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SQL Query Optimization: Techniques and Best Practices

Learn SQL query optimization strategies, components and best practices to improve database performance, reduce costs and deliver faster results.

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OVERVIEW

Every modern organization depends on data, using it for everything from processing customer orders to driving insights about how services are being used. The volume of data collected, stored, moved and processed is both an asset and an obstacle, as the scale of these essential processes can increase the risk of inefficiency. A single ill-conceived SQL query can slow down critical operations, create security risks and cause system instability.

This challenge has brought SQL query optimization to the forefront of many IT organizations, as creating faster and more efficient database interactions is critical for any organization that wants to maintain high performance at scale. SQL query optimization, done properly, can deliver meaningful cost savings, helping to ensure your queries don't burn excessive computational resources as the underlying data changes. Query optimization also improves overall system efficiency by freeing up resources and ultimately improving the end-user experience.

In this article, we'll discuss SQL query optimization in depth and explore some of the key benefits of the practice.

WHAT IS SQL QUERY OPTIMIZATION?

SQL query optimization is a process that identifies and selects the most time- and energy-efficient database query while still successfully returning results. These optimization processes use a database query optimizer to analyze the way a query is executed, examining query syntax and structure, interactions among tables and other potential sources of increased computational load.

Optimization techniques can vary greatly depending on database size, data type and whether the database contains any sensitive information. Query optimization often relies on indexes and efficient use of joins and changes to syntax to reduce the amount of data pulled into memory. The query execution plan is also a critical tool, as it can identify bottlenecks and other opportunities to increase query efficiency.

KEY COMPONENTS OF SQL QUERY OPTIMIZATION

A number of different methods are available to optimize SQL queries, including:

1. INDEXING STRATEGIES

Indexing can greatly reduce the time it takes a query to run by sorting a dataset and then querying only the relevant section of the data, based on the way your index sorted it. Similar to a library cataloging system, which sorts books by genre, then author, then call number and so on, an index will break down the data into a sub-tree of "nodes," allowing your query to quickly identify and check only the relevant nodes rather than the whole table.

2. EXECUTION PLANS

Modern SQL databases include a query optimization feature which will interpret your query and pick an optimal path to return results. You can examine the path the optimizer is taking by requesting its execution plan. Different database management systems will have different commands, but they will all break out the exact approach the optimizer is using, allowing you to make any changes necessary to address bottlenecks and improve efficiency.

3. JOIN ORDER & TYPES

If they are not used carefully, joins between tables can greatly increase the processing time of a query. A query optimizer will compute the join order to find the most efficient query plan, generally by starting with the table with the fewest records. Before you join two tables, it can be more efficient to index the tables first, and then use INNER joins to reduce the necessary output to only the rows that each table has in common.

4. SARGABLE QUERIES

A contraction of "search argument able," a sargable query is one which can utilize an index to improve its speed and efficiency. A non-sargable query has elements which make the query unable to use indexes, most often predicates in SQL clauses like WHERE. Common non-sargable queries have the WHERE column value inside a function or begin a text string with the % symbol. Query optimizers will typically work to make queries sargable before running them.

5. REDUCING RESULT SET SIZE

Specifying the number of rows you want to use in the query can help optimize certain operations by reducing the amount of data your query returns. This has a number of uses. For example, in situations where you want to run a small-scale test using data from a PostgreSQL database with 10,000 rows, you might use LIMIT 100 to pull only 100 rows of output. A common UX example of this is a search engine which only returns 10 results per page with many pages, rather than every single result on one page.

6. USE OF QUERY HINTS

A query hint is a piece of an instruction which can override the query optimizer's execution plan. For example, if you wanted a mySQL database to favor the use of a certain index over another, a hint would allow you to encourage this with USE INDEX or require it with FORCE INDEX. Keep in mind that using a hint to avoid a bottleneck doesn't solve the issue of the bottleneck but simply bypasses it.

COMMON SQL QUERY OPTIMIZATION TECHNIQUES

Whether you have identified a specific inefficiency or are working to improve query performance more broadly, these techniques can make SQL queries less time- and resource-intensive:

OPTIMIZE SELECT CLAUSES

Using SELECT * pulls all of the data from a table, greatly increasing the size of each query. Being more exact about the columns you want can boost operation speed and reduce load. This approach can also offer security benefits, as pulling sensitive data into memory or onto other systems unnecessarily can increase the risk of data misuse.

USE WHERE INSTEAD OF HAVING

WHERE and HAVING clauses both filter the data that your query returns. WHERE filters for rows which meet your condition, while HAVING filters output after the GROUP BY statement has grouped rows together. Because WHERE is processed before grouping, it can greatly reduce the amount of data that your query processes, while using the less efficient HAVING might mean processing the entire table, grouping it and then filtering the results.

ORDER JOINS LOGICALLY

Choosing a join order that requires the least amount of processing typically means joining smaller tables first before moving on to larger ones. Setting your join order to start with the smallest table will help the database query optimizer find the optimal path.

ANALYZE EXECUTION PLANS

Investigating different execution plans can help you uncover opportunities to improve query performance or determine if the optimizer itself is choosing a less performant approach. Using plans allows you to experiment, comparing execution plans on expressions which use SELECT * versus SELECT column_1, column_2, for example.

CHALLENGES IN DATABASE OPTIMIZATION

Common challenges you might encounter when attempting to optimize SQL queries include:

MISLEADING OR OUTDATED STATISTICS

In order to choose their optimal path, SQL query optimizers rely on a set of internal database statistics which allow them to estimate the cost of each query and use that information to choose the most efficient way forward. These statistics involve analysis of data distribution, density and other key pieces of information, and you can set them to be updated on a schedule or a per-event basis, or you can update them manually. When a table does not have accurate statistics, this can create a misallocation of resources, as the optimizer over- or underestimates how much compute power it needs to run an operation.

COMPLEX QUERY STRUCTURE

Overly complex queries can create performance bottlenecks and increase costs. Complex queries are difficult to optimize and debug, particularly queries which join multiple tables or which rely on layered subqueries. Breaking down complex queries into multiple simpler queries, using common table expressions (CTEs) for subqueries and using temporary tables can help reduce complexity.

PERFORMANCE OVERHEAD OF PLAN ANALYSIS

Database query optimizers are sophisticated tools which interpret your expression and identify the optimal path to finding your desired results. They do this by estimating the costs of each different approach and choosing the most efficient method from among them. However, complex queries can create so many different paths that the process of estimation itself can start to use too much computational power, constraining the optimizer's ability to find the optimal plan.

QUERY PERFORMANCE DEGRADATION

Databases which are subject to frequent change or growth can become inefficient, as what was once an effective query suddenly needs to draw significantly more resources to work. Larger amounts of data or frequent changes can make index architecture less effective, which requires you to reassess query execution plans and update indexes accordingly.

BEST PRACTICES FOR ONGOING QUERY OPTIMIZATION

While your exact approach will depend on the data type and specific database you are using, here are some general steps you can take to ensure you are proactively optimizing SQL queries:

1. KEEP STATISTICS UPDATED FOR COST-BASED OPTIMIZERS

Cost-based query optimizers (CBOs) create execution plans optimized to lower computational cost as much as possible. CBOs depend on database statistics to estimate the optimal plan, which means that old, inaccurate statistics can lead to erroneous decisions. Keeping the database statistics updated and relevant will help your CBO identify the most efficient plan.

2. REVIEW AND REFACTOR LONG-RUNNING QUERIES

Refactoring queries can help you identify potential performance improvements and can make each query more legible to other users. Analyzing the execution plan, breaking elements of a complex query up using WITH clauses, removing cases of SELECT * and refining database indexes can all make your SQL database more accessible.

3. USE EXPLAIN PLANS BEFORE PRODUCTION

Using EXPLAIN to check the plan your query optimizer has chosen is an essential step to help refine your query, identify unnecessary elements and make sure it returns the minimum required results. By checking the plan in this way, you can uncover issues in your query or in the plan itself before you deploy it and use computational resources.

4. IMPLEMENT INDEXES WITH BALANCE IN MIND

In databases where data is frequently added, removed or modified, each change prompts your indexes to update, which can increase latency. Indexes also take up storage space, which can be an inefficient use of database resources. Reducing the number and size of indexes by only including columns which you frequently query and conducting index maintenance can help ensure you're not overindexing.

CONCLUSION

Query optimization is a critical component of working with SQL data and the systems you use to manage it. Inefficient queries can increase costs and create security risks, and may harm your customer experience with increased latency and lower application performance. Utilizing indexes, analyzing execution plans and ensuring that your queries only process and return the minimum amount of data necessary can help you maintain high database performance. By combining these techniques with proactive query maintenance, you can ensure that your internal systems are able to allocate resources more efficiently and operate at scale.

QUERY OPTIMIZATION FAQS

What tools are available to optimize SQL queries?

What is an optimizer in SQL and how does it work?

How do you optimize SQL query joins?

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