowflake.com/guides/htap-hybrid-transactional-and-analytical-processing/#:~:text=Hybrid%20transactional%2Fanalytical%20processing%20(HTAP,to%20support%20both%20processing%20sets. [Assessed 14/02/2024]

7. K. Ksiazek (2021) *Benchmarking databases 101 – part 1* https://severalnines.com/blog/benchmarking-databases-101-part-1/ [Assessed 14/02/2024]

8. Indicative (no date) *What Is A TPC-H Benchmark?* https://www.indicative.com/resource/tcp-h-benchmark/ [Assessed 14/02/2024]

9. TPC (no date) *TPC Benchmark Overview* https://www.tpc.org/information/benchmarks5.asp [Assessed 14/02/2024]

10. LinkedIn (2023) *How do you load test and benchmark databases?* https://www.linkedin.com/advice/0/how-do-you-load-test-benchmark-databases#:~:text=Benchmarking%20is%20the%20process%20of,your%20specific%20needs%20and%20goals. [Assessed 14/02/2024]