# Open Source Business Intelligence Tools: Metabase and Redash

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Abstract: This electronic document is an article that explores the capabilities of Business Intelligence tools, primarily their ability to analyze generated business data gathered from a company. These corporations can improve (or even create) their products according to the insights provided by these platforms, with the possibility of outclassing their direct competitors, something to be proved crucial for an ever-evolving market. In this article, we have tested and compared two of the most promising open-source BI platforms currently available: these are Metabase and Redash. Our focus is to analyze what they offer as a package, where we defined some key points, such as: overall performance, search engine compatibility, key features, etc. May we remind that the implementation of a platform of choice, concerning BI software, may vary according to company demands. Some tools may be more suitable for a corporation, while others may be the best choice for a different entity.

## 1 INTRODUCTION

In recent years, technology has grown in the innovation component on a tremendous scale. G. R. Gangadharan and S. N. Sundaravall (Gangadharan and Sundaravall, 2004) wrote that: “Managing an organization requires access to information in order to monitor activities and assess performance”.

However, one of the current realities is that there are still business owners who use Excel sheets and paper records to track business development and record data. Neil Raden (Raden, 2005) acknowledged this by stating: “There are over 150 million business users of Excel worldwide, and a large proportion of them are devoted, at least part of the time, to entering data by hand, extracting data manually from other systems and functioning as report servers”.

These owners maintain a high level of confidence in these methods which, unfortunately, ends up revealing how much of a "closed mindset" they have when it comes to adopting new strategies.

The necessity of a platform for decision support is rapidly increasing, especially if it’s a large business we’re speaking of. We must consider that with the amount of data stored by companies growing exponentially, it comes to no surprise that finding a more efficient data management solution should be at the top of these industry owners’ priority list. Chandra Nandyala and Haeng-Kon Kim (Nandyala and Kim, 2016) wrote: “Data needs to be secure, and its distribution must be done efficiently so that important and up-to-date business decisions are made. In today’s world, the way to store and retrieve or access personal as well as other information has captured a massive revolution”.

To resolve this matter, the concept of Business Intelligence started to gain more traction, although it wasn’t quite study yet. Bernhard Wieder and Maria-Luise Ossimitz (Wieder and Ossimitz, 2015) stated that: “Business Intelligence (BI) systems have been a top priority of CIOs for a decade, but little is known about how to successfully manage those systems beyond the implementation phase”.

Undeniably, it’s critical for companies that gathered data is translated into information for planning future business strategies. For a lot of these, valuable data is stored on large-scale servers, the so-called clusters. Ideally, this stored data should provide information on sales trends, consumer behaviors, and resource allocation.

And for this reason, the market started to appraise Business Intelligence, investing more into these systems. William Yeoh and Andy Koronios (Yeoh and Koronios, 2010) wrote that: “(The) BI market appears vibrant and the importance of BI systems is more widely accepted, few studies have investigated the critical success factors that affect the implementation success”.



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Company data can indicate the viability of a given product and determine key indicators for potential future expansion and/or growth. In this way, data can help maximize revenues and reduce costs.

Currently, huge organizations are adopting BI systems in the field of Information Technology that are able of operations such as extract data, convert what was collected into understandable values, and then cram those into the platform, being then able to fully analyze the given data.

Mihaela Muntean and Traian Surcel (Muntean and Surcel, 2013) state that: “Traditional BI systems use ETL tools for extracting data from multiple sources and temporarily storing those datasets at a staging area. Organizations use data warehouses to aggregate cleaned and structured data”.

Another relevant area that should be mentioned is IoT (Internet of Things). According to In Lee and Kyoochun Lee (Lee and Lee, 2015): “IoT devices and machines with embedded sensors and actuators generate enormous amounts of data and transmit it to business intelligence and analytics tools for humans to make decisions. These data are used to discover and resolve business issues - such as changes in customer behaviors and market conditions - to increase customer satisfaction, and to provide value-added services to customers”. They further expand stating: “Business analytics tools may be embedded into IoT devices, such as wearable health monitoring sensors, so that real-time decision making can take place at the source of data”.

The remainder of this article will be structured as follows: section II dives more into what Business Intelligence stands for while correlating with the topic of open-source technologies, also expanding on the technologies to be tested; section III describes the experimental setup used to perform tests on the open-source BI platforms in study, e. g., utilized hardware; section IV displays the obtained results derived from testing; and in section V we present our conclusions, adding a perspective for our future work.

# 2 STATE OF ART

*A. Business Intelligence*

It’s primarily in the data analysis component that Business Intelligence (also known by the abbreviation BI) tools materialize. According to Solomon Negash and Paul Gray (Negash and Gray, 2008): “Business Intelligence (BI) is a Data-Driven Decision Support System (DSS) that encompasses data collections, data storage, and curriculum management to facilitate entry into the decision-making process. (...) Business Intelligence is an analysis of large volumes of data about a company and its operations. Includes competitive intelligence (customer concentration) as a subset. In computing environments, a large database, such as a data warehouse or data mart, is used as a source of information and as a database for the sophisticated ones. Reads range from receiving the "data slices", will receive an ad hoc review, a real-time analysis and a forecast. (...) Recent developments in this area include business performance analysis (BPM), business activity monitoring (BAM) and BI expansion of your workforce for people across the organization (BI for the masses). In the longer term, BI techniques and discoveries are embedded in business processes”.

This line of thought is expanded by Hugh J. Watson and Barbara H. Wixom (Watson and Wixom, 2007), as they imply: “(…) BI reduces IT infrastructure costs by eliminating redundant data extraction processes and duplicate data housed in independent data marts across the enterprise. (…) BI also saves time for data suppliers and users because of more efficient data delivery”.

Likewise, Marcus Gibson, David Arnott and Ilona Jagielska (Gibson, Arnott and Jagielska, 2004) state that: “The role of BI is to extract the information deemed central to the business, and to present or manipulate that data into information that is useful for managerial decision support. In their simplest form, these tools permit a decision maker to access an up to date, often consolidated, view of business performance.”

The concept of Business Intelligence can be traced back to the early 90’s, according to Matteo Golfarelli, Stefano Rizzi and Iuris Cella (Golfarelli, Rizzi and Cella, 2004): “BI was born within the industrial world in the early 90’s, to satisfy the managers’ request for efficiently and effectively analyzing the enterprise data in order to better understand the situation of their business and improving the decision process. In the mid-90’s BI became an object of interest for the academic world, and ten years of research managed to transform a bundle of naive techniques into a well-founded approach to information extraction and processing”.

BI has seen a rise in popularity in the Northern Europe region, according to Mika Hannula and Virpi Pirttimaki (Hannula and Pirttimaki, 2003): “Business Intelligence activities have recently become much common in Finland. It is common knowledge that large-scale companies operating in a global marketplace – especially in the ICT sector – do put effort into sophisticated BI activities”.

Similar to an OLAP (On-Line Analytical Processing) tool, BI is integrated in the Data Access Tools stage of an Data Warehouse platform. As pointed out by Dr. Jawahar Babu (Babu, 2012): "The data warehouse is the significant component of business intelligence. It is subject oriented, integrated. The data warehouse supports the physical propagation of data by handling the numerous enterprise records for integration, cleansing, aggregation and query tasks. It can also contain the operational data which can be defined as an updateable set of integrated data used for enterprise wide tactical decision-making of a particular subject area. It contains live data, not snapshots, and retains minimal history".

Supporting this claim are Barbara H. Wixom and Hugh J. Watson (Wixom and Watson, 2010), when mentioning people who work on Data Warhouse systems: "A variety of stakeholders play essential BI roles. Extraction, Transformation and Loading (ETL) experts, data modelers and database administrators focus on preparing the data warehouse for use".

So, subsequently, we can safely assume that software provided by technologies in the BI department is fulfilling a lot of the criteria present in the current market. As stated by Joaquim Lapa, Jorge Bernardino and Ana Figueiredo (Lapa, Bernardino and Figueiredo, 2014): "(…) we consider the presence of Collaborative Technologies in BI platforms will be a requirement for organizations (…)".

The possibilities that BI reports offer, whether for their clearly understandable information, or for their facilitated interaction, coupled with intuitively designed dashboards for a more assessed evaluation from the user, makes Business Intelligence a "must" in order to organizations have a thriving future.

*B. Open source BI*

We've seen so far how promising Business Intelligence software is, but most of the tools out there are "locked" behind a monthly subscription fee, tools that are only within the realm of larger corporations. But what about smaller firms? These organizations may not have the economic capabilities to afford a tool that may cost more than 5000$ per month.

Thankfully, there has been a notable ascension in BI platforms that are open source. And contrary to what you may think, these are no slouch either. Karim Lakhani and Eric von Hippel (Lakhani and von Hippel, 2004) state that: "Open source software products represent the leading edge of innovation development and diffusion systems conducted for and by users themselves – no manufacturer required". The question here is, why use open source BI platforms? Well, to answer that, we must briefly discuss the benefits of open source.

One of the most prominent reasons to "go open" is how you can access an application developed by a "team" of talented people, with the release of several stable versions, and be instructed how to use it with the help of pages of detailed online documentation they have created, available to the general public. Chris Coppola and Ed Neelley (Coppola and Neelley, 2004) claim that: "New versions are released very often and rely on the community of users and developers to test it, resulting in superior quality software tested on more platforms, and in more environments than most commercial software".

Other benefit resides in the fact that you may be able to customize (depending on a license) the application to suit your needs, or the company's. Brian Fitzgerald (Fitzgerald, 2006) stated that: "High-profile organizations like Amazon, Google and Salesforce.com take advantage of the reliability and low cost of open source to create a platform on which they can offer value-added services in their own business domains. (…) These companies also customize open source products to suit their internal needs".

Lastly, we must not forget what makes these applications open source, the price. Or rather, the lack of it. A big reason that attracts customers and companies alike is the fact that you don't have to pay for the software whilst having a well-supported app by the community that is also able to combine proprietary technology with open source technology. InduShobha Chengalur-Smith, Saggi Nevo and Pindaro Demertzoglou (Chengalur-Smith, Nevo and Demertzoglou, 2010) concluded that: "(…) compatibility of the open source technology with the existing technology infrastructure creates an environment that promotes use of the technology and increases the opportunity for realizing business value".

The open source model has proven itself to be as crucial as it is viable and combining this with Business Intelligence may possibly give us a powerful tool that is within the reach of both smaller and larger companies.

*C. Metabase*

Metabase is an open source tool that allow people in a company to ask questions and learn from data descendant from data sources. This software allows filter and/or group data according to user needs, without resorting to Structured Query Language (SQL). If needed, Metabase also provides with a SQL interface for users.

This tool has a functionality that monitors questions created by users to gain insights on the available data. These questions can produce graphs and charts, and these visualizable results can be saved and organized in Dashboards.

The Metabase platform is available under three types of licences: AGPL, which is free of costs, Premium Embedding License, with acquisition costs (includes a White labeled Embedding option), and Metabase Commercial License, with acquisition costs (offers more functionalities not present in the previous mentioned license). For this project, we used the free v0.32.7 version of Metabase.

### *D. Redash*

Redash is an open source platform that lets a user connect and query his data sources by browsing the existing schemas through the usage of an incorporated SQL editor. Available also is an option to schedule data sources refresh times.

A user can visualize data by building dashboards with graphs and charts, by simply dragging and dropping them. These dashboards can be shared within the company with other users or can be shared publicly.

The Redash platform is available in two models: free and paid. Within the paid model there are three types of packages: Starter, Pro, and Business, where the key difference between these three is the number of data sources, dashboards, saved queries and maximum query execution times allowed. For this project, we used the free v7.0.0 version of Redash.

## 3 EXPERIMENTAL SETUP

With this project, we wish to demonstrate the potential of the Business Intelligence tools under study, by querying the data present in databases, which will be connected to the BI tools, and transform that data into easily perceived dashboards and/or graphs to demonstrate how they allow us to identify patterns and facts of potential relevance. These created graphics are entirely dependent on the capabilities of the tool. The queries will be made in the same way for either.

In order to carry out the desired tests, databases were set up with large amounts of data coming from a search engine of our choice. These databases are stored on personal computers, meaning that they are not present in the cloud.

The search engine in question is MySQL, since it is compatible with both of the Business Intelligence tools. This proved to be beneficial for us, since we have experience working with this search engine, whilst having an idea of the capabilities of it. Although, we must mention that it was not our first choice.

We initially thought of using PostgreSQL, but we found issues when trying to insert more than 20 million rows with the inclusion of indexes (this subject will be expanded further). So, we resorted to MySQL instead, a search engine we had work with during our scholar years, which proved to be capable of handling these large datasets, both with indexes and without them.

To generate the data that would populate our MySQL databases, it was necessary to use the TPC-H tool. This tool allowed us to generate data on the threshold of Gigabytes, which are fragmented into 8 TBL files. In order to insert the data in the tables directly into the search engine, it was necessary to convert the files in TBL format to CSV format.

The two databases used have the same tables: Orders, Lineitem, Customer, Supplier, Part, Partsupp, Nation and Region, as they have the same number of records in them:

- Region: 5 rows.
- Nation: 25 rows.
- Supplier: 80 thousand rows.
- Customer: 1,2 million rows.
- Part: 1,6 million rows.
- Partsupp: 6,4 million rows.
- Orders: 12 million rows.
- Lineitem: 48 million rows (aprox.).

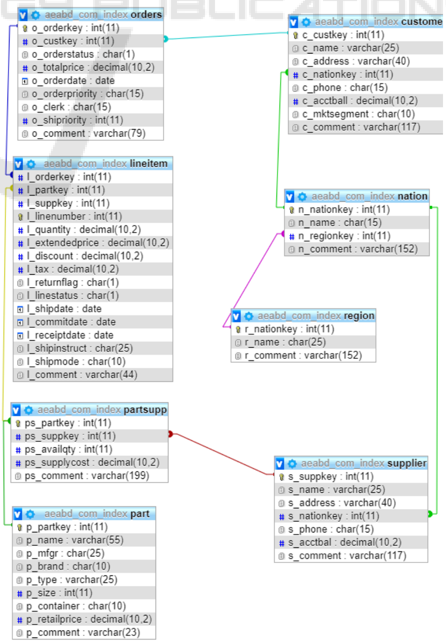


Figure 1: Schematic of the used tables (with index example).

In the above available Fig.1 we present the schema, created using a tool present in MySQL, that includes the tables and relations shared by the two databases.

The key difference between the two is that indexes have been created in one of the databases. This implies that the index database will have a larger size than the non-index database. The Database with indexes has a total of 10.1 Gigabytes of data, while the indexless DB totals at 9.3 Gigabytes, as can be seen in Fig. 2 and Fig. 3.

It is intended to compare databases without indexes directly with the DB with indexes to verify if there are any differences between the Business Intelligence software regarding the processing of queries made, more specifically, what are the response times.

All test queries made in the Business Intelligence tools and the MySQL search engine were performed using two laptops with the same CPU: Intel i7-8750H

| Table | Rows | Type | Collation | Size |
|---|---|---|---|---|
| customer | 1,200,000 | InnoDB | utf8_general_ci | 243.3 MiB |
| lineitem | 47,989,007 | MyISAM | utf8_general_ci | 6.5 GiB |
| nation | 25 | InnoDB | utf8_general_ci | 32 KiB |
| orders | 12,000,000 | InnoDB | utf8_general_ci | 1.9 GiB |
| part | 1,600,000 | InnoDB | utf8_general_ci | 291.4 MiB |
| partsupp | 6,400,000 | InnoDB | utf8_general_ci | 1.2 GiB |
| region | 5 | InnoDB | utf8_general_ci | 32 KiB |
| supplier | 80,000 | InnoDB | utf8_general_ci | 15 MiB |
| **8 table(s)** | **69,269,037** | **InnoDB** | **utf8_general_ci** | **10.1 GiB** |

Figure 2: Database Tables with Indexes (Action tab removed).

| Table | Rows | Type | Collation | Size |
|---|---|---|---|---|
| customer | 1,200,000 | InnoDB | utf8_general_ci | 225.8 MiB |
| lineitem | 47,989,007 | MyISAM | utf8_general_ci | 6 GiB |
| nation | 25 | InnoDB | utf8_general_ci | 16 KiB |
| orders | 12,000,000 | InnoDB | utf8_general_ci | 1.7 GiB |
| part | 1,600,000 | InnoDB | utf8_general_ci | 263.8 MiB |
| partsupp | 6,400,000 | InnoDB | utf8_general_ci | 1.1 GiB |
| region | 5 | InnoDB | utf8_general_ci | 16 KiB |
| supplier | 80,000 | InnoDB | utf8_general_ci | 13.5 MiB |
| **8 table(s)** | **69,269,037** | **InnoDB** | **utf8_general_ci** | **9.3 GiB** |

Figure 3: Database Tables without Indexes (Action tab removed).

Hexa-Core, with a base clock of 2.2 GHz, max clock of 4.1 GHz and 9 MB of Cache. A third computer was used to house the tools described in this study. The computer has a different CPU than the previously described laptops: Intel i7-4710HQ Quad-Core, with a base clock of 2.5 GHz, max clock of 3.5 GHz and 6MB of Cache.

Finally, Fig. 4 shows the queries that will serve as a test for what we will search for in both BI softwares.

```
Query A:
SELECT count(*)
FROM lineitem;
```

```
Query B:
SELECT o_orderkey, n1.n_name, n2.n_name
FROM orders, lineitem, partsupp, supplier, nation n1, nation n2,
WHERE o_orderkey = l_orderkey
AND l_partkey = ps_partkey
AND l_suppkey = s_suppkey
AND s_nationkey = n1.n_nationkey
AND o_custkey = c_custkey
AND c_nationkey = n2.n_nationkey
AND o_orderkey = 492164;
```

```
Query C/D:
SELECT l_orderkey, l_linenumber, l_extendedprice
FROM lineitem
WHERE l_extendedprice < [VALOR];
Com [VALOR] a tomar os valores 1000 (Query C) e 100000 (Query D).
```

```
Query E:
SELECT l_orderkey, l_partkey
FROM lineitem, part
WHERE l_partkey = p_partkey
AND p_size = 20
AND p_container = 'JUMBO BOX'
AND p_type = 'PROMO BURNISHED COPPER';
```

```
Query F:
SELECT c_custkey, c_name FROM customer
WHERE lower(c_name) = 'customer#000000010';
```

Figure 4: Test Queries.

# 4 RESULTS

By using the SQL Editor in each of the Business Intelligence tools, the SQL queries mentioned in the previous chapter were performed. Fig. 5 and Fig. 6 show the software editors used in the context of our project in its fullness.

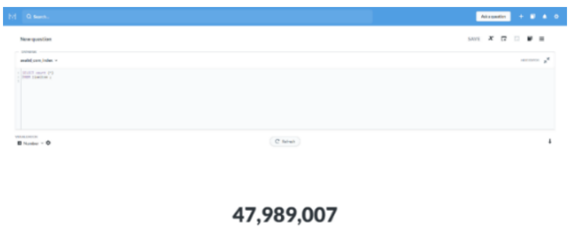


Figure 5: Metabase SQL Editor.

After querying the data using the Business Intelligence tools without index and with index, as desired, the query execution times were recorded, as well as graphs were created using the results obtained by the queries in the respective tools, with the purpose of exploring their potential in this field.

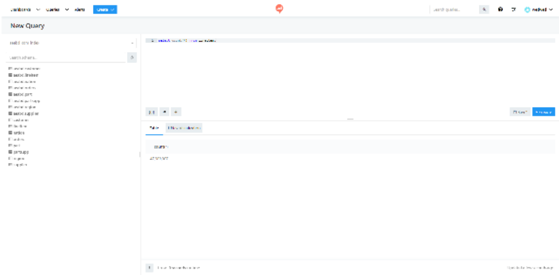

Figure 6: Redash SQL Editor.

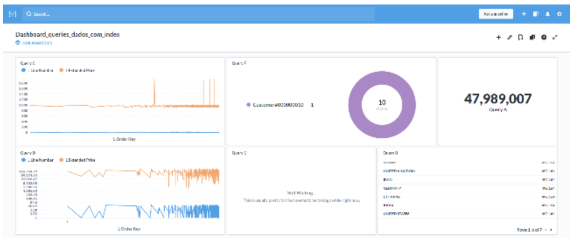

Figure 7: Metabase's Dashboard of data with indexes.

The dashboards created in Metabase can be found in Fig. 7 and Fig. 8, where the first figure corresponds to the index data dashboard, while the second is related to the data without index.

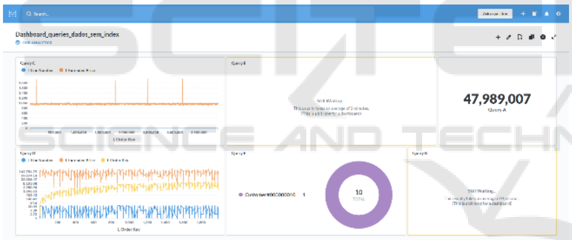

Figure 8: Metabase's Dashboard of data without indexes.

Similarly, the dashboards created in the BI Redash tool are shown in Fig. 9 and Fig. 10, where, according to the previously shared line of thought, the first figure corresponds to the dashboard of the index data, while the second corresponds to the data without index.

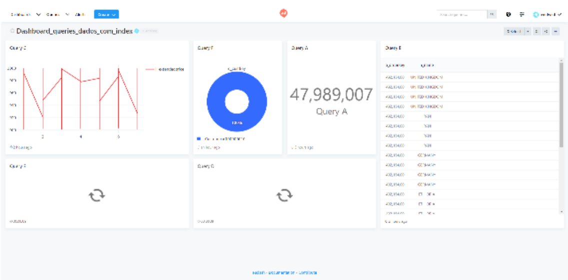

Figure 9: Redash's Dashboard of data with indexes.

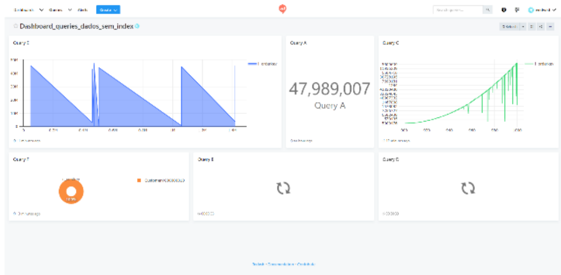

Figure 10: Redash's Dashboard of data without indexes.

In order to analyze the obtained results, in the execution times of the SQL queries component, charts were created where it's possible to make a direct comparison of Metabase with Redash, regarding the time that each query took to return the result.

This is true for both the indexed data, Fig. 11, as well as for the non-indexed data, Fig. 12.

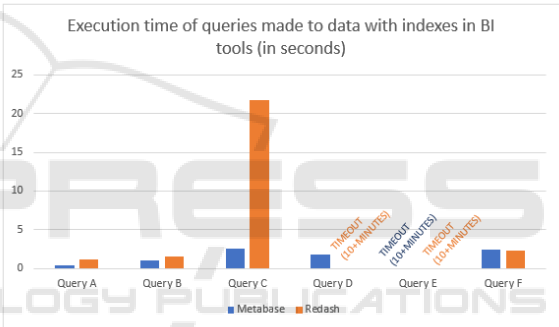


Figure 11: Chart of query results with indexes.

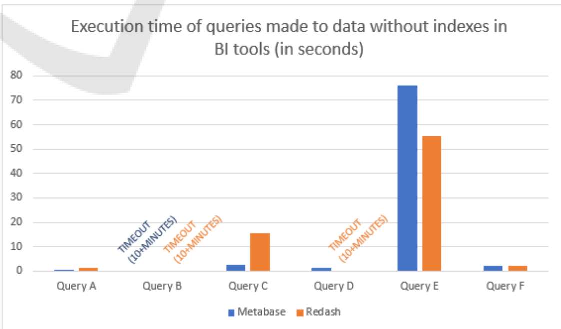


Figure 12: Chart of query results without indexes.

Based on the results obtained, we can draw the following conclusions:

- The query B, in the data without index, was not able to return any result, both in Metabase and in Redash.

- Contrary to the previous point, in the indexed data, the query returned results in both tools, both of which took less than 2 seconds.
- Interestingly, inversely to query B, query E, in indexed data, was unable to return results either in Metabase or Redash, returning only on non-indexed data, where Redash took less time to return information.
- In query D, for both indexed and non-indexed data, Redash was unable to obtain any kind of information.
- In query C, Redash took more time than Metabase to return information, either for data with indexes or data without them.
- In queries A, C and F, response times between index and non-index data showed no significant changes.
- It's particularly interesting to note that in Metabase, although query E has returned data, since it took more than 60 seconds to process it, the dashboard failed to display information about it.

## 5 CONCLUSIONS

With this article, we have analyzed BI in its essence by conducting several tests with big amounts of data. We found that the core definition of BI is mostly shared by several authors, defining Business Intelligence as a process where data is gathered, stored and transformed into information through analysis, and where information is transformed into knowledge that, ultimately, aids on the decision making side of organizations.

Developing on the topic of indexing, the results indicate that, for more general queries, where, in the most specific cases, ranges of values are specified (WHERE clause), there is a considerable difference that justifies the use of indexes. However, the biggest difference comes in the form of the JOIN clauses, where it's evident that the usage of indexes on table columns is noticeable in terms of performance. We recommend using indexes if a Business Intelligence expert is required to use queries with a JOIN clause.

Mentioning the results obtained in the execution of query B, as a reference point, it was noticed that, without the use of indexes, the query was not able to return results, however, with the use of these, the query returned data in a matter of seconds. It's in this perspective that, although the indexes imply an increase in size of the data present in tables, we recommend the implementation of these.

Speaking of user experience, the BI Metabase and Redash tools did not show a huge learning curve. The intended functionalities are located and organized in a very explicit way, and the documentation of the tools, when they were consulted, provided a good level of clarification.

Table 1: Comparison of integrations and search engines supported between Metabase and Redash.

| | Redash | Metabase |
|---|---|---|
| MySQL | ✓ | ✓ |
| PostgreSQL | ✓ | ✓ |
| MongoDB | ✓ | ✓ |
| Microsoft SQL Server | ✓ | ✓ |
| AWS Redshift | ✓ | ✓ |
| Google BigQuery | ✓ | ✓ |
| Druid | ✓ | ✓ |
| H2 | X | ✓ |
| SQLite | X | ✓ |
| Oracle | ✓ | ✓ |
| Crate | X | ✓ |
| Google Analytics | ✓ | ✓ |
| Vertica | ✓ | ✓ |
| Spark | X | ✓ |
| Presto | ✓ | ✓ |
| Snowflake | ✓ | ✓ |
| Amazon Athena | ✓ | X |
| Amazon Aurora | ✓ | X |
| Amazon Redshift | ✓ | X |
| Amazon DynamoDB | ✓ | X |
| Axibase TSDB | ✓ | X |
| Cassandra | ✓ | X |
| ClickHouse | ✓ | X |
| Druid | ✓ | X |
| ElasticSearch | ✓ | X |
| Graphite | ✓ | X |
| Greenplum | ✓ | X |
| Hive | ✓ | X |
| Impala | ✓ | X |
| InfluxDB | ✓ | X |
| MemSQL | ✓ | X |
| Rockset | ✓ | X |
| ScyllaDB | ✓ | X |
| Snowflake | ✓ | X |
| TreasureData | ✓ | X |
| **Total:** | **31** | **16** |

In terms of resource usage, Metabase has proved to be a more dependent tool regarding the hosted machine's hardware than Redash. The percentage of CPU and Hard Drive utilization in Metabase reached

26% and 92%, respectively, while Redash reached 12% and 76%, respectively.

In the compatibility side of things, Redash offers a greater number of integrations and compatible search engines, as it can be seen in the following table.

Of these documented search engines, integrations were tested only for with PostgreSQL and MySQL, with the later being used due to issues with PostgreSQL mentioned in the Experimental Setup chapter.

For future work, we intend to test these Business Intelligence tools using NoSQL search engines, e. g., MongoDB, supported by both Metabase and Redash, in the Internet of Things (IoT) area. Data generated by IoT devices is generally stored in these type of Database Management Systems (DBMS), and, as we mentioned in the State of Art chapter, IoT is one of Business Intelligence's most important areas of actuation currently.

Likewise, we intend to test these BI platforms on machines with more powerful specifications than the computers used in this project, in order to verify the differences in response times between databases with configured indexes and databases without indexes.

Finally, although we have used some charting options provided by these BI tools, we believe there is margin for further exploration of these options in a future approach.

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