MySQL

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1 Introduction

MySQL is one of the most popular databases that is used everywhere around the world. It is defined as an open source SQL database management system which is developed, distributed, and supported by the Oracle corporation.[8] A normal database is defined as a structured collection of data. Hence, in order to insert the data or to access the data or to process the data which is stored in computer database, we require a database management system called MySQL server. MySQL databases are referred as relational databases. The relational databases mainly stores the data in different tables rather than storing the data all in one. In this system, the logical model with tables, views, rows and columns gives a flexible programming environment. Since it is defined as an open source, that means anyone can download MySQL and perform operations on it. The free source which is available in the internet is defined as the MySQL community server. There is also an availability to change the source code as per the user wants and can use it accordingly. The MySQL server has a component named GNU General Public License(GPL) which allows the user about what to change and what not to change the server in different situations.

Along with that, MySQL databases are considered as very faster, reliable, scalable and easy to use. That means, the server can run on any application comfortably and has the availability to adjust the settings so that we can acquire an advantage of memory, CPU power and I/O capacity as well. MySQL server is mainly developed to handle the debases which has large amount of information. It is been successfully used in high demanding production environments, still it is being developed every day with the new features. MySQL has the ability to work in client/server or embedded format. The MySQL database is considered as a client/server system that has the ability to support different backends, client programs and libraries, some administrative tools, and several API's with the help of multithreaded SQL server. Some of the important features in MySQL according to the latest version are: It has the best security system by protecting with a password, Best for scalability by supporting the big databases, Best connectivity by using client/server approach, Best localization by providing the error messages to the client in different languages as per the requirement, provides both transactional and non-transactional storage engines.

2 History

MySQL is a combination of two names. One is "My" and the other one is "SQL". The word "My" came from the name of the daughter of MySQL cofounder Michael Widenius.[20] The word "SQL" is normal which stands for structured query language. The original author of MySQL it MySQL AB which is a Swedish company founded by David Axmark, Allan Larsson and Michael Monty Widenius. The first version is initially released on 23rd May 1995. Primarily, it was created for a personal usage from mSQL which is based on a low level language ISAM. Later, the creators thought that the system is too slow and decided to develop a faster database. By the end of 1996, the MySQL 3.19 version is released, and is being developed everyday. The current stable version is 8.0.15 is released on 1st February 2019. The MySQL AB is acquired by the Oracle company and developed the later versions.

3 Competitors of MySQL

Currently MySQL is used by 107055 websites world-wide and that accounts for 54.73% market share. The main competitors of MySQL are

- Microsoft SQL server (18368 websites)
- PostGreSQL (13550 websites)
- NoSQL (12280 websites)
- MongoDB (11370 websites)
- Oracle database (6178 websites)

3.1 Novel differences about MySQL from its Competitors

3.1.1 Mysql vs MS SQL Server

Supported Platforms

MS SQL server was originally designed for windows operating systems exclusively. It recently announced that it will provide support for both linux and mac os via docker. But still it will lack some features onto the linux and the mac os platforms. Whereas Mysql enterprise was designed to work across multiple operating systems like windows, linux and mac os.

Supported languages

Both MySQL and MS SQL server supports multiple programming languages but addition to their common language support MySQL also supports languages like Perl, Scheme, Tcl, Haskel and Eiffel.

Storage Engine

MySQL supports a number of storage engines. While using mysql, the programmers even have option to use a plug-in storage engine. This was not available in the older versions of the RDBMS. The multiple storage engine support makes Mysql more flexible than MS SQL Server.

Filtering

In Mysql filtering can be done on tables, rows and users in a number of way. But it requires users to filter out the tables, rows or users by individual databases. While this filtering the data, the developers have to filter tables individually by running multipe queries. On the other hand MS SQL server enables developers to take advantages of row based filtering. It filters data on a database by database way and stored in a separate distribution database.

Web Support

The enterprise can choose from several editions of MS SQL Server according to the number of concurrent users and requirements of the project. They can even integrate the RDBMS with a variety of proprietary and open source technologies. But MySQL is designed with features complement the needs of the modern web applications. Many web application developers use MySQL as a component of LAMP stack along with linux operatinf system, Apache Web Server and PHP programming language.

3.1.2 MySQL vs PostgreSQL

Reliability

The PostgreSQL 10 added logical replication, which makes it closer to MySQL's. As replication has been one of the reasons to choose MySQL, but PostgreSQL has caught up with it.

Speed

For apps with long running SELECTs for analytics, PostgreSQL works better thanks to parallel query, etc. For smaller SELECTs, covering index and clustered index on MySQL works great. For apps with a lot of small INSERTs, MySQL is better for concurrency. For apps with bulk INSERTs, PostgreSQL is better for not needing to copy to rollback segments. For apps with heavy UPDATEs, MySQL works much better due to many reasons described in the article above. For apps with heavy DELETEs on ephemeral data, both supports partition, and both work well if you use the feature carefully. Otherwise, keep in mind both DBs are very slow at bulk DELETEs.

In general, comparing with PostgreSQl, MySQL has better commercial support like Redhat Enterprise Linux. Has plenty of applications that target it. Has a blazing fast performace, particularly when predominantly SELECT queries, especially on MyISAM tables. So to conclude MySQL is widely used and easy to set up, and has reasonable flexibility, high scalability and platform independent.

3.1.3 MySQL vs NoSQL

MySQL is a relational database that is based on tabular design whereas NoSQL is non-relational in nature with its document-based design. MySQL has established a database, covering huge IT market whereas NoSQL databases are the latest arrival, hence still gaining popularity among big IT giants. MySQL database with its settled market encompasses a huge community whereas the NoSQL database with the short span arrival has a comparatively short community. MySQL is not so easily scalable with their rigid schema restrictions whereas NoSQL can be easily scaled with their dynamic schema nature. The detailed database model is required before database creation in MySQL whereas no detailed modeling is required in the case of NoSQL database types. MySQL is one of the types of relational database whereas NoSQL is more of design based database type with examples like MongoDB, Couch DB, etc. MySQL is available with a wide array of reporting tools help application's validity whereas NoSQL databases lack reporting tools for analysis and performance testing. MySQL being a relational database is less flexible with its design constraint whereas NoSQL being non-relational in nature, provides a more flexible design as compared to MySQL. MySQL is being used with a standard query language called SQL whereas NoSQL like databases misses a standard query language.

3.1.4 MySQL vs MongoDB

In MongoDB, data is stored in JSON-like documents that can have varied structures. To improve query speed, MongoDB can store related data together, which is accessed using the MongoDB query language. MongoDB is schema-free, allowing you to create documents without having to define the structure of the document first. These documents can be easily changed by adding or deleting fields.

Replication/Clustering

MySQL supports master – slave replication and master – master replication (as of MySQL 5.7.6 and later). Multisource replication allows you to replicate from several masters in parallel. MongoDB supports built-in replication, sharding, and auto-elections. Using auto-elections, you can set up a secondary database to automatically take over if the primary database fails. Sharding allows for horizontal scaling, which is difficult to implement in MySQL. MongoDB uses replica sets to create multiple copies of the data. Each member of the replica set can have the role of primary or secondary at any point in the process. Reads and writes are done on the primary replica by default and then replicated to the secondary replicas. There are many use cases for a relational database like MySQL. Any type of application that requires multi-row transactions such as an accounting system, would be better suited for a relational database. MongoDB is not an easy replacement for legacy systems that were built for relational databases.

3.1.5 MySQL vs Oracle

The benefits of MySQL include:

- Free to use, has Great Performance and is Very user-friendly.
- Incredible security
- Scalable
- Works with many operating systems
- Supports many development interfaces

MySQL provides a high-speed database system perfect for small to medium projects. It works great for startup companies, but doesn't have as many features as Oracle. However, most of the companies using MySQL don't need the features provided by Oracle because they build the functionality in the middle-tier. Many content management systems, such as WordPress, Joomla and Drupal, use MySQL databases. Whenever you plan to use one of these CMS choices, you will use MySQL. Often, these projects are on a smaller scale and MySQL provides the better choice. It's free to use, provides plenty of speed and is very user-friendly. Startup companies and smaller companies fit best with MySQL. This can also include blogs and those planning to build many niche sites.

4 Architecture

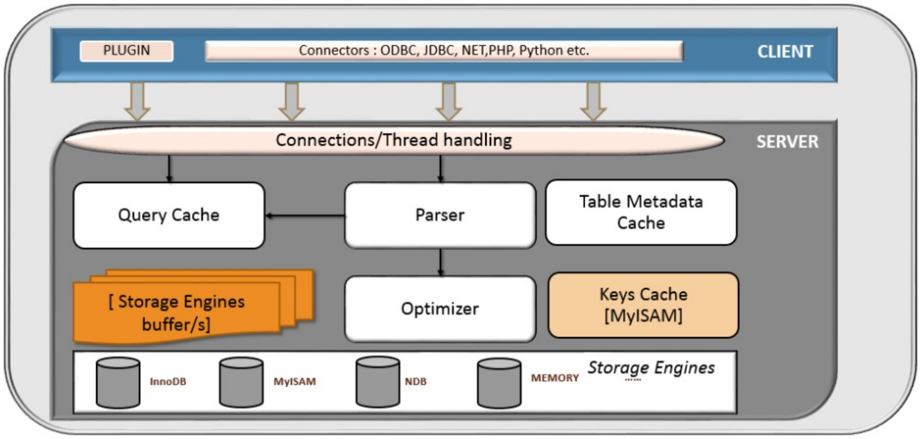

Figure 1: MySQL Architecture

Primarily MySQL follows client-server approach such that, when the client requests for data, the server processes the request and give the data to the client. In this architecture, the client system has a plugin and some of the connectors like ODBC, which is used for normal oracle databases, JDBC is used for java programming related databases, .NET, PHP, Python...Etc.[17] In this system, each connector in client has the unique individual applications that helps in connecting the server. Finally, the process implemented in this architecture is described as follows. When the client requests for data from the server, the server initially goes to the connection block. Since, client connections are managed by using threads, each client is allocated with a thread. Hence, when client hits a query to the server, then the request will be sent to the connection part where it primarily looks for a parser. The parser is one of the major components in the architecture where it helps in checking the correct syntax of the SQL query. Along with the parser, there is another important component called optimizer, which creates many ways to execute a query and among multiple ways, it helps in choosing the best execution plan to execute a query that takes short period of time. So, once the parser confirms that the SQL syntax is correct, then the parser sends that query to the optimizer and executes the query. But when the passed SQL query is already been executed by some other client, then instead of sending the query to the optimizer, the parser sends the query to the query cache and checks whether the same SQL query is executed or do they have the same plan which is already stored in the query cache. Hence, if the same plan is available in the query cache, then the system will follow the same plan without creating a new one for executing the query. Other components in the architecture are table metadata cache which helps in storing the information about meta data and statistics of each table. MyISAM helps in reducing the disk I/O by using a cache mechanism to store the most frequently used table blocks in memory.[4] For that purpose, a special component called key cache is used so that whenever the indexes are created based on the keys, the data will be stored in key cache. But, whenever the key cache is observed as non-operational, then the index files are accesses by the using the original file system buffer which is provided by the operating system. Another important component called storage engine which provides the platform where the actual execution of a query takes place. In addition to that, MySQL has the flexibility to change the storage engine based on the requirements and according to that, some of the storage engines in MySQL are InnoDB, MyISAM, NDB, Memory... Etc. InnoDB helps in keeping the transactional data and performing operations on it. While MyISAM is used for best performance in read operation but there is no transactional benefit.

4.1 InnoDB Storage Engine

The InnoDB storage engine in MySQL is mainly used for general-purpose which mainly helps in balancing the high reliability and performance.[5] In 5.6 version of MySQL, InnoDB is considered as the default storage engine. There are some of the main advantages of using InnoDB are defined as follows:

- The DML operations in InnoDB follows ACID model which also includes transaction features such as commit, rollback and crash-recovery and helps in protecting the user data.
- InnoDB storage engine follows row-level locking system and the consistent reads are helpful in increasing the multi-user concurrency and performance as well.
- The tables which are stored in the InnoDB storage engine helps in arranging the data on disk so that the queries can be optimized based on primary keys.
- InnoDB supports foreign key constraints to maintain the integrity of the data. By using foreign keys, inserts, deletes and updates it helps to know whether there are any inconsistencies that occur across the tables.
- InnoDB does not support hash indexes but utilizes the hash index internally for adaptive hash index feature.

4.2 MyISAM Storage Engine

It is the oldest version of storage engine and is considered as a default storage engine prior to MySQL 5.5 version.[7] Each table of MyISAM will be stored in disk in three files. They begin with a name for the table then have an extension to indicate the type of the file, and stores the table format. The list of characteristics that are available for MyISAM is defined as follows:

- The dat values are stored in ascending order, that means the low level byte will be stored first. Through this, the data machine and the OS will become independent and there is no speed penalty for storing in this way.
- All the numeric key values in MyISAM are stored in the descending order. That means the high byte level comes first.
- The number of rows that MyISAM can store is $(2^{32})^2$ (1.844E+19) with maximum of 64 indexes and 16 columns. The maximum key length is 1000 bytes which is related to default and this is not constant. It changes from time to time.
- This kind of storage engine also supports concurrent inserts.

The main differences between these two main storage engines in MySQL are

- InnoDB is completely transactional while MyISAM is non-transactional.
- InnoDB supports clustered indexes while MyISAM does not support for it.
- There is no foreign key support in MyISAM while InnoDB has.
- MyISAM has table based locking system while InnoDB has row based locking system.
- InnoDB supports ACID properties while MyISAM don't.
- InnoDB does not have the ability to save the data in table level. Hence for retrieving the data, it must scan the whole data again to calculate number of rows. But MyISAM saves data at table level and it helps to read easily.[9]

5 Indexes

Indexes is one of the important concepts in the database management system which helps in improving the performance and can get the faster access to retrieve the data from the database. The indexes in the database can be referred as pointers to the rows in the table by allowing the SQL query to determine the rows which are having the exact match with the condition of the "where" clause and based on that it retrieves the other column values for those particular rows as well. All data types which are used in MySQL can be indexed. But, creating index on every column is waste of space and time for MySQL in determining which index to use, and it is better to index only the required columns that plays a major role in retrieving the data. Also, whenever updates are made in database, then the indexes must also get updated.[1] The MySQL 8 can create indexes up to 16 columns and index length up to 256 bytes in a table in the latest version. The indexes can be created on a single or multiple column and the usage of these will depend on the type of the data. Using multicolumn index will increase the speed to execute queries by testing all the indexes in the table. Even though all the indexes look similar, there are main 5 types of indexes in MySQL. They are primary key index, a simple, regular and normal index, full text index, unique index and a descending index.

- In unique index, all column values must be unique. While creating a unique index on a single column, then no duplicate values are allowed. But while using the multicolumn index, it allows the duplicate values for a single column and the combinations of the values of that row must be unique. This index does allow the NULL values and consider them as distinct values in the table. We usually define unique index after the table creation.

- Primary index is like the unique index, but the only difference between them is that the primary index does not allow NULL values. Each row in the table must have values for a column or combination of columns, because we define primary key on small number of columns and most of the time, it is fixed on a single column only. Once the primary key is set, it cannot be changed, and we define the primary key during the table creation.

- A regular, normal index is completely different from the other indexes. They are just used to help the databases to make search faster.

- Full text indexes are used for full text searches. This index will search for the individual words rather than searching the entire value. This mainly helps in having the faster search for particular words and phrases that are available in the whole text.

- A descending index is generally stored in reverse order. It is mainly used in executing the queries for most recently added data.

We can also create indexes on spatial data types like GEOMETRY, POINT, LINESTRING, POLYGON with the support of R-tree indexes from InnoDB and MyISAM. Also, the memory storage engine uses hash indexes as its default, but it also supports B-TREE indexes as well. MySQL can use the data structures while creating indexes. This category has two types of indexes. One is clustered and the other one is non-clustered indexes. The rows of the data in clustered index are stored on disk in the same order as indexes are stored and through this, only a single clustered index will be available on any table. While non-clustered indexes are used as pointers to the data such that the structure of the index is separate from the structure of the rows of the table. Hence, we can rearrange the indexes and can use many indexes possible. The difference between the clustered and non-clustered indexes are clustered indexes are generally referred as faster in read because, it can acquire all the information from the original table and slower in writing process, when a new data is wants the previous data to be reorganized for the index. On the other hand, non-clustered indexes require a specific index to get the data from the table. Other than these two indexes, there are other two important indexes that are used in data structures. They are defined as B-Tree and Hash indexes. The B-tree structure is mainly used for making comparisons for expressions such as <, >, <= , >= , or BETWEEN operators. This is also used for LIKE operators. The hash index works in a way such that, instead of ordering the records of the index based on the comparisons made using B-tree structure, it uses a hashing function and create one semi-unique hash for each key in the index. The value then determined to where the key/value pair must be stored in the index. These are used for equality operators and they are fast. But they are not good at finding the range of the values and they cannot sort the results using ORDER BY clause. MyISAM uses only B-tree indexes and InnoDB uses hash indexes in an adaptive way. Hence, an adaptive hash index is built on top of the B-tree index. If the hash index is not found, then it uses B-tree indexes and the performance will become low but gets successful. In this way, MySQL uses the indexing system. One of the recent modifications in the indexes is index merge optimization which is introduced from MySQL 5.0 version. It mainly retrieves the rows with multiple range scans and merges the result into one. This can be done only with one table and it does not have access for multiple tables. The merge can produce operations like unions, intersections, or unions of intersections from the scans. But this technique is not applicable for full text indexes.

6 Query Optimization

The optimization of MySQL depends on various factors such as tables, queries and configuration settings.[19] MySQL uses a cost-based optimizer, which means it tries to predict the cost of various execution plans and choose the least expensive. MySQL's query optimizer is a highly complex piece of software and it uses many optimization techniques to transform the query it an execution plan. Some of the optimizations that MySQL knows to do are

Reordering joins

Tables don't always have to be joined in the order you specify in the query. Determining the best join order is an important optimization.

Converting OUTER JOINs to INNER JOINs

An OUTER JOIN doesn't necessarily have to be executed as an OUTER JOIN. Some factors, such as the WHERE clause and table schema, can actually cause an OUTER JOIN to be equivalent to an INNER JOIN. MySQL can recognize this and rewrite the join, which makes it eligible for reordering.

Applying algebraic equivalence rules

MySQL applies algebraic transformations to simplify and canonicalize expressions. It can also fold and reduce constants, eliminating impossible constraints and constant conditions. For example, the term (5=5 AND a>5) will reduce to just a>5. Similarly, (a<b AND b=c) AND a=5 becomes b>5 AND b=c AND a=5. These rules are very useful for writing conditional queries, which we discuss later in the chapter.

Index Merge optimizations

In MySQL 5.0 and newer, however, the query can use both indexes, scanning them simultaneously and merging the results. There are three variations on the algorithm: union for OR conditions, intersection for AND conditions, and unions of intersections for combinations of the two.

COUNT(), MIN(), and MAX() optimizations

Indexes and column nullability can often help MySQL optimize away these expressions. For example, to find the minimum value of a column that's leftmost in a B-Tree index, MySQL can just request the first row in the index. It can even do this in the query optimization stage, and treat the value as a constant for the rest of the query. Similarly, to find the maximum value in a B-Tree index, the server reads the last row. If the server uses this optimization, you'll see "Select tables optimized away" in the EXPLAIN plan. This literally means the optimizer has removed the table from the query plan and replaced it with a constant. Likewise, COUNT(*) queries without a WHERE clause can often be optimized away on some storage engines (such as MyISAM, which keeps an exact count of rows in the table at all times). In MySQL, the query execution plan is actually a tree of instructions that the query execution engine follows to produce the query results. The final plan contains enough information to reconstruct the original query. MySQL always begins with one table and finds matching rows in the next table. Thus, MySQL's query execution plans always take the form of a left-deep tree.

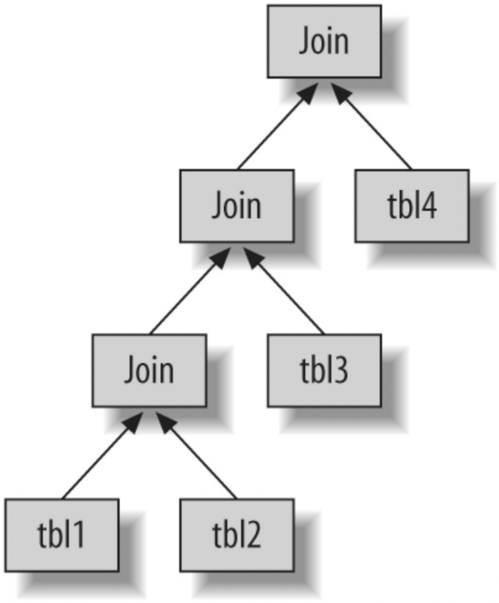

Figure 2: Left - Deep Tree

Best Query Optimization Practices

- **Use EXPLAIN keyword to see the execution plan for the query**. Here the things to look for is the index usage and the rows scanned. This gives the information needed for a MySQL developer to choose the right logic and right optimization technique for executing a query.

- **Use LIMIT 1 clause when retrieving Unique Row** – It also helps to improve the performance of aggregate functions like MIN or MAX. If we do not use the LIMIT clause then for simple SELECT statement MySQL wills generate the entire result set and then discards the ones that does not apply to the conditions.

- **Try to convert (<>) operator to = operator** – because = operator increases chances of using the index to be used for your query.

- We should always be careful when we use SELECT *, do we really need all the rows/columns. Sometimes we don't, retrieving all the columns can prevent optimizations such as covering indexes, as well as adding I/O, memory and CPU overhead for the server. Avoid using SELECT * unless we are trying to print the entire contents of the table as this will force a full table scan by ignoring the indexes and executing the query. Also, when we return unwanted data it simply wastes our network bandwidth.

- **Split big DELETE, UPDATE or INSERT query into multiple smaller queries** – because this improves the performance and as well as gives better control on data movement.

- **Use Appropriate data types for columns** – example if you're only going to store integers do not use VARCHAR. The smaller columns are faster for performance.

- **MySQL query cache is case and space sensitive** – is we are going to get the same results set many times, then we should us the same query with the same letters and spacing, this increases the performance by many times, this is because MySQL would be able to return your results set with regard to the index. This is because, before even parsing a query. MySQL checks for it in the query cache, if the cache is enabled. This operation is a case sensitive hash lookup. If the query is similar query in the cache by every single byte, then MySQL retrieves the stored result from the query cache and sends it to the client, bypassing every other stage in the query execution. Here the query is never parsed, optimized or executed.

- **Index Columns in the WHERE clause** – if we use index on the column which you have used in the WHERE clause it increases the performance.

- **Use index on the Columns which you have used in the JOIN** – this increases the performance, use this judgement based on the expected result as this may not be applicable for all the conditions of the results set.

- **Use UNION ALL instead of UNION if duplicate data is permissible in result set** – Here UNION ALL gives better performance than UNION as it does not have to do distinct operation on your query.

- Table order in your JOIN clause does not matter when we are just going to use INNNER JOIN clause.

- If the column used in the ORDER BY clause are indexed then they help in the performance especially when we are doing the most expensive operation of MySQL which is SORTING.

- If the application uses pagination then it's a good idea that we use LIMIT clause to implement paging in your database itself as this increases the performance as well as reduces the network traffic between the database and the client application.

Choosing the right Query optimization methods are based on the query itself. One method might work for one query whereas another method works for another query. Always test the queries with near real data and schema on the development server before deploying to the production server for choosing and implementing the best query optimization techniques.

7 Drawbacks and Limitations of MySQL

Even though MySQL is the best open source database and is being used widely, there are some drawbacks and limitations on this software.[13] Some of the drawbacks in MySQL are defined as follows:

- Creating incremental backups is difficult in MySQL as it requires lot of time and effort to do it.
- MySQL has no built-in support for XML or OLAP.
- In PostgreSQL, the stored procedures gives the code to reuse and use it for encapsulation, while MySQL doesn't have many choices like this ones has.
- Even though MySQL is having a good scalability, it is an expensive process and it is very hard to implement for larger database.
- The performance of the MySQL gets decreased when the dataset grows.
- MySQL does not support ACID compliance to a standard SQL. But it has the ability to comply with ACID properties in InnoDB storage engine.

Limits in Joins

For a single join, the maximum number of tables that can be referenced are 61 only.[6] This applies for views also.

Limits on number of Databases and Tables

MySQL does not have limit to store the number of tables, but the file system may have the limitation.

Limitations on Table Size

Based on the operating system, the limit on table size happens.

Limits on Table Column Count and Row Size

MySQL has a column limit up to 4096 columns and the effect of columns depends on different factors like row size limit, storage requirements, storage engines, and functional key parts.

Windows Platform Limits

The limitations for MySQL in windows are processing memory in 32-bit platforms, file system aliases cannot be used in MyISAM tables, Windows can have only 4000 ports for client connections, it has can-insensitive names, MySQL server supports the files which are compatible with ANSI code pages, using "/"

operator for separating paths which is also meant as an escape character in MySQL, and in windows, pipes are not good at reliability.

8 MySQL - Oracle Corporation

The MySQL RDBMS is owned by Oracle Corporation. [15] MySQl community edition is the freely downloadable version of the worlds most popular open source database. Which is supported by an active community of developers and enthusiasts. This is for personal use and has limited functionality when compared with other commercial versions.

Commercial customers have the flexicibility of choosing from multiple editions to meet specific business and technical requirements. They are

- Standard Edition
- Enterprise Edition
- Cluster CGE

8.1 MySQL Standard Edition

The cost of the standard edition starts at **USD 2,000**. [16] MySQL Standard Edition enables you to deliver high-performance and scalable Online Transaction Processing (OLTP) applications. It provides the ease of use that has made MySQL famous along with industrial strength performance and reliability. MySQL Standard Edition includes InnoDB, making it a fully integrated transaction-safe, ACID compliant database. In addition, MySQL Replication allows you to deliver high performance and scalable applications

- **Lower TCO** - MySQL enables you to minimize your database TCO.
- **Reliability, Performance Ease of Use** - MySQL is proven as the world's most popular open source database.
- **Database Development, Design and Administration** - MySQL Workbench provides an integrated development, design and administration environment to make developers and DBAs more productive.

When you need additional capabilities it is easy to upgrade to MySQL Enterprise Edition or MySQL Cluster Carrier Grade Edition.

8.1.1 MySQL Standard Edition Plans

MySQL Standard Edition Subscription (1 - 4 Socket Server) Price: **USD 2,000.00 - USD 6,000.00**.

MySQL Standard Edition Subscription (5+ Socket Server) Price: **USD 4,000.00 - USD 12,000.00**

8.2 MySQL Enterprise Edition

The cost of the Enterprise edition starts at **USD 5,000**. MySQL Enterprise Edition includes the most comprehensive set of advanced features, management tools and technical support to achieve the highest levels of MySQL scalability, security, reliability, and uptime. It reduces the risk, cost, and complexity in developing, deploying, and managing business-critical MySQL applications.

Oracle MySQL Cloud Service

Oracle MySQL Cloud Service is built on MySQL Enterprise Edition and powered by Oracle Cloud, providing an enterprise-grade MySQL database service. It delivers the best in class management tools, self service provisioning, elastic scalability and multi-layer security.

MySQL Document Store

MySQL Document Store gives users maximum flexibility developing SQL and NoSQL, schema-free document database applications. This eliminates the need for a separate database for NoSQL data.

MySQL Enterprise Transparent Data Encryption (TDE)

MySQL Enterprise Transparent Data Encryption (TDE) enables data-at-rest encryption by encrypting the physical files of the database. Data is encrypted automatically, in real time, prior to writing to storage and decrypted when read from storage.

MySQL Enterprise Masking and De-identification

MySQL Enterprise Masking and De-identification provides an easy to use, built-in database solution to help organizations protect sensitive data from unauthorized uses by hiding and replacing real values with substitutes.

MySQL Enterprise Backup

MySQL Enterprise Backup reduces the risk of data loss by delivering online ”Hot” backups of your databases. It supports full, incremental and partial backups, Point-in-Time Recovery and backup compression.

MySQL Enterprise High Availability

MySQL InnoDB Cluster delivers an integrated, native, HA solution for your databases. It tightly integrates MySQL Server with Group Replication, MySQL Router, and MySQL Shell, so you don’t have to rely on external tools, scripts or other components.

MySQL Enterprise Scalability

MySQL Enterprise Scalability enables you to meet the sustained performance and scalability requirements of ever increasing user, query and data loads. MySQL Thread Pool provides an efficient, thread-handling model designed to reduce overhead in managing client connections, and statement execution threads.

MySQL Enterprise Authentication

MySQL Enterprise Authentication provides ready to use external authentication modules to easily integrate MySQL with existing security infrastructures including PAM and Windows Active Directory. MySQL users can be authenticated using Pluggable Authentication Modules (”PAM”) or native Windows OS services.

MySQL Enterprise Encryption

MySQL Enterprise Encryption provides encryption, key generation, digital signatures and other cryptographic features to help organizations protect confidential data and comply with regulatory requirements.

MySQL Enterprise Firewall

MySQL Enterprise Firewall guards against cyber security threats by providing real-time protection against database specific attacks, such as an SQL Injection. MySQL Enterprise Firewall monitors for database threats, automatically creates a whitelist of approved SQL statements and blocks unauthorized database activity.

MySQL Enterprise Audit

MySQL Enterprise Audit enables you to quickly and seamlessly add policy-based auditing compliance to new and existing applications. You can dynamically enable user level activity logging, implement activity-based policies, manage audit log files and integrate MySQL auditing with Oracle and third-party solutions.

MySQL Enterprise Monitor

The MySQL Enterprise Monitor and the MySQL Query Analyzer continuously monitor your databases and alerts you to potential problems before they impact your system. It’s like having a ”Virtual DBA Assistant” at your side to recommend best practices to eliminate security vulnerabilities, improve replication, optimize performance and more. As a result, the productivity of your developers, DBAs and System Administrators is improved significantly.

Oracle Enterprise Manager for MySQL

The Oracle Enterprise Manager for MySQL provides real-time monitoring and delivers comprehensive performance, availability and configuration information for your MySQL databases.

MySQL Router

MySQL Router is lightweight middleware that provides transparent routing between your application and any backend MySQL Servers. It can be used for a wide variety of use cases, such as providing high availability and scalability by effectively routing database traffic to appropriate backend MySQL Servers.

MySQL Workbench

MySQL Workbench is a unified visual tool for database architects, developers, and DBAs. It provides data modeling, SQL development, database migration and comprehensive administration tools for server configuration, user administration, and much more.

MySQL Technical Support

MySQL Technical Support Services provide 24x7 direct access to our expert MySQL Support engineers who are ready to assist you in the development, deployment, and management of MySQL applications.

8.2.1 MySQL Enterprise Edition Plans

MySQL Enterprise Edition Subscription (1 - 4 Socket Server) Price: **USD 5,000.00 - USD 15,000.00**

MySQL Enterprise Edition Subscription (5+ Socket Server) **Price: USD 10,000.00 - USD 30,000.00**

8.3 MySQL Cluster Carrier Grade Edition

The cost of the MySQL Cluster CGE starts at USD 10,000. MySQL Cluster is the distributed database combining linear scalability and high availability. It provides in-memory real-time access with transactional consistency across partitioned and distributed datasets. It is designed for mission critical applications. MySQL Cluster has replication between clusters across multiple geographical sites built-in. A shared nothing architecture with data locality awareness make it the perfect choice for running on commodity hardware and in globally distributed cloud infrastructure.

MySQL Cluster 7.6

MySQL Cluster 7.6 is all about supporting the latest hardware, scaling to even larger and easier to maintain systems.

- **Improved Recovery** - Faster restarts, faster checkpointing and less disk space for building larger systems.
- **Improved Data Loading** - Import tool for loading data into cluster at maximum parallel speed.
- **Improved SQL Support** - Even more parallel query processing, making some joins up to 50 % faster.
- Improved Communication - Local nodes connect via shared memory for faster communication.
- **Improved Parallelism** - For faster and more balanced operations making better use of hardware resources.

Proven daily and serving billions Billions of users get in contact with MySQL Cluster every day during every phone call. MySQL Cluster's distributed, shared-nothing architecture is used at the core of mobile phone networks, authentication systems and gaming platforms. 99.9999% Availability Cluster maintains multiple copies of its dataset for maximum availability. MySQL Cluster has proven to deliver 99.9999% availability ensuring resilience to failures and the ability to perform scheduled maintenance without downtime.

In-memory Real Time Database

Using memory-optimized tables, MySQL Cluster provides real-time response time and throughput meet the needs of the most demanding web, telecommunications and enterprise applications.

Auto-partitioning and Scalability

MySQL Cluster automatically partitions tables across nodes (shards), enabling databases to scale horizontally on low cost, commodity hardware while maintaining complete application transparency.

Parallel Distributed Query Engine

MySQL Cluster's unique parallel query engine and distributed cross partition queries give an always consistent access to the entire distributed and partitioned dataset making scalable applications programing straightforward and simple.

Data Locality Awareness

Cluster has data locality awareness build into its APIs. No name or data management nodes are needed. Point selects go to the correct node, and the closest copy of the dataset.

SQL NoSQL APIs

MySQL Cluster enables users to blend the best of both relational and NoSQL technologies into solutions that reduce cost, risk and complexity.

Multi-site Clusters with Active Active Geographical Replication

Update-anywhere geographic replication enables multiple clusters to be distributed geographically for disaster recovery and the scalability of global web services.

Online Scaling Schema Upgrades

To support continuous operation, MySQL Cluster allows on-line addition of nodes and updates to live database schema to support rapidly evolving and highly dynamic workloads.

MySQL Cluster Auto-Installer

Get MySQL Cluster up and running in minutes! Graphically configure and provision a production-grade cluster, automatically tuned for your workload and environment.

MySQL Cluster Manager

MySQL Cluster Manager simplifies the creation and management of the MySQL Cluster Carrier Grade Edition database by automating common management tasks.

24x7 Technical Support

MySQL Technical Support Services provide 24x7 direct access to our expert MySQL Support engineers who are ready to assist you in the development, deployment, and management of MySQL applications.

8.3.1 MySQL Cluster Carrier Grade Edition Plans

MySQL Cluster Carrier Grade Edition Subscription (1 - 4 Socket Server) - Price: **USD 10,000.00 - USD 30,000.00**

MySQL Cluster Carrier Grade Edition Subscription (5+ Socket Server) - Price: **USD 20,000.00 - USD 60,000.00**

9 Companies that use MySQL and their Use Cases

Verizon

The Verizon company mainly used MySQL in its wireless system by supporting the mission-critical employee. Since Verizon is the number one mobile carrier with 3G and 4G networks and many number of subscribers. Hence the issue is, social media has a lot of video streaming, live broadcasting. . . etc which became the latest technology and hence Verizon has decide to provide their employees so that they could network socially, view, and host microsite, stream live videos and also to provide the latest news and updates.

So the Verizon developers had to go through the large number of open resource databased to check whether the architecture will the Verizon rigid requirements or not. So, finally they decided to go with MySQL on Linux as the backend. Hence, Verizon used MySQL 5.1 version in 2010 to implement. They made some upgrades in MySQL by moving from MyISAM to InnoDB storage engine and upgraded to the latest version of MySQL which is MySQL 5.1.54. Finally, upgraded the MySQL 5.1 to the modern GA release and leveraged MySQL thread pool as part of the MySQL enterprise edition so that the scaling can be done in a better way.[14]

After making those changes and upgrades, the performance became 1400% in improvement and much better response time in high concurrency use cases.

F5 Networks

F5 networks is one of the market share leaders in application delivery controllers with revenue over $882 million. F5 used the MySQL with partitioning process to increase the performance over 1000%, which helped in achieving the real time performance. Through this, the company took their product from maximum of 3500 records to 22,000 records per second which made a huge impact in gaining the performance.[2]

YouTube

Youtube is the top level website which is known for watching and uploading videos and those videos are seen by millions of people. The youtube considers the MySQL database as the main key aspect for scalability which includes MySQL, Memcache and python replication.[18] The main database for storing the videos in the youtube and assigning the users and uploaded videos with a uniqueID is done by MySQL. It mainly uses a concept called Vitess which is a database solution for scaling MySQL. Vitess is serving the database traffic in youtube since 2011. This runs effectively in public or private cloud architecture and helps in extending many important features of MySQL with the scalability of a NoSQL database. Hence in Youtube, the large amount of data and its traffic is controlled by using MySQL. Due to these reasons, Youtube chose MySQL as the best database to store when compared with the other databases. [11]

Facebook

Facebook is the top level website where millions of people use to connect with other people all around the world. The Facebook get very huge amounts of data. In this context, Facebook considers MySQL as its primary database to store the user data. This website mainly has three layers where the first layer is the database tier, that the MySQL sits over.[12]

MySQL mainly helped the facebook by handling the terms of scale, performance and reliability. MySQL handled the user interaction in a great way by dealing with likes, requests, status updates, shares... etc. There are about 800 million users and handling around 60 million requests per second.[10] Back in 2010, in MySQL 5.1 version, facebook made the partitioning process by using less number of servers to purge the old data than to delete it. Even though there are some issues found while implementing this, facebook MySQL team helped in solving those bugs without depending on other companies to solve it.[3]

Facebook uses other database named HBase, which is quite expensive and in order to implement this, facebook needs more resource-intuitive process for HBase than MySQL. Based on all the reasons, Facebook chose MySQL as its best database to store the large amount of user data by improving it everyday when compared to other databases available.[10]

10 Conclusions

Even though there are so many databases that are being developed everyday, MySQL place its own uniqueness by providing so many benefits with its latest features. Ever since MySQL started, it is being developed and upgraded everyday and it is been observed that many companies around the world use MySQL as their primary database.

11 Lists of Tasks Completed by The Team

Jithin Jacob Benjamin Jacob

- Competitors of MySQL, its Novel Difference from Them.
- Query Optimization.
- Types of MySQL and How Oracle Makes Money.
- Key functionalities of each MySQL Plan and its cost.

Sreeja Matturu

- MySQL Architecture.

- MySQL Indexes and its Performances.
- Company that uses MySQl and its Use Cases.
- Drawbacks of MySQL.

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