SQL Explain is your friend: PostgreSQL edition

sweemeng · Follow

5 min read · Feb 13, 2025

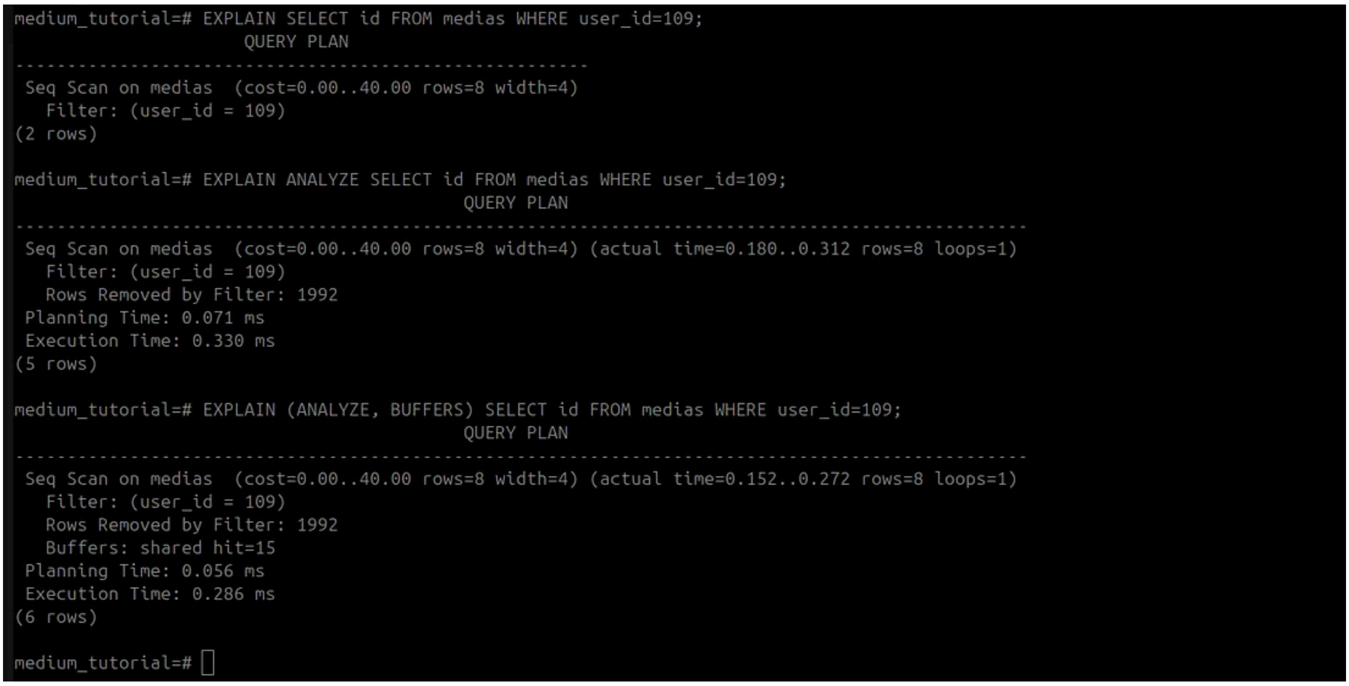
Disclosure: I came out with the content, database setup, and queries. But I use ChatGPT and perplexity to fix the grammar, tone, and spelling.

So you discovered an application running slow. You suspect that the application is running a slow database query. How do you find out?

One way is to use pg_stat_statements. The `pg_stat_statements` tool collect all queries and their performance metrics. It allows you to identify the slowest query, but it does not show why they are slow. This is where the `EXPLAIN` comes in, complementing `pg_stat_statements` in your investigation.

The SQL `EXPLAIN` query is a way for you view the execution plan of your query. It provides information that will help you make changes to improve performance. `EXPLAIN` query is not an SQL standard, but many database engines supports it. Since I primarily use PostgreSQL— and different engines output information in various formats — I will focus solely on PostgreSQL's implementation.

There are several forms of the `EXPLAIN` command that I use. While there are additional variations available that you might find useful, the following are the ones I typically rely on:

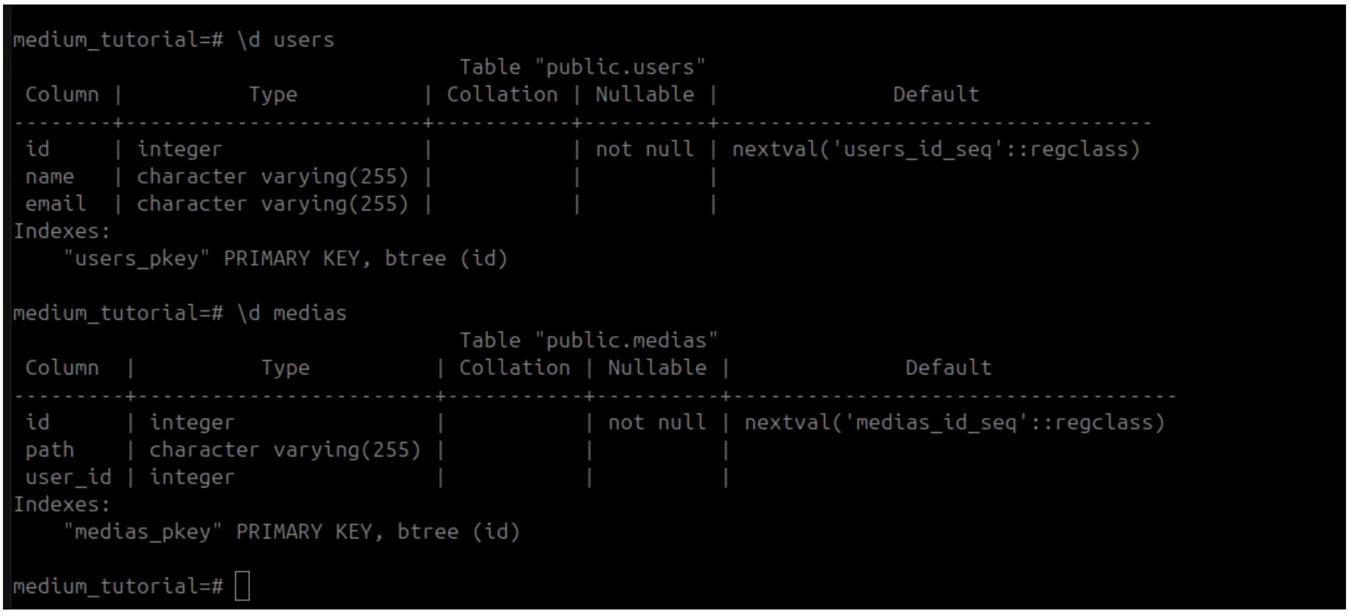


```
medium_tutorial=# EXPLAIN SELECT id FROM medias WHERE user_id=109;
                      QUERY PLAN
-------------------------------------------------------
 Seq Scan on medias  (cost=0.00..40.00 rows=8 width=4)
   Filter: (user_id = 109)
(2 rows)

medium_tutorial=# EXPLAIN ANALYZE SELECT id FROM medias WHERE user_id=109;
                                           QUERY PLAN
-------------------------------------------------------------------------------------------------
 Seq Scan on medias  (cost=0.00..40.00 rows=8 width=4) (actual time=0.180..0.312 rows=8 loops=1)
   Filter: (user_id = 109)
   Rows Removed by Filter: 1992
 Planning Time: 0.071 ms
 Execution Time: 0.330 ms
(5 rows)

medium_tutorial=# EXPLAIN (ANALYZE, BUFFERS) SELECT id FROM medias WHERE user_id=109;
                                           QUERY PLAN
-------------------------------------------------------------------------------------------------
 Seq Scan on medias  (cost=0.00..40.00 rows=8 width=4) (actual time=0.152..0.272 rows=8 loops=1)
   Filter: (user_id = 109)
   Rows Removed by Filter: 1992
   Buffers: shared hit=15
 Planning Time: 0.056 ms
 Execution Time: 0.286 ms
(6 rows)

medium_tutorial=# 
```

Key differences

- `EXPLAIN $query` : Display the query plan without executing query
- `EXPLAIN ANALYZE $query` : Executes the query and returns the query plan along with the execution time. Note that if you use this with `UPDATE` , `DELETE` , or `INSERT` statements, it will modify your data.
- `EXPLAIN (ANALYZE, BUFFERS) $query` : Performs the same as `EXPLAIN ANALYZE` but additionally provides information on shared buffers.

Let’s start with an example database I have created:-



```
medium_tutorial=# \d users
                                    Table "public.users"
 Column |          Type          | Collation | Nullable |              Default
--------+------------------------+-----------+----------+-----------------------------------
 id     | integer                |           | not null | nextval('users_id_seq'::regclass)
 name   | character varying(255) |           |          |
 email  | character varying(255) |           |          |
Indexes:
    "users_pkey" PRIMARY KEY, btree (id)

medium_tutorial=# \d medias
                                    Table "public.medias"
 Column  |          Type          | Collation | Nullable |              Default
---------+------------------------+-----------+----------+------------------------------------
 id      | integer                |           | not null | nextval('medias_id_seq'::regclass)
 path    | character varying(255) |           |          |
 user_id | integer                |           |          |
Indexes:
    "medias_pkey" PRIMARY KEY, btree (id)

medium_tutorial=# 
```

Table created for testing

There is around 200 users, and 2000 medias.

My go-to query is the `EXPLAIN (ANALYZE, BUFFERS)` command. Below is an example session:

```
medium_tutorial=# EXPLAIN (ANALYZE, BUFFERS) SELECT id FROM medias WHERE user_i
                                           QUERY PLAN
-------------------------------------------------------------------------------
 Seq Scan on medias  (cost=0.00..40.00 rows=8 width=4) (actual time=0.150..0.27
   Filter: (user_id = 109)
   Rows Removed by Filter: 1992
   Buffers: shared hit=15
 Planning Time: 0.063 ms
 Execution Time: 0.285 ms
(6 rows)
```

Let's parse the output:

- `Seq Scan on medias`
  This indicates that the query is performing a sequential scan on the `medias` table—meaning it is not using an index. (I will show an example of an index search later.)

- `(cost=0.00..40.00 rows=8 width=4)`
  The query planner estimates an initial cost of `0.00` and a final cost of `40.00` . It also estimates that the query will return 8 rows, with each row being 4 bytes wide. These cost metrics help the planner decide on the most optimal execution plan.

- `(actual time=0.150..0.270 rows=8 width=4)`
  This shows the actual time taken to execute the query. In this case, the execution started at `0.150 ms` and ended at `0.270 ms` .

- `Rows Removed by Filter: 1992`
  This indicates that 1992 rows were scanned and then discarded based on the filter condition. A high number of rows being filtered out may impact performance.

- `Buffers: shared hit=15`
  This shows that 15 blocks of data were retrieved from the shared buffer cache. (In PostgreSQL, each block is typically 8KB.)

- `Execution Time: 0.285 ms`
  The total time taken to execute the query was `0.285 ms` .

Now let's add an index in the `medias` table.

```
CREATE INDEX medias_user_id_idx ON medias(user_id);
```

Now rerun the query:

```
medium_tutorial=# EXPLAIN (ANALYZE, BUFFERS) SELECT id FROM medias WHERE user_i
                                                    QUERY PLAN
--------------------------------------------------------------------------------
 Bitmap Heap Scan on medias  (cost=4.34..18.09 rows=8 width=4) (actual time=0.0
   Recheck Cond: (user_id = 109)
   Heap Blocks: exact=5
   Buffers: shared hit=5 read=2
   ->  Bitmap Index Scan on medias_user_id_idx  (cost=0.00..4.34 rows=8 width=
         Index Cond: (user_id = 109)
         Buffers: shared read=2
 Planning:
   Buffers: shared hit=10 read=1
 Planning Time: 0.782 ms
 Execution Time: 0.082 ms
(11 rows)
```

Now, there are a couple of differences:

- `Bitmap Heap Scan on Media`
  This indicates that the query is now using the index.
- `Buffers: shared hit=5 read=2` :
  The new metric, `read` , shows the number of blocks read from disk (each block is typically 8KB, so 2 blocks equal 16KB). These blocks are then stored in the cache.
- Time Breakdown:
  The output now provides a more detailed breakdown of the execution time, including both planning and execution phases.
- Faster Execution Time:
  Finally, note that the overall execution time is faster after adding the index!

Finally, you can also use `EXPLAIN` to test your assumptions. Here are a couple of reasons why it's important to do so:

- Unexpected Query Plans:
  The query planner might not produce the query plan you expect, choosing instead a plan that it deems more cost-effective.
- ORM-Generated Queries:
  Your ORM may generate queries that are not optimal. For example, it might generate a `SELECT *` query—even when you only need a few columns—which can be inefficient if the table has many columns.

Consider a concrete example. One might assume that a query like selecting `id` from `users` would simply use the index on `medias`. However, the actual plan shows that a join is performed instead:

```
medium_tutorial=# EXPLAIN (ANALYZE, BUFFERS) SELECT id FROM medias WHERE user_i
                                                      QUERY PLAN
--------------------------------------------------------------------------------
 Hash Semi Join  (cost=3.25..54.62 rows=1000 width=4) (actual time=0.093..1.102
   Hash Cond: (medias.user_id = users.id)
   Buffers: shared hit=17
   ->  Seq Scan on medias  (cost=0.00..35.00 rows=2000 width=8) (actual time=0.
         Buffers: shared hit=15
   ->  Hash  (cost=2.00..2.00 rows=100 width=4) (actual time=0.065..0.066 rows=
         Buckets: 1024  Batches: 1  Memory Usage: 12kB
         Buffers: shared hit=2
         ->  Limit  (cost=0.00..2.00 rows=100 width=4) (actual time=0.009..0.04
               Buffers: shared hit=2
               ->  Seq Scan on users  (cost=0.00..4.00 rows=200 width=4) (actua
                     Buffers: shared hit=2
 Planning:
   Buffers: shared hit=14 read=1
 Planning Time: 0.397 ms
 Execution Time: 1.207 ms
(16 rows)
```

In this case, the plan reveals that the query uses a join rather than simply scanning the index on `medias`. This unexpected join is a perfect example of why it's essential to test your assumptions with `EXPLAIN` before finalizing query optimizations.

In conclusion, if you suspect that a query is running slowly, start by checking it with `pg_stat_statements` and then use `EXPLAIN` to dive deeper into its execution plan. These tools are essential for validating your assumptions and gaining a clear understanding of your database's behavior—especially in complex systems where subtle differences in execution can significantly impact performance.

Postgresql Database

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Codemonkey coding for tea. Startup developer at day, community organizer at night. I also happens to be on patreon https://www.patreon.com/sweemeng

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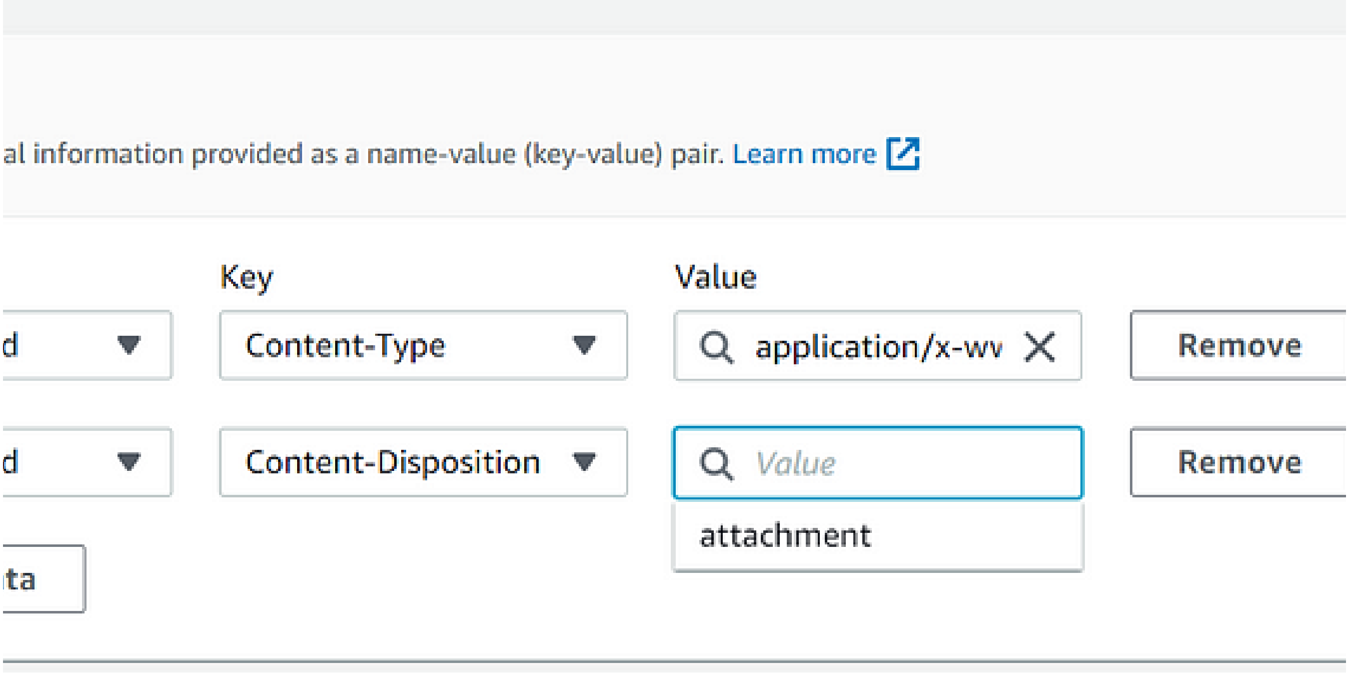

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d	Content-Type	application/x-wv	Remove
d	Content-Disposition	Value attachment	Remove

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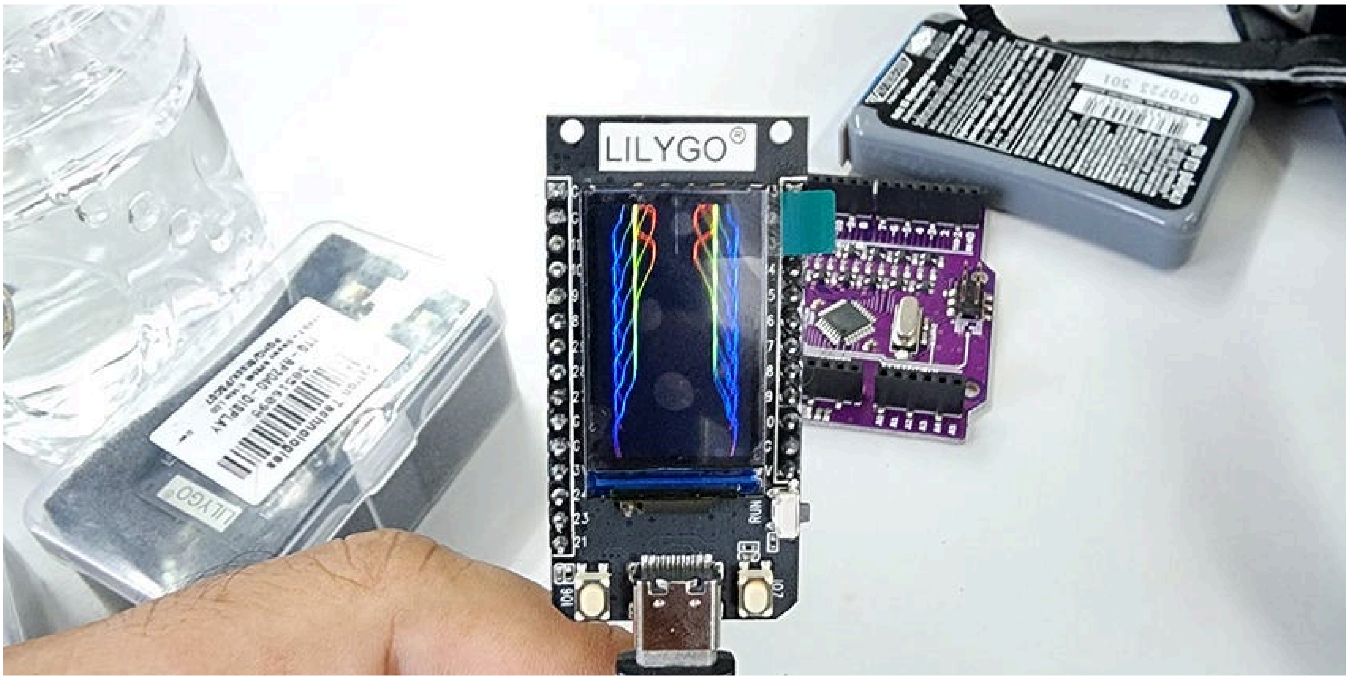

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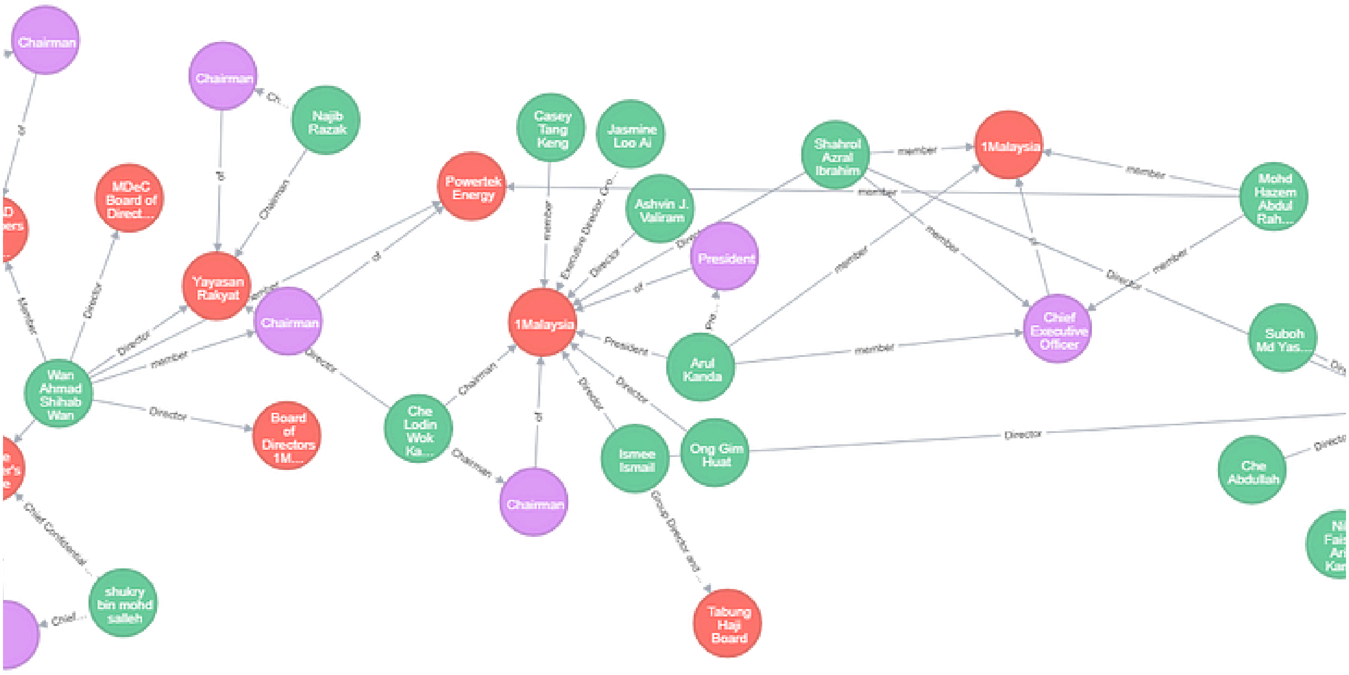

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Note: I originally write this on https://devkami.com/blogs/2021/05/17-vim-escape-key/

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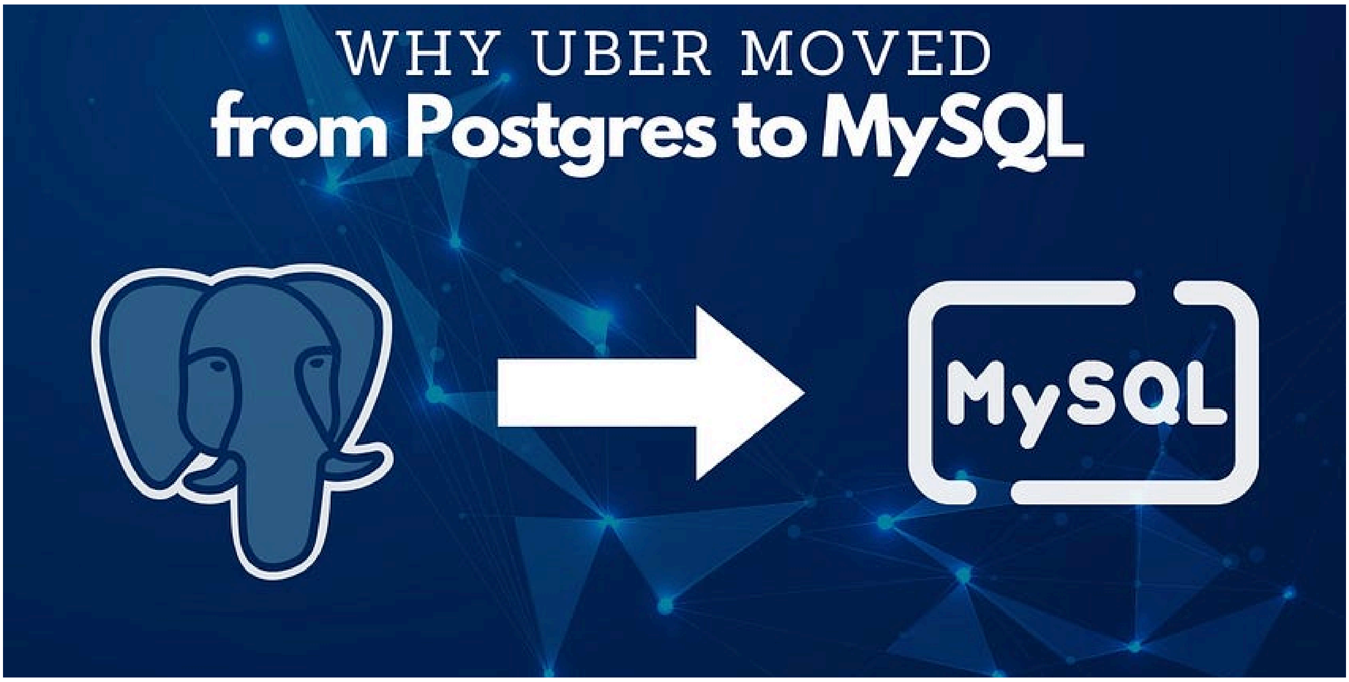

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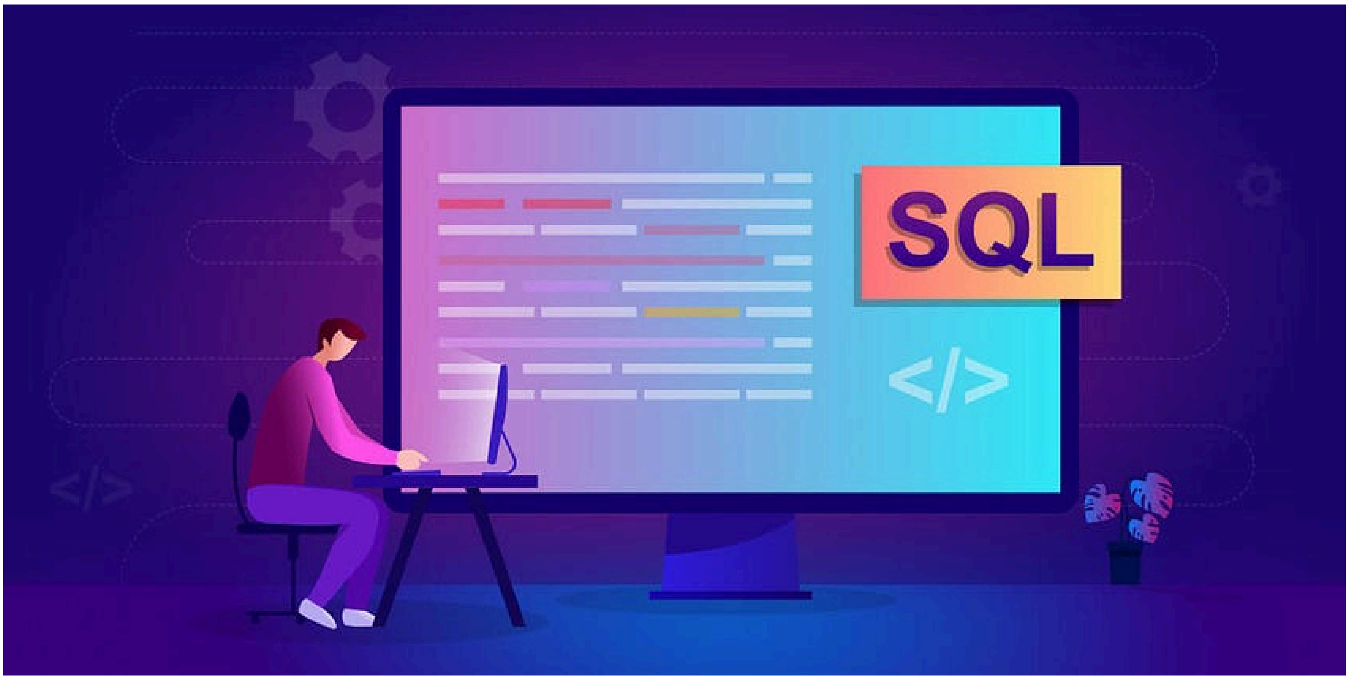

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