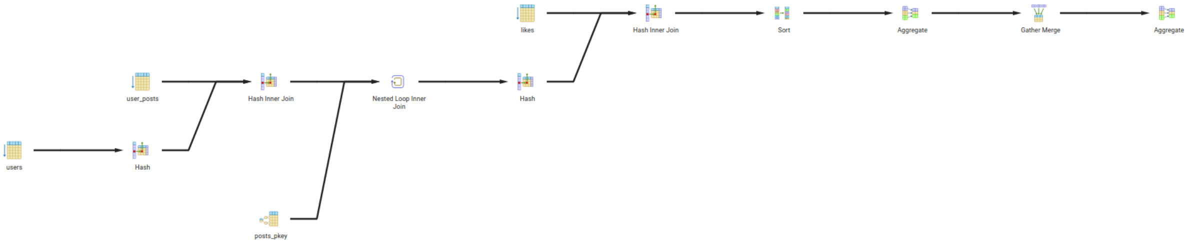
Database Tuning

Queries

1. Query 1:
    1. Description: Find posts of users in city 1 with more than 20 likes.
    2. Query:

```
SELECT p.body FROM posts p
JOIN user_posts up ON up.post_id = p.id
JOIN users u ON u.id = up.user_id
JOIN likes l ON l.post_id = p.id
WHERE u.city = 'city 1'
GROUP BY p.id
HAVING COUNT(l.id) > 20;
```

    3. Explain:
        1. The query will first join the `posts` table with `user_posts` table on `post_id` column.
        2. Then it will join the result with `users` table on `user_id` column.
        3. Then it will join the result with `likes` table on `post_id` column.
        4. Then it will filter the result by `city` column.
        5. Then it will group the result by `id` column.
        6. Then it will filter the result by `COUNT(l.id) > 20`.
    4. Query Tree:

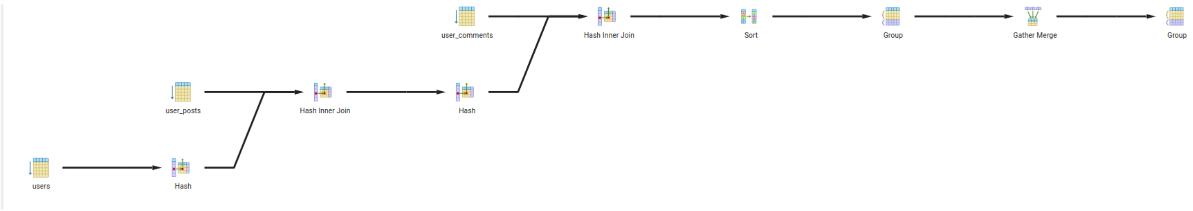


2. Query 2:
    1. Description: Find all the comments and posts of a user that is older than 25 and lives in city 1
    2. Query:

```
SELECT uc.comment_id, up.post_id FROM users u
INNER JOIN user_posts up ON u.id = up.user_id
INNER JOIN user_comments uc ON u.id = uc.user_id
WHERE u.age > 25 and u.city = 'city 1'
GROUP BY up.post_id , uc.comment_id;
```

    3. Explain:
        1. The query will first join the `users` table with `user_posts` table on `id` column.
        2. Then it will join the result with `user_comments` table on `user_id` column.

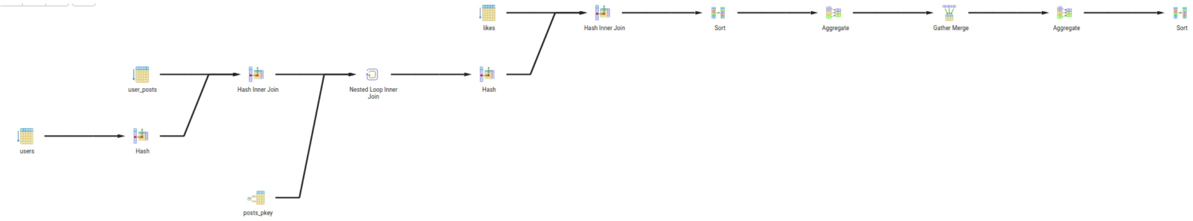
        3. Then it will filter the result by `age > 25` and `city = 'city 1'`.
        4. Then it will group the result by `post_id` and `comment_id`.
    4. Query Tree:



3. Query 3:
    1. Description: Find the posts with most likes in city 1.
    2. Query:

```sql
SELECT p.body, u.city, COUNT(l.id) AS likes_count
FROM posts p
JOIN user_posts up ON up.post_id = p.id
JOIN users u ON u.id = up.user_id
JOIN likes l ON l.post_id = p.id
WHERE u.city = 'city 1'
GROUP BY u.city, p.body
ORDER BY likes_count DESC;
```

    3. Explain:
        1. The query will first join the `posts` table with `user_posts` table on `post_id` column.
        2. Then it will join the result with `users` table on `user_id` column.
        3. Then it will join the result with `likes` table on `post_id` column.
        4. Then it will filter the result by `city = 'city 1'`.
        5. Then it will group the result by `city` and `body`.
        6. Then it will order the result by `likes_count` in descending order.
    4. Query Tree:

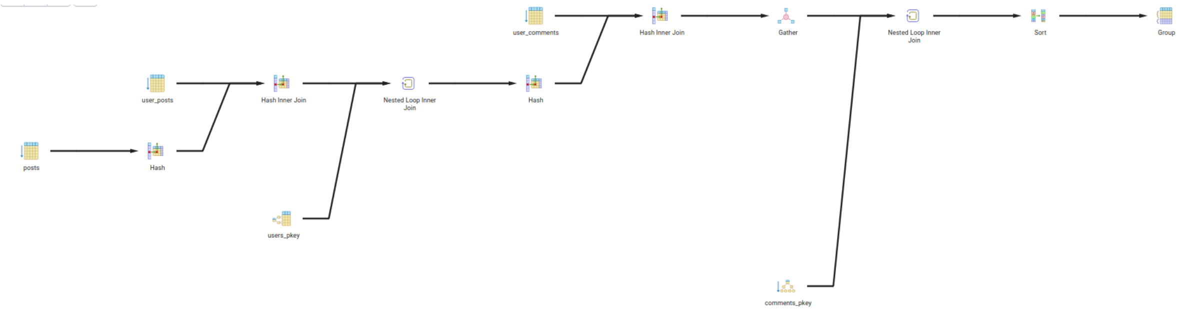


4. Query 4:
    1. Description: Get the full details of all the posts that has 1 in the title and 2 in the body from users that are older than 28 and live in city 1
    2. Query:

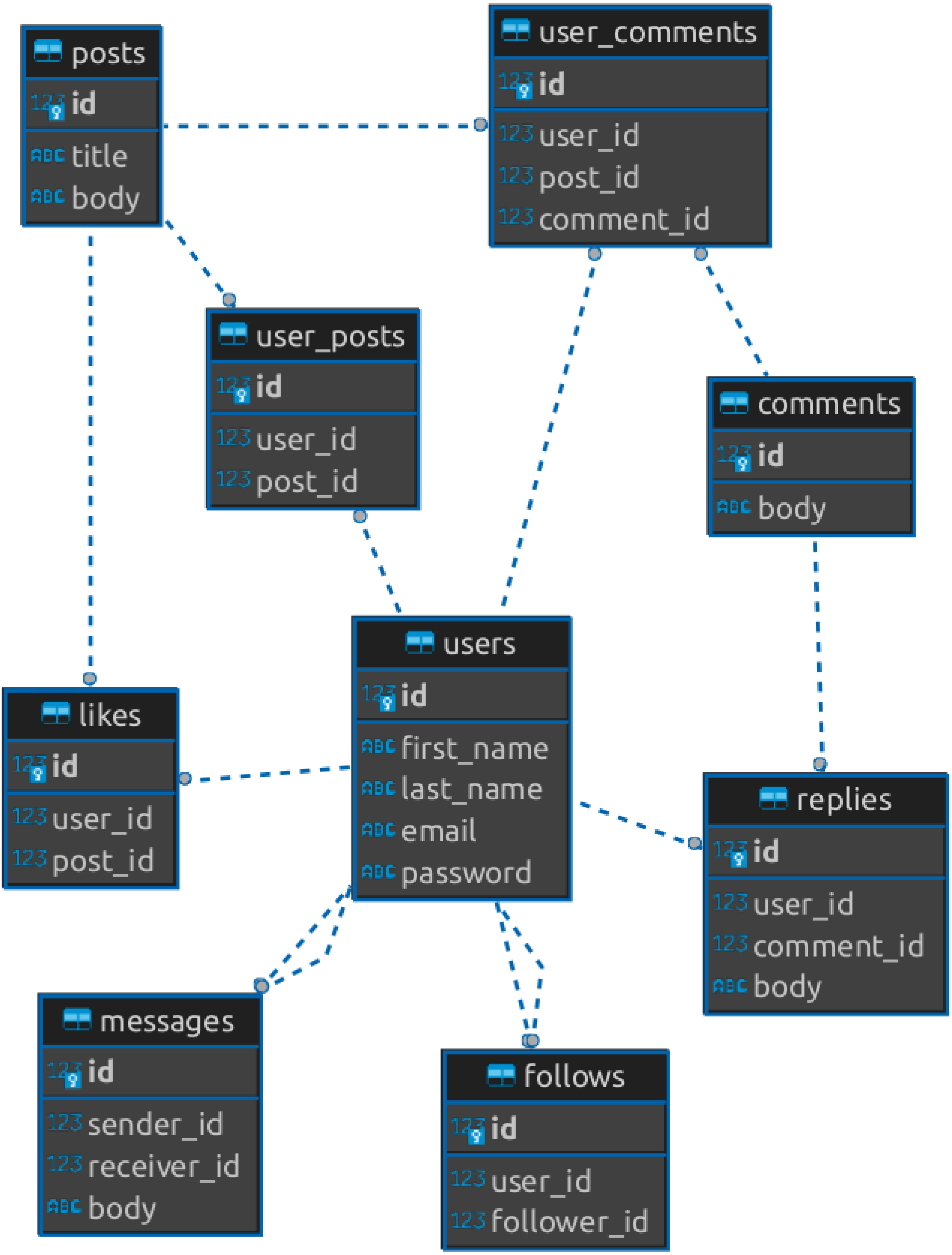
```sql
SELECT up.post_id , p.body , p.title
FROM  users u
INNER JOIN user_posts up ON u.id = up.user_id
INNER JOIN user_comments uc ON u.id = uc.user_id
INNER JOIN posts p ON p.id = up.post_id
INNER JOIN comments c ON c.id = uc.comment_id
WHERE u.age > 28 and u.City = 'city 1' and
```

```
            p.title LIKE '%title 1%' and p.body LIKE '%body 2%'
            GROUP BY up.post_id, p.body, p.title;
```

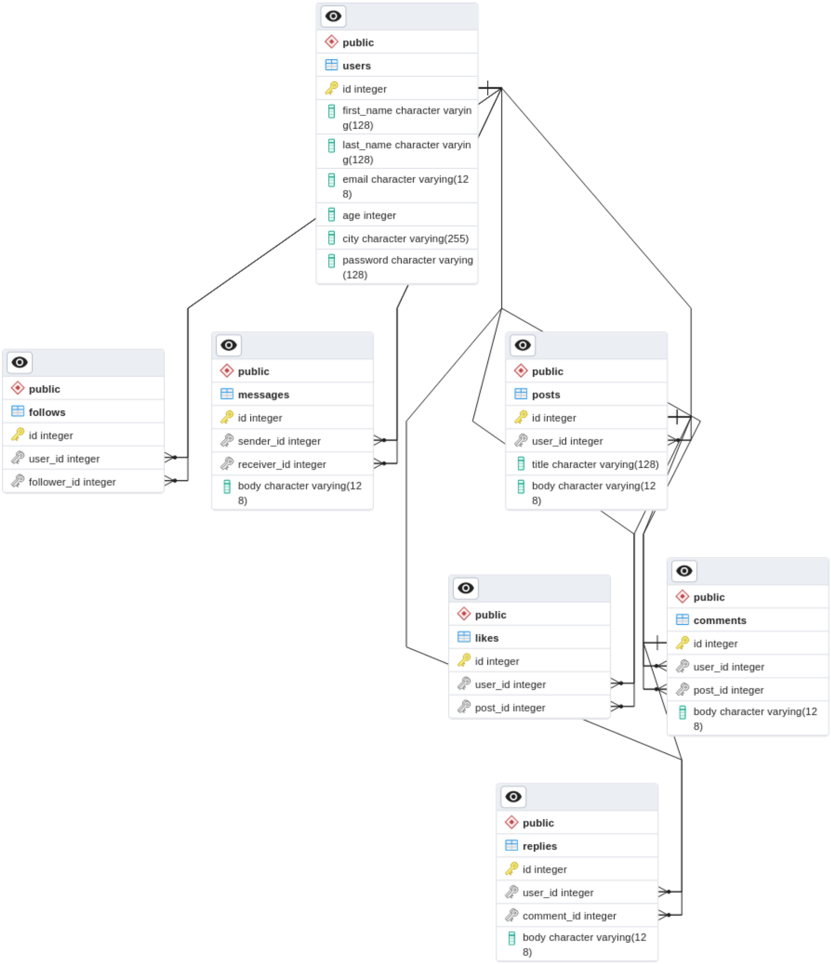
3. Explain:
    1. The query will first join the `users` table with `user_posts` table on `id` column.
    2. Then it will join the result with `user_comments` table on `user_id` column.
    3. Then it will join the result with `posts` table on `post_id` column.
    4. Then it will join the result with `comments` table on `comment_id` column.
    5. Then it will filter the result by `age > 28` and `city = 'city 1'` and `title LIKE '%title 1%'` and `body LIKE '%body 2%'`.
    6. Then it will group the result by `post_id`, `body`, `title`.
4. Query Tree:



Postgres Server Old Schema



Postgres Server Enhanced Schema



Optimizations

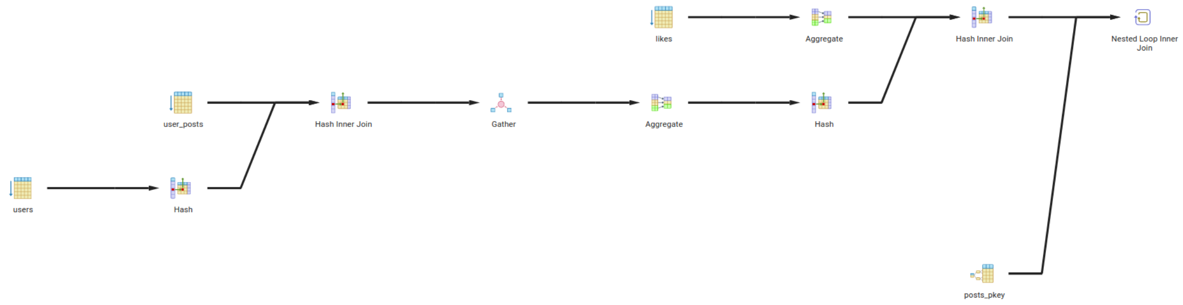
Subquery Optimizations

1. Query 1:
    1. Description: Find posts of users in city 1 with more than 20 likes.
    2. Query:

```
        SELECT p.body FROM posts p
        where p.id in
        (SELECT up.post_id FROM user_posts up JOIN users u ON u.id =
up.user_id WHERE u.city = 'city 1')
        And p.id in
        (SELECT l.post_id FROM likes l GROUP BY l.post_id HAVING
COUNT(l.id) > 20);
```

    3. Explain:
        1. The query will first join the `user_posts` table with `users` table on `id` column.
        2. Then it will filter the result by `city = 'city 1'`.
        3. Then it will join the result with `likes` table on `post_id` column.
        4. Then it will group the result by `post_id`.
        5. Then it will filter the result by `COUNT(l.id) > 20`.
        6. Then it will select the `body` column from the result.

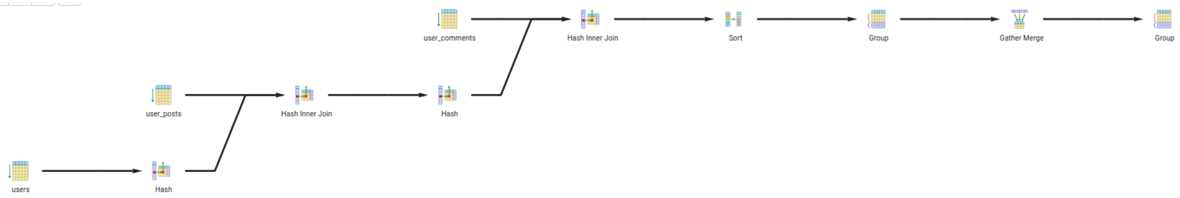
4. Query Tree:



2. Query 2:
    1. Description: Find all the comments and posts of a user that is older than 25 and lives in city 1
    2. Query:

```
        with CTE as (SELECT * FROM users WHERE age > 25 and city = 
'city 1')
        SELECT uc.comment_id, up.post_id FROM CTE AS u
        INNER JOIN user_posts up ON u.id = up.user_id
        INNER JOIN user_comments uc ON u.id = uc.user_id
        GROUP BY up.post_id , uc.comment_id;
```

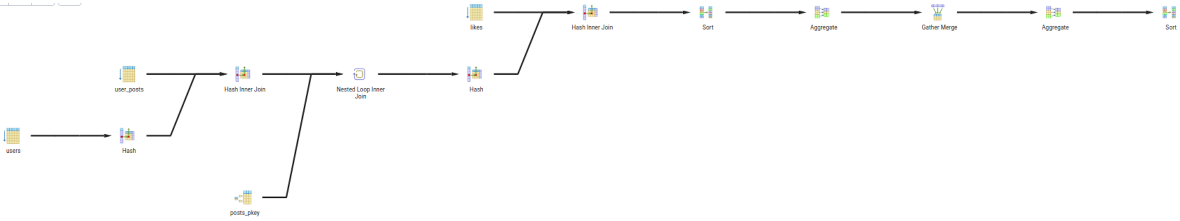
    3. Explain:
        1. The query will first filter the `users` table by `age > 25` and `city = 'city 1'` using a CTE.
        2. Then it will join the result with `user_posts` table on `user_id` column.
        3. Then it will join the result with `user_comments` table on `user_id` column.
        4. Then it will group the result by `post_id` and `comment_id`.
    4. Query Tree:



3. Query 3:
    1. Description: Find the posts with most likes in city 1.
    2. Query:

```
         SELECT p.body, u.city, COUNT(l.id) AS likes_count
         FROM posts p
         INNER JOIN user_posts up ON up.post_id = p.id
         INNER JOIN users u ON u.id = up.user_id
         INNER JOIN likes l ON l.post_id = p.id
         WHERE u.city = 'city 1'
         GROUP BY u.city, p.body
         ORDER BY likes_count DESC;
```

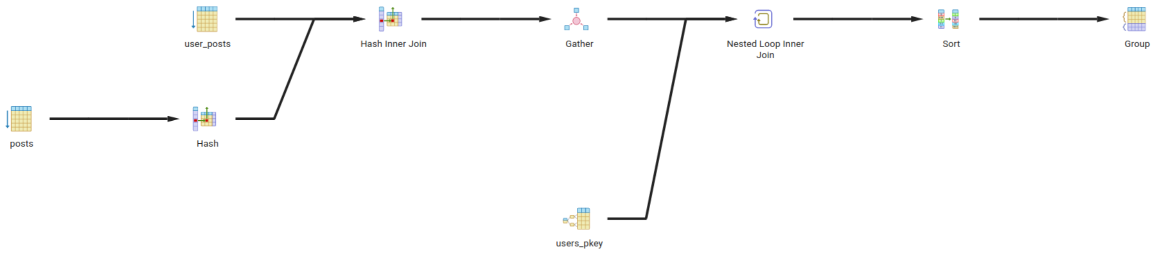
3. Explain:
    1. The query will first join the `posts` table with `user_posts` table on `post_id` column.
    2. Then it will join the result with `users` table on `user_id` column.
    3. Then it will join the result with `likes` table on `post_id` column.
    4. Then it will filter the result by `city = 'city 1'`.
    5. Then it will group the result by `city`, `body`.
    6. Then it will order the result by `likes_count` in descending order.
    7. Then it will select the `body`, `city`, `likes_count` columns.
4. Query Tree:



4. Query 4:
    1. Description: Get the full details of all the posts that has 1 in the title and 2 in the body from users that are older than 28 and live in city 1
    2. Query:

```
        with CTE as (SELECT * FROM users WHERE age > 25 and city =
'city 1')
        SELECT  up.post_id FROM CTE AS u
        INNER JOIN user_posts up ON u.id = up.user_id
        inner join posts p on p.id = up.post_id
        where p.title LIKE '%title 1%' and p.body LIKE '%body 2%'
        GROUP BY up.post_id;
```

3. Explain:
    1. The query will first filter the `users` table by `age > 25` and `city = 'city 1'` using a CTE.
    2. Then it will join the result with `user_posts` table on `user_id` column.
    3. Then it will join the result with `posts` table on `post_id` column.
    4. Then it will filter the result by `title LIKE '%title 1%'` and `body LIKE '%body 2%'`.
    5. Then it will group the result by `post_id`.
    6. Then it will select the `post_id` column.
4. Query Tree:



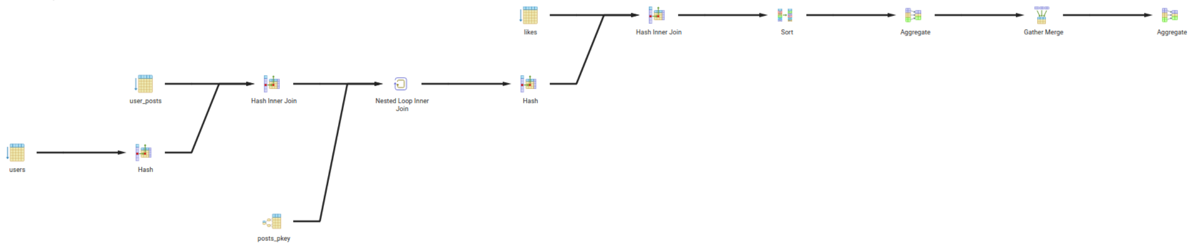
Indexes

1. Query 1:
    1. Description: Find posts of users in city 1 with more than 20 likes.
    2. Query:

```
        -- add index for post_id in user_posts table if not exists
        CREATE INDEX IF NOT EXISTS user_posts_post_id_idx ON user_posts (post_id);
        -- add index for post_id in likes table if not exists
        CREATE INDEX IF NOT EXISTS likes_post_id_idx ON likes (post_id);
        -- add index for city in users table if not exists
        CREATE INDEX IF NOT EXISTS users_city_idx ON users (city);
        -- add index for user_id in user_posts table if not exists
        CREATE INDEX IF NOT EXISTS user_posts_user_id_idx ON user_posts (user_id);

        -- use explain analyze to see the difference in execution time
        SELECT p.body FROM posts p
        JOIN user_posts up ON up.post_id = p.id
        JOIN users u ON u.id = up.user_id
        JOIN likes l ON l.post_id = p.id
        WHERE u.city = 'city 1'
        GROUP BY p.id
        HAVING COUNT(l.id) > 20;
```

    3. Explain:
        1. We have added indexes for `post_id` in `user_posts` table, `post_id` in `likes` table, `city` in `users` table, and `user_id` in `user_posts` table.
        2. We have added those indexes to make the query more computationally efficient.
        3. For instance, we have added an index for `city` in `users` table to make the filtering by `city = 'city 1'` more efficient.
        4. We have added an index for `post_id` in `user_posts` table to make the join between `posts` table and `user_posts` table more efficient.
        5. We have added an index for `post_id` in `likes` table to make the join between `posts` table and `likes` table more efficient.
        6. We have added an index for `user_id` in `user_posts` table to make the join between `users` table and `user_posts` table more efficient.
    4. Query Tree:



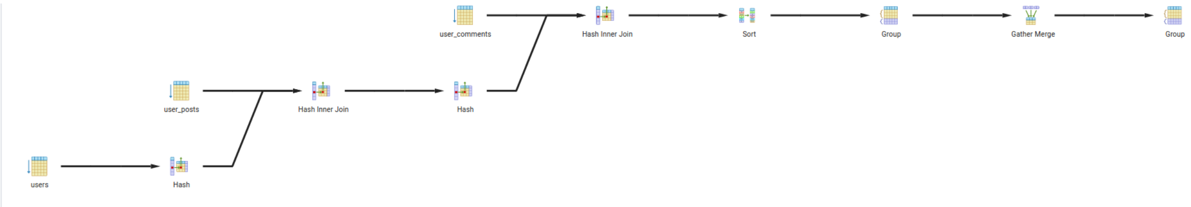
2. Query 2:
    1. Description: Find all the comments and posts of a user that is older than 25 and lives in city 1

2. Query:

```
        -- add composite index for users table if not exists
        CREATE INDEX IF NOT EXISTS users_age_city_idx ON users (city,
age);
        -- add index for user_id in user_posts table if not exists
        CREATE INDEX IF NOT EXISTS user_posts_user_id_idx ON
user_posts (user_id);

        -- we changed the order of the conditions in the where clause
to make indexing more efficient
        SELECT uc.comment_id, up.post_id FROM users u
        INNER JOIN user_posts up ON u.id = up.user_id
        INNER JOIN user_comments uc ON u.id = uc.user_id
        WHERE u.city = 'city 1' and  u.age > 25
        GROUP BY up.post_id , uc.comment_id;
```

3. Explain:
    1. We have added a composite index for `city` and `age` in `users` table, and an index for `user_id` in `user_posts` table.
    2. We have added those indexes to make the query more computationally efficient.
    3. We have added a composite index for `city` and `age` in `users` table to make the filtering by `city = 'city 1'` and `age > 25` more efficient.
    4. We changed the order of the conditions in the `where` clause to make indexing more efficient.
    5. We have added an index for `user_id` in `user_posts` table to make the join between `users` table and `user_posts` table more efficient.
4. Query Tree:



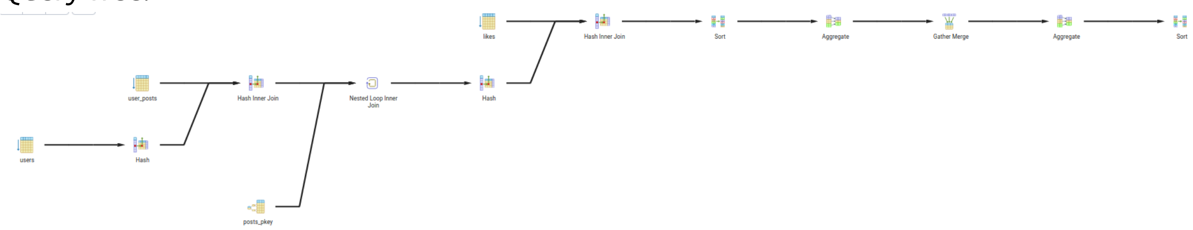
3. Query 3:
    1. Description: Find the posts with most likes in city 1.
    2. Query:

```
          -- add index for city in users table if not exists
          CREATE INDEX IF NOT EXISTS users_city_idx ON users (city);
          -- add index for user_id in user_posts table if not exists
          CREATE INDEX IF NOT EXISTS user_posts_user_id_idx ON
user_posts (user_id);

          -- get the posts with max likes in every city
          SELECT p.body, u.city, COUNT(l.id) AS likes_count
          FROM posts p
          JOIN user_posts up ON up.post_id = p.id
          JOIN users u ON u.id = up.user_id
```

```
         JOIN likes l ON l.post_id = p.id
         WHERE u.city = 'city 1'
         GROUP BY u.city, p.body
         ORDER BY likes_count DESC;
```

   3. Explain:
      1. We have added an index for `city` in `users` table, and an index for `user_id` in `user_posts` table.
      2. We have added those indexes to make the query more computationally efficient.
      3. We have added an index for `city` in `users` table to make the filtering by `city = 'city 1'` more efficient.
      4. We have added an index for `user_id` in `user_posts` table to make the join between `users` table and `user_posts` table more efficient.
   4. Query Tree:



4. Query 4:
   1. Description: Get the full details of all the posts that has 1 in the title and 2 in the body from users that are older than 28 and live in city 1
   2. Query:

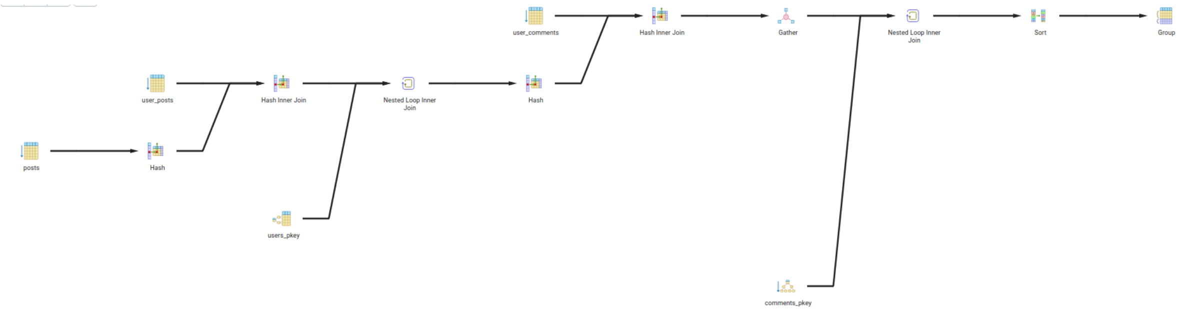
```
         -- add composite index for users table if not exists
         CREATE INDEX IF NOT EXISTS users_age_city_idx ON users (city,
age);

         -- we changed the order of the conditions in the where clause
to make indexing more efficient
         -- indexing won't be efficient due to the use of LIKE
operator
         SELECT up.post_id , p.body , p.title
         FROM  users u
         INNER JOIN user_posts up ON u.id = up.user_id
         INNER JOIN user_comments uc ON u.id = uc.user_id
         INNER JOIN posts p ON p.id = up.post_id
         INNER JOIN comments c ON c.id = uc.comment_id
         WHERE u.City = 'city 1' and  u.age > 28  and
         p.title LIKE '%title 12%' and p.body LIKE '%body 22%'
         GROUP BY up.post_id, p.body, p.title;
```

   3. Explain:
      1. We have added a composite index for `city` and `age` in `users` table.
      2. We have added those indexes to make the query more computationally efficient.
      3. We have added a composite index for `city` and `age` in `users` table to make the filtering by `city = 'city 1'` and `age > 28` more efficient.

4. We changed the order of the conditions in the `where` clause to make indexing more efficient.

4. Query Tree:



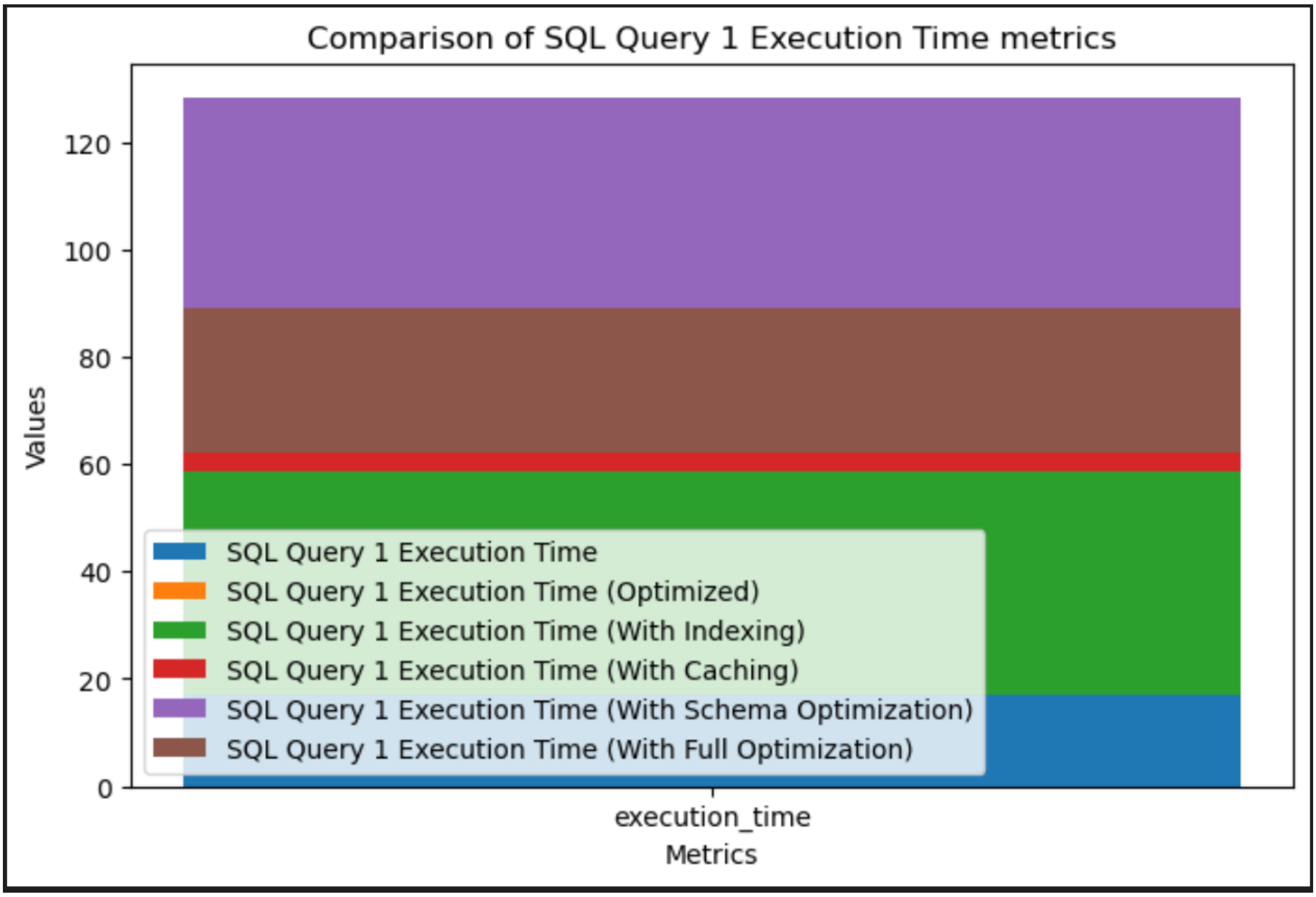
Postgres Server Statistics Report

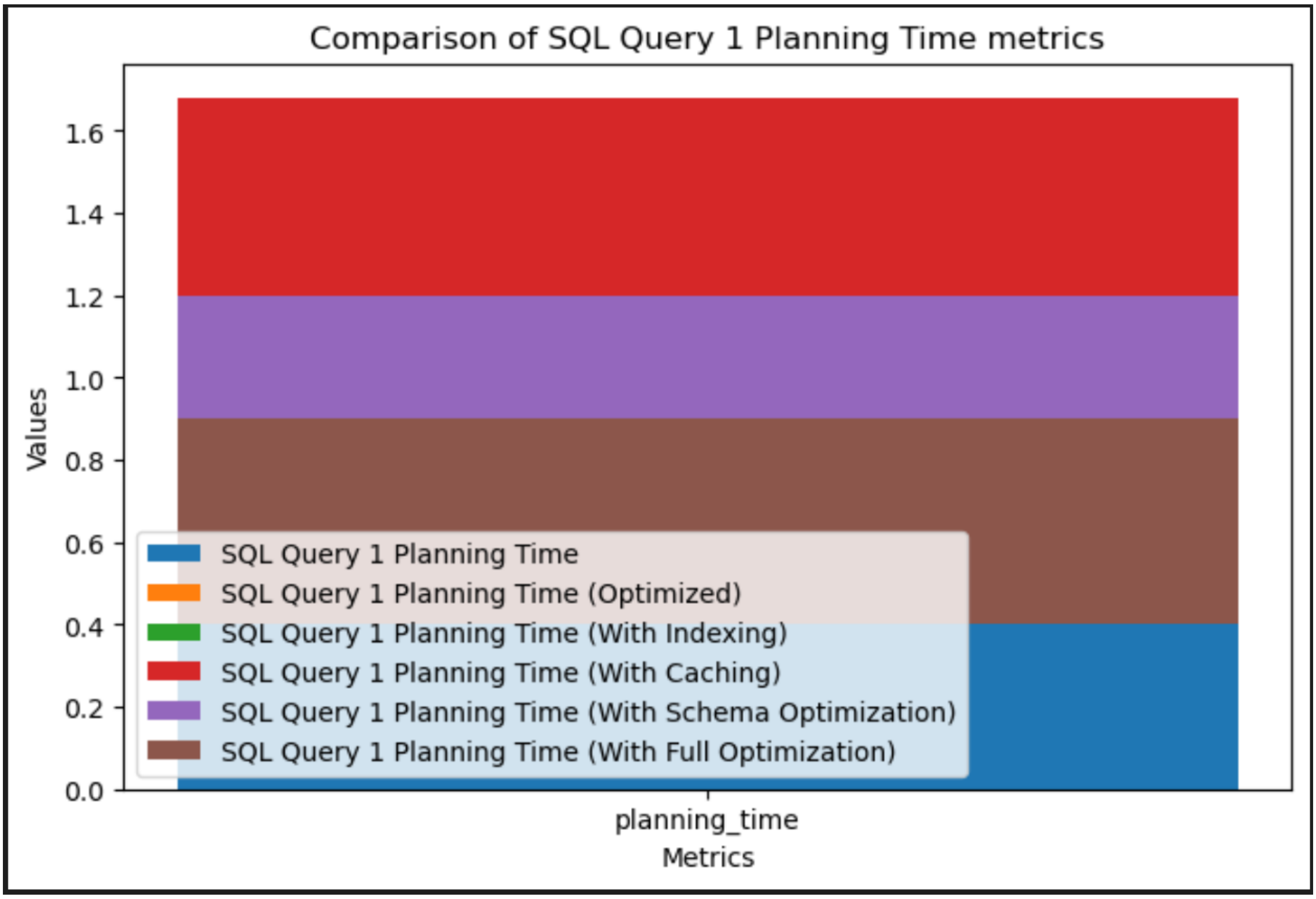
Table Name	Row Count	Main Key	Indexes	FK	Identity Column	Max Row Size(Bytes)
users	50k	Yes	No	No	Yes	87
posts	50k	Yes	No	No	Yes	50
user_posts	48734	Yes	No	Yes	Yes	35
comments	50k	Yes	No	No	Yes	38
user_comments	48734	Yes	No	Yes	Yes	39
replies	9920	Yes	No	Yes	Yes	46
likes	48734	Yes	No	Yes	Yes	35
follows	39302	Yes	No	Yes	Yes	35
messages	50k	Yes	No	Yes	Yes	46

Validation Details and Comparisons

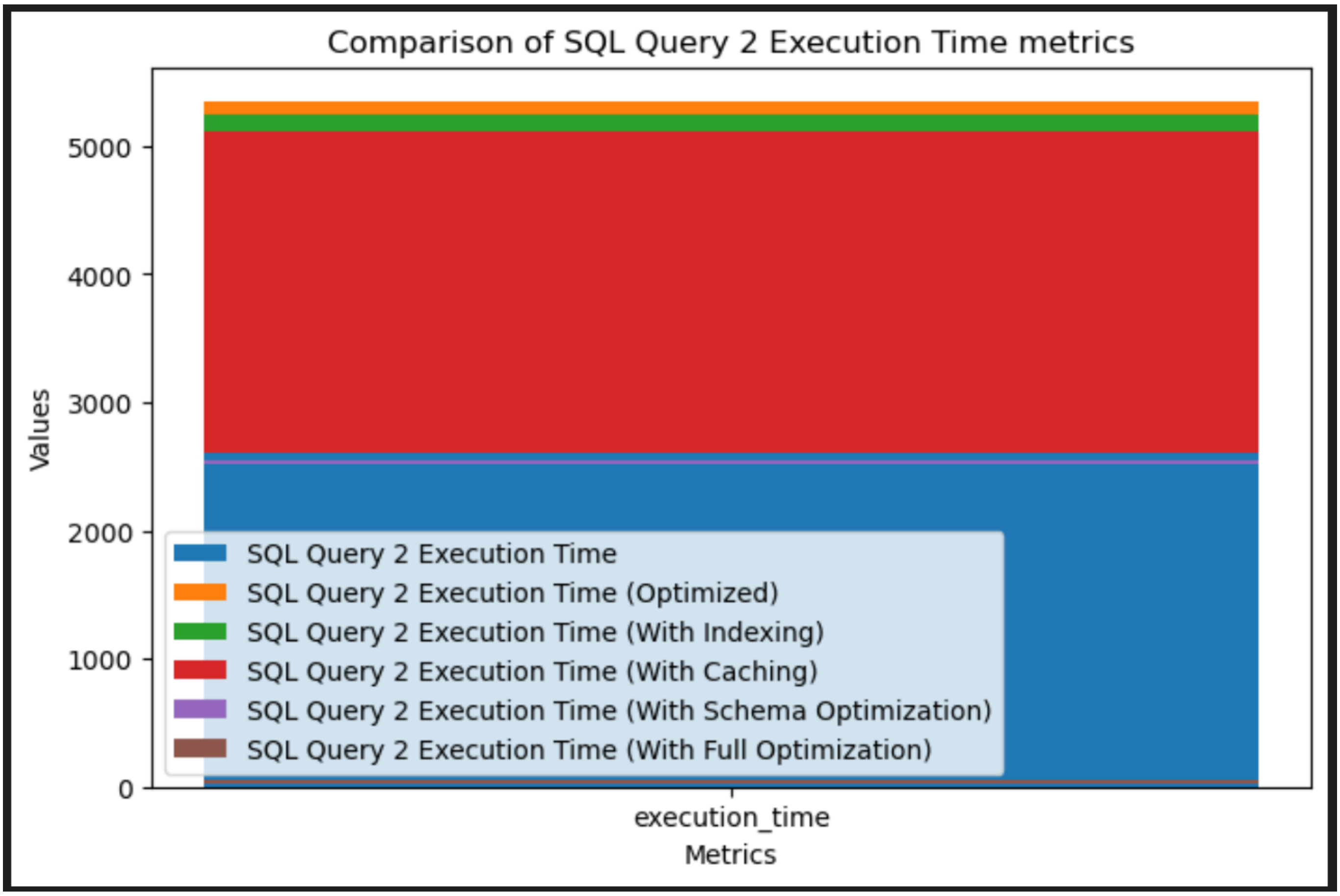
Comparison of the plan and execution times for the queries with different optimization techniques.

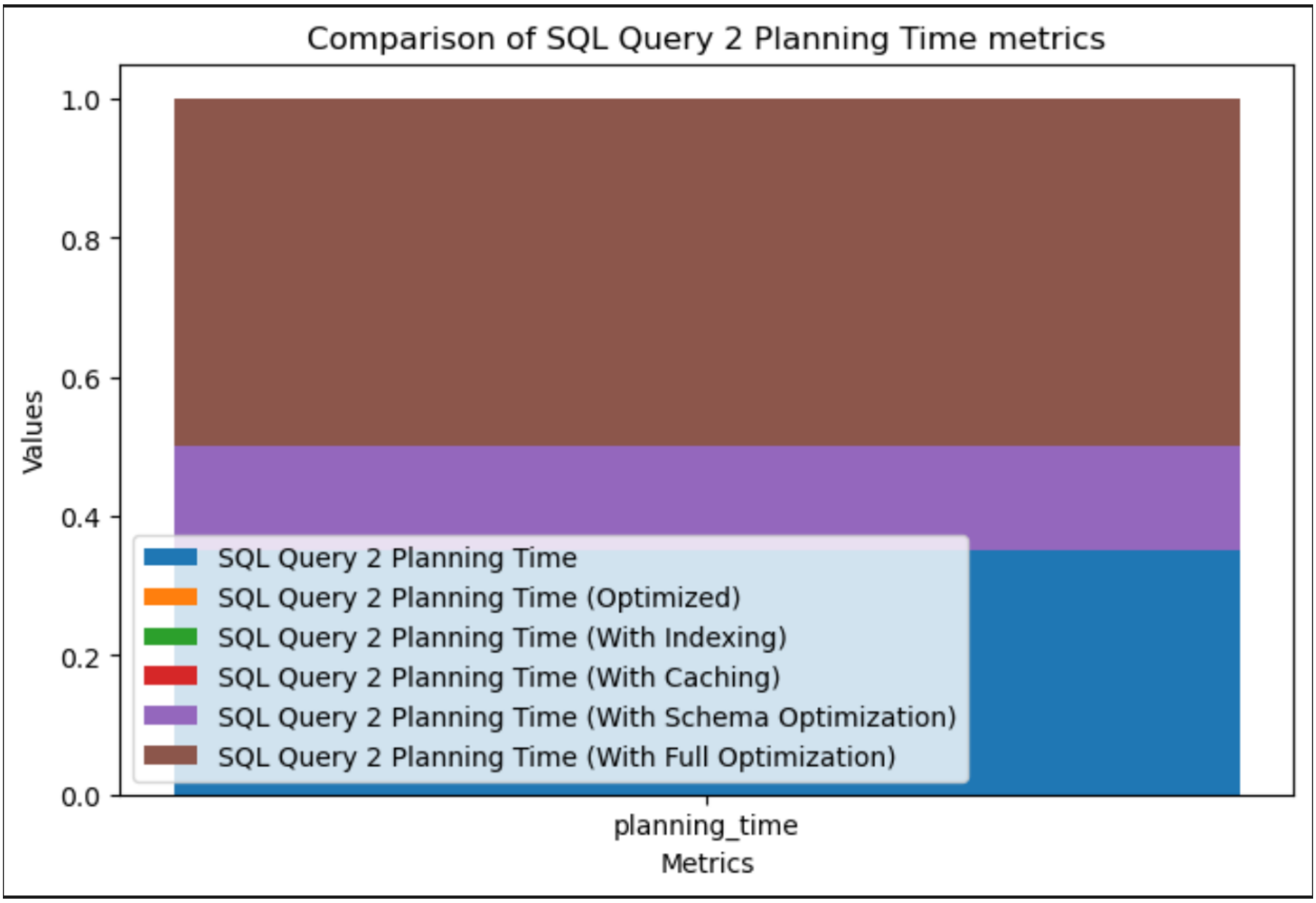
Query 1


Comparison of SQL Query 1 Execution Time metrics
Values
0
20
40
60
80
100
120
execution_time
Metrics
SQL Query 1 Execution Time
SQL Query 1 Execution Time (Optimized)
SQL Query 1 Execution Time (With Indexing)
SQL Query 1 Execution Time (With Caching)
SQL Query 1 Execution Time (With Schema Optimization)
SQL Query 1 Execution Time (With Full Optimization)

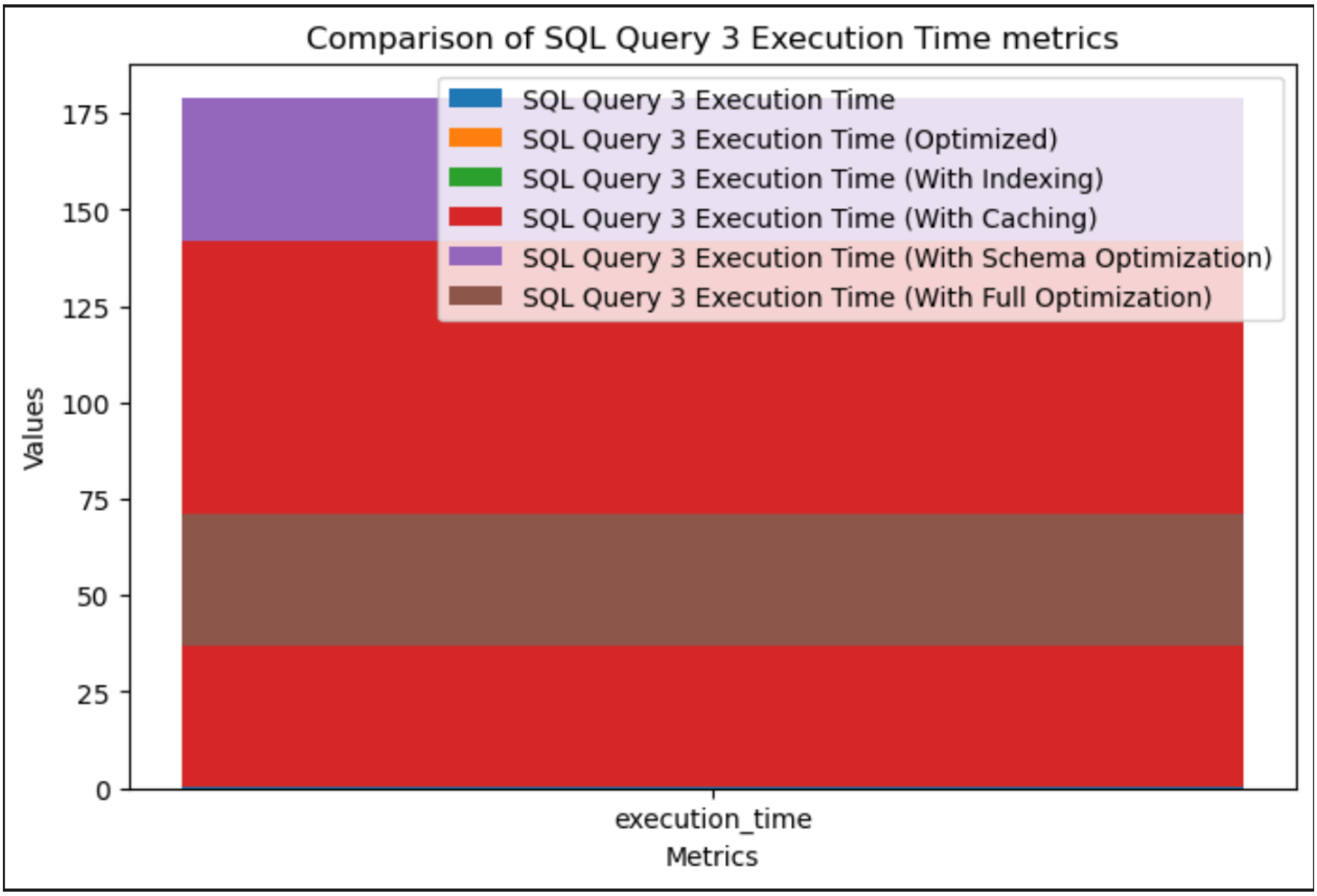

Comparison of SQL Query 1 Planning Time metrics
Values
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
planning_time
Metrics
SQL Query 1 Planning Time
SQL Query 1 Planning Time (Optimized)
SQL Query 1 Planning Time (With Indexing)
SQL Query 1 Planning Time (With Caching)
SQL Query 1 Planning Time (With Schema Optimization)
SQL Query 1 Planning Time (With Full Optimization)

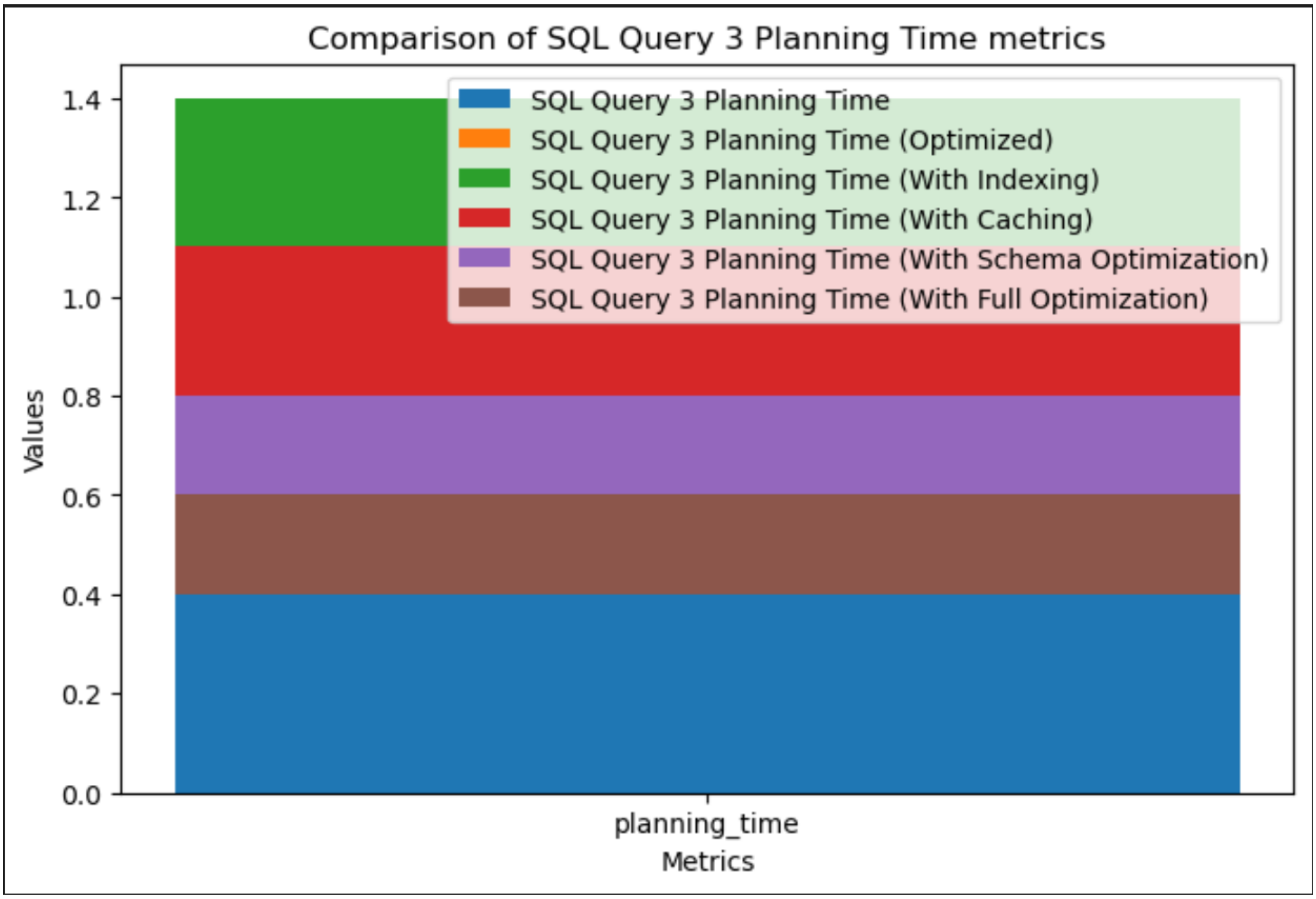
Query 2


Comparison of SQL Query 2 Execution Time metrics
Values
0
1000
2000
3000
4000
5000
execution_time
Metrics
SQL Query 2 Execution Time
SQL Query 2 Execution Time (Optimized)
SQL Query 2 Execution Time (With Indexing)
SQL Query 2 Execution Time (With Caching)
SQL Query 2 Execution Time (With Schema Optimization)
SQL Query 2 Execution Time (With Full Optimization)

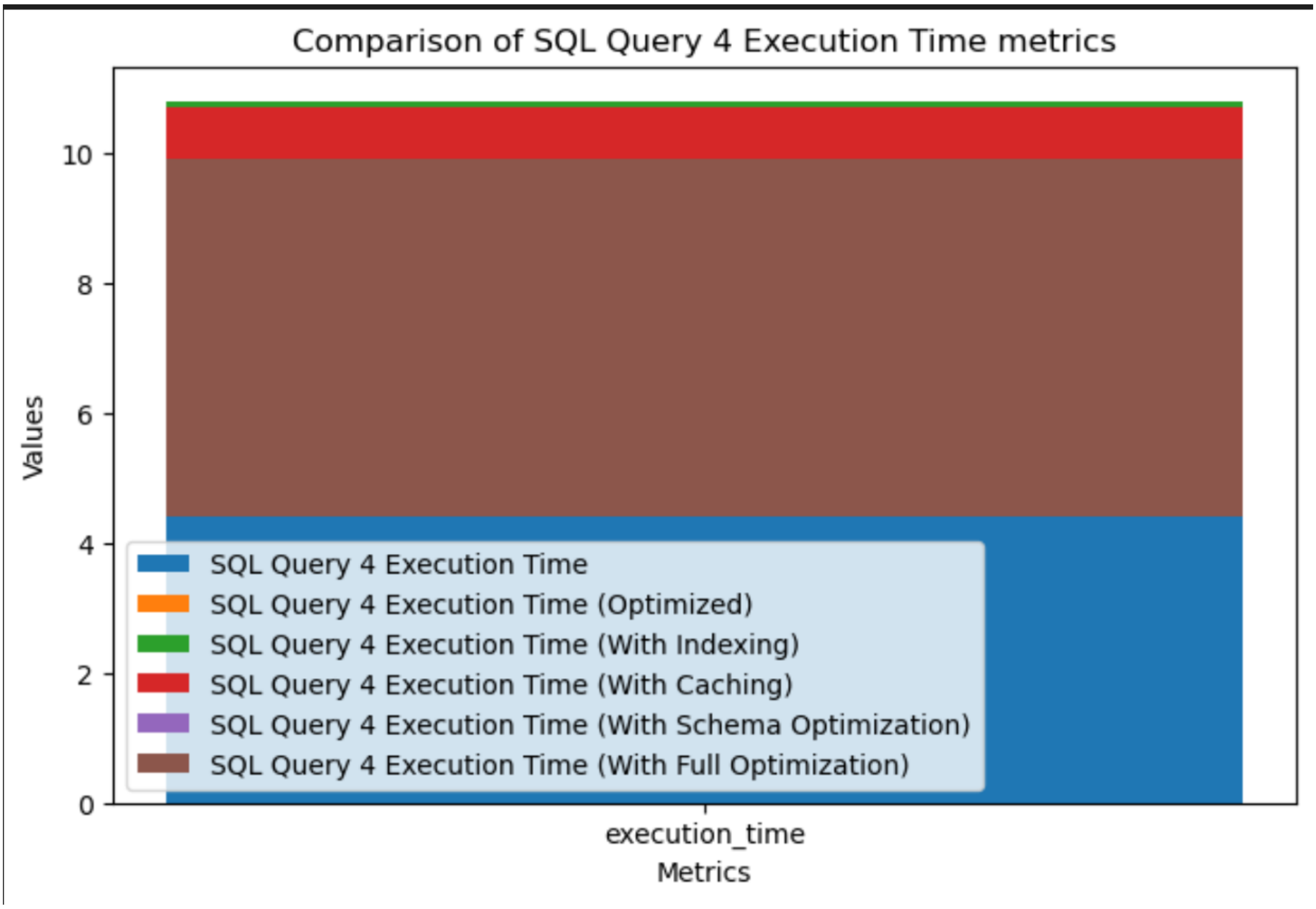

Comparison of SQL Query 2 Planning Time metrics
Values
0.0
0.2
0.4
0.6
0.8
1.0
planning_time
Metrics
SQL Query 2 Planning Time
SQL Query 2 Planning Time (Optimized)
SQL Query 2 Planning Time (With Indexing)
SQL Query 2 Planning Time (With Caching)
SQL Query 2 Planning Time (With Schema Optimization)
SQL Query 2 Planning Time (With Full Optimization)

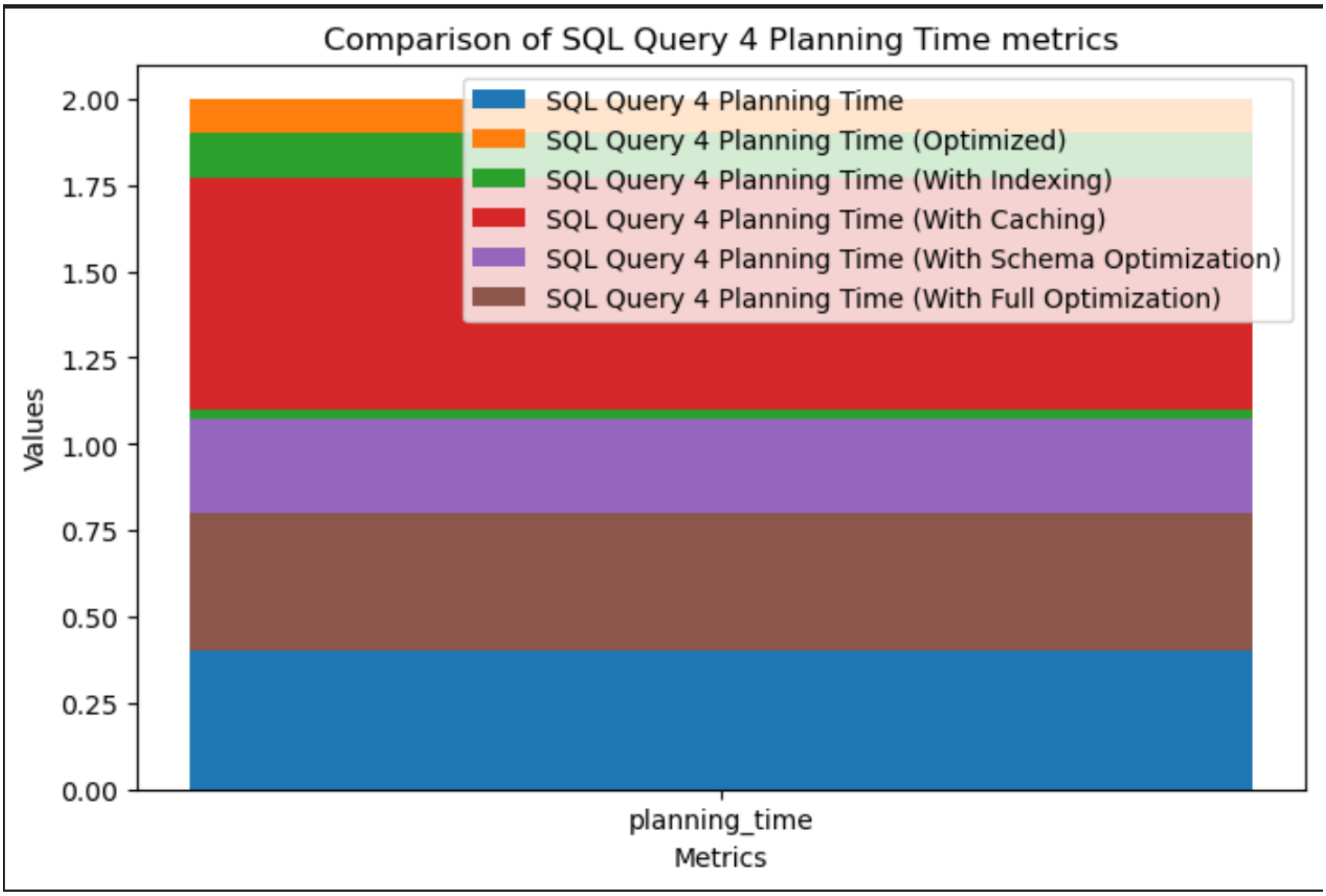
Query 3


Comparison of SQL Query 3 Execution Time metrics
SQL Query 3 Execution Time
SQL Query 3 Execution Time (Optimized)
SQL Query 3 Execution Time (With Indexing)
SQL Query 3 Execution Time (With Caching)
SQL Query 3 Execution Time (With Schema Optimization)
SQL Query 3 Execution Time (With Full Optimization)
Values
175
150
125
100
75
50
25
0
execution_time
Metrics


Comparison of SQL Query 3 Planning Time metrics
SQL Query 3 Planning Time
SQL Query 3 Planning Time (Optimized)
SQL Query 3 Planning Time (With Indexing)
SQL Query 3 Planning Time (With Caching)
SQL Query 3 Planning Time (With Schema Optimization)
SQL Query 3 Planning Time (With Full Optimization)
Values
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
planning_time
Metrics

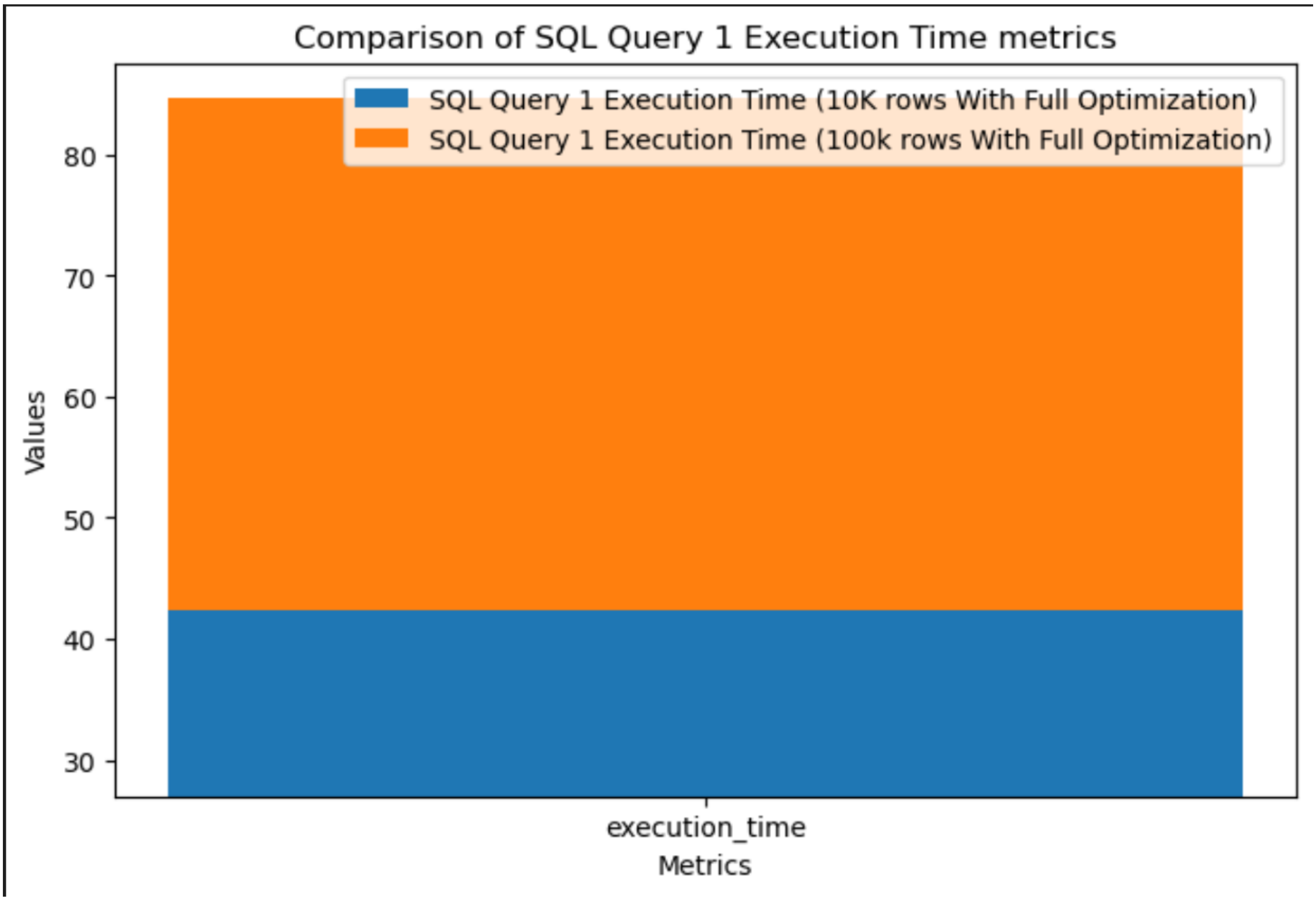
Query 4

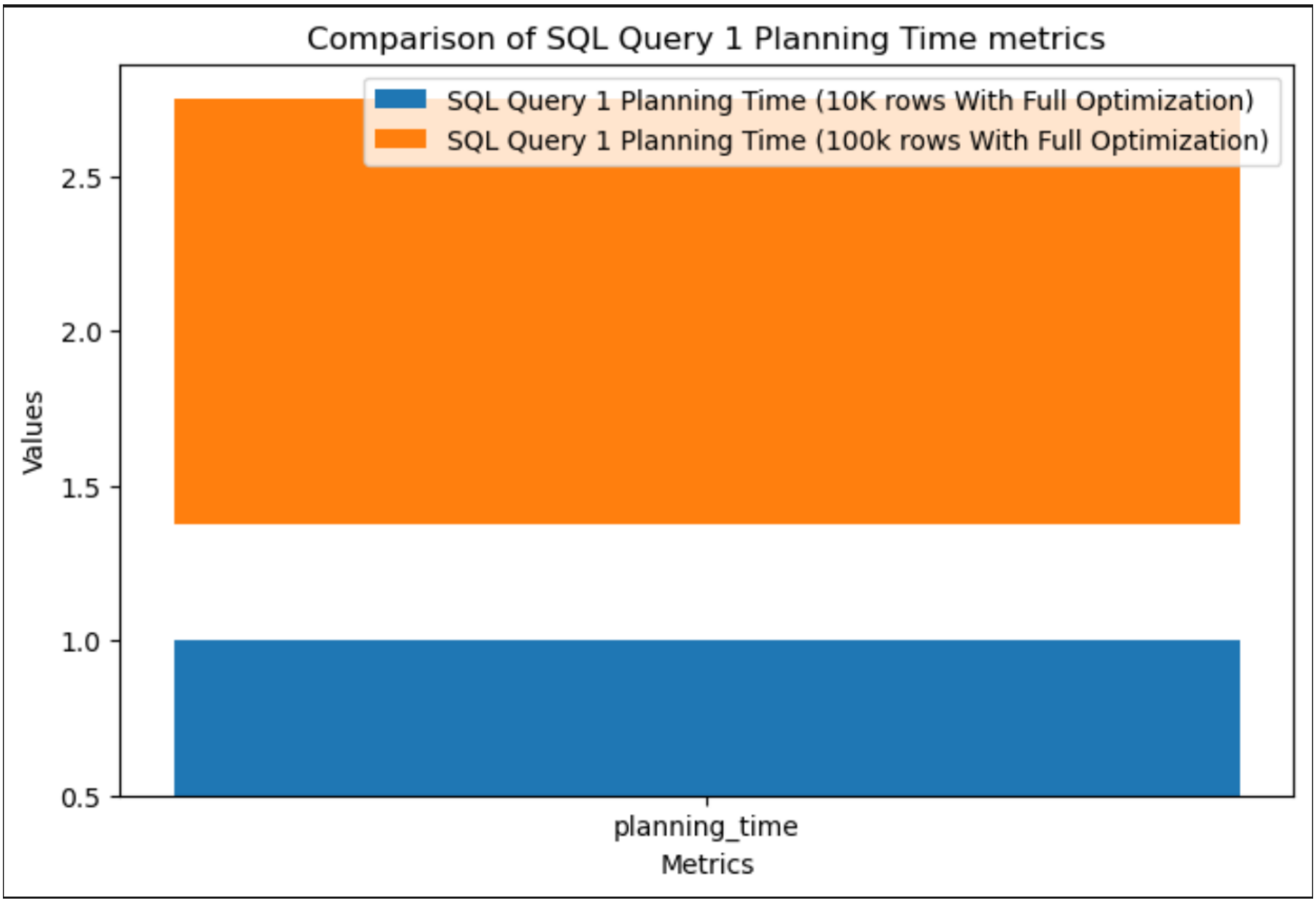




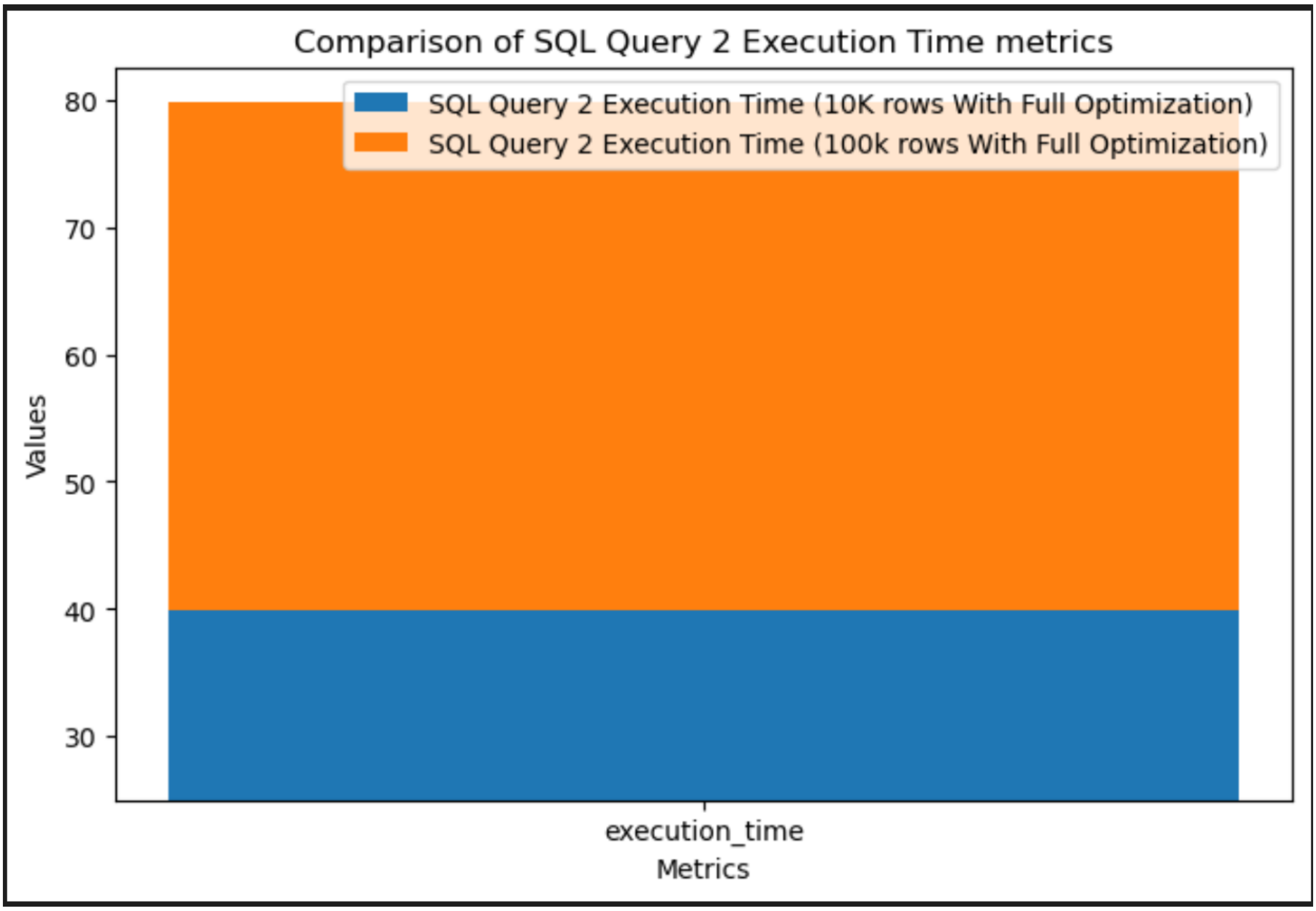
Comparison of the plan and execution times for the queries with different sizes.

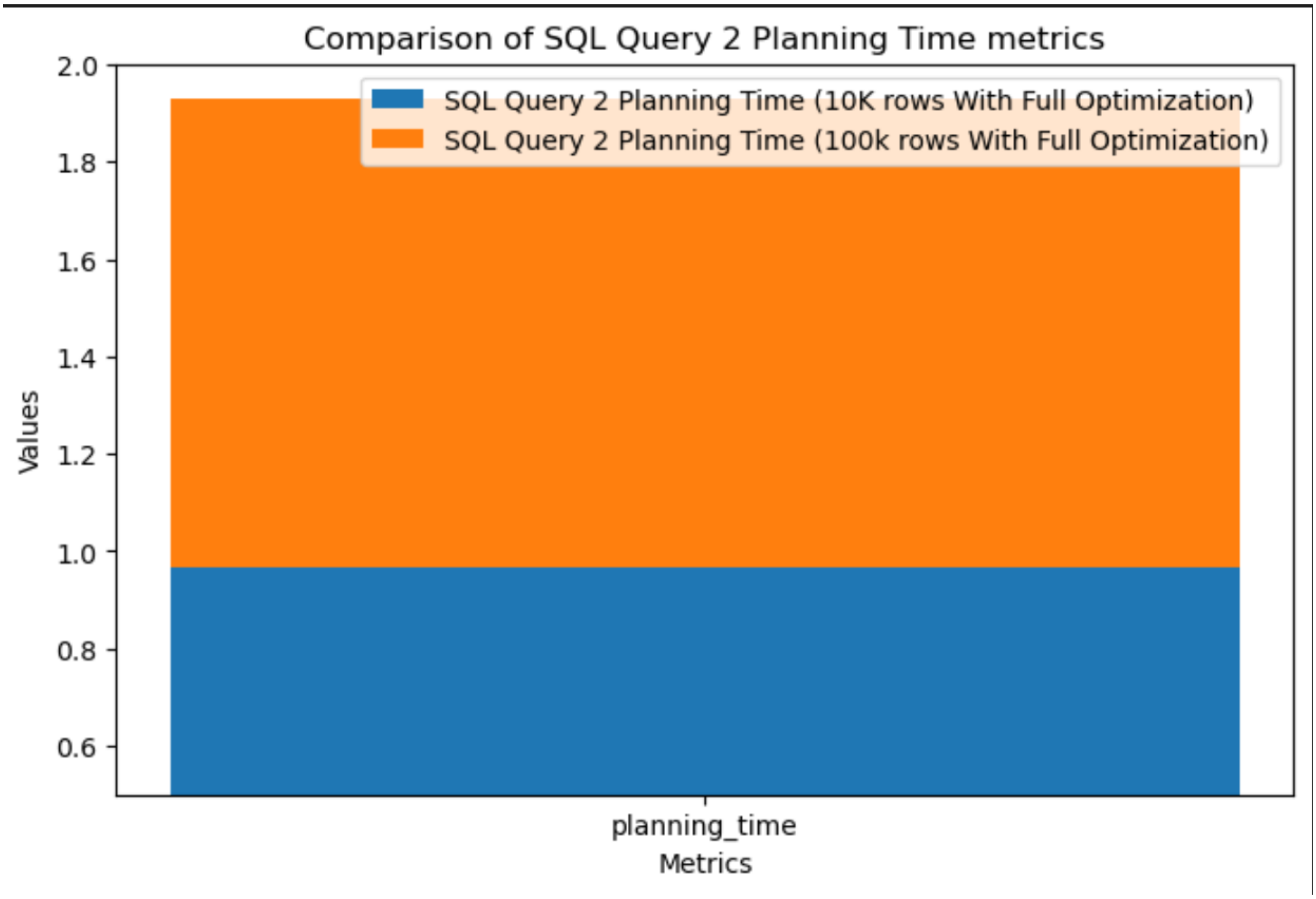
Query 1


Comparison of SQL Query 1 Execution Time metrics
SQL Query 1 Execution Time (10K rows With Full Optimization)
SQL Query 1 Execution Time (100k rows With Full Optimization)
Values
30
40
50
60
70
80
execution_time
Metrics

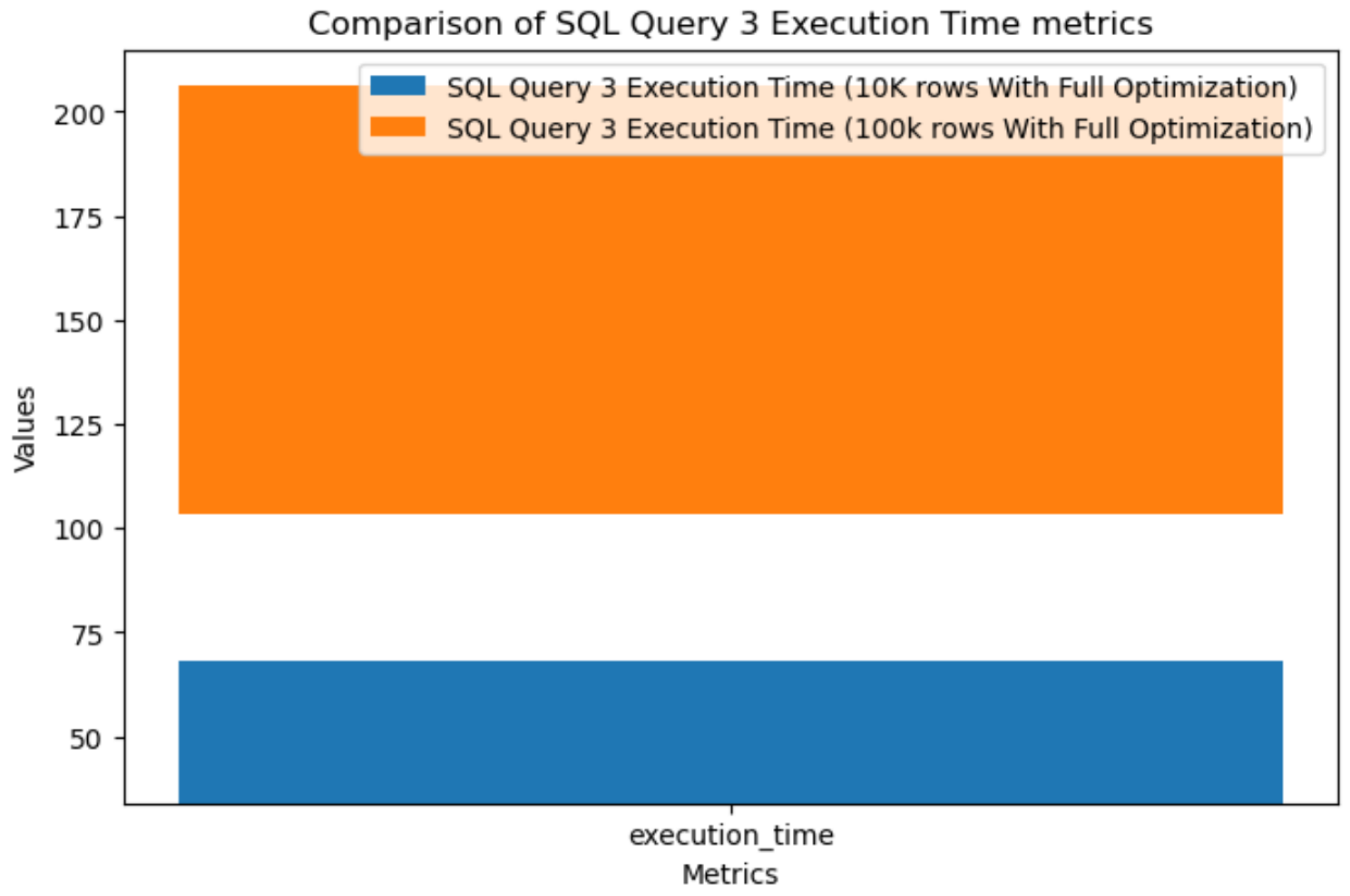

Comparison of SQL Query 1 Planning Time metrics
SQL Query 1 Planning Time (10K rows With Full Optimization)
SQL Query 1 Planning Time (100k rows With Full Optimization)
Values
0.5
1.0
1.5
2.0
2.5
planning_time
Metrics

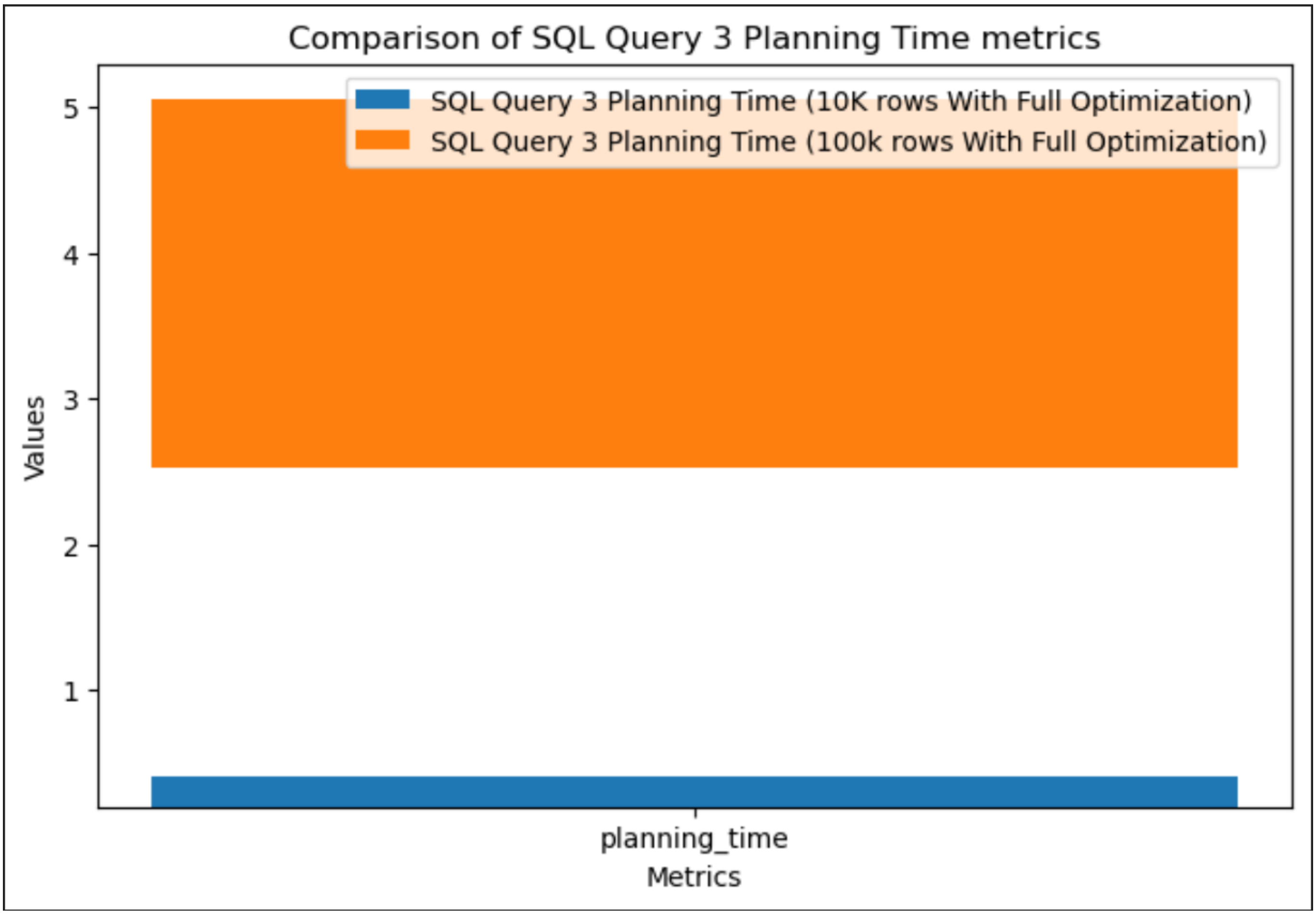
Query 2


Comparison of SQL Query 2 Execution Time metrics
SQL Query 2 Execution Time (10K rows With Full Optimization)
SQL Query 2 Execution Time (100k rows With Full Optimization)
Values
80
70
60
50
40
30
execution_time
Metrics

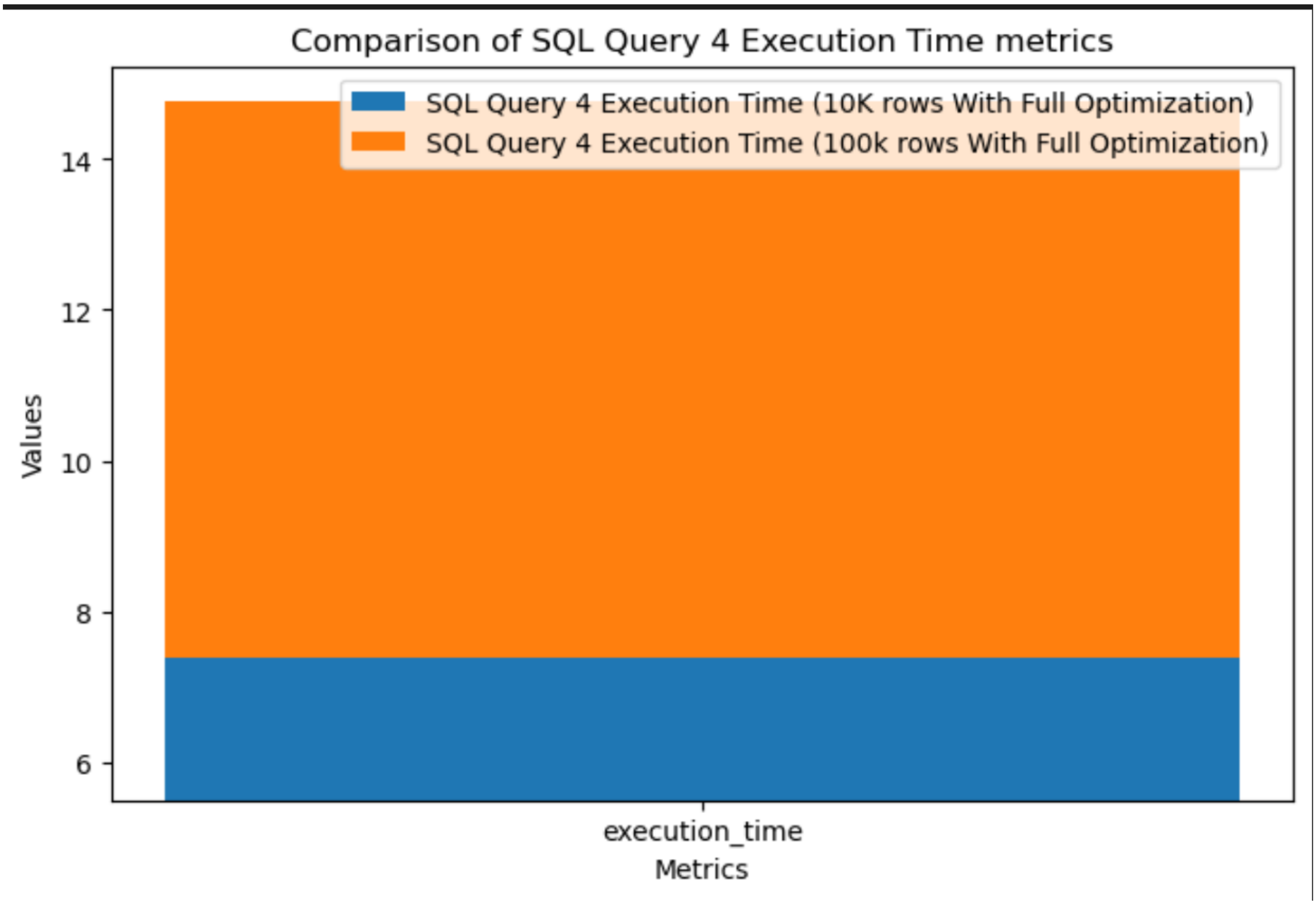

Comparison of SQL Query 2 Planning Time metrics
SQL Query 2 Planning Time (10K rows With Full Optimization)
SQL Query 2 Planning Time (100k rows With Full Optimization)
Values
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
planning_time
Metrics

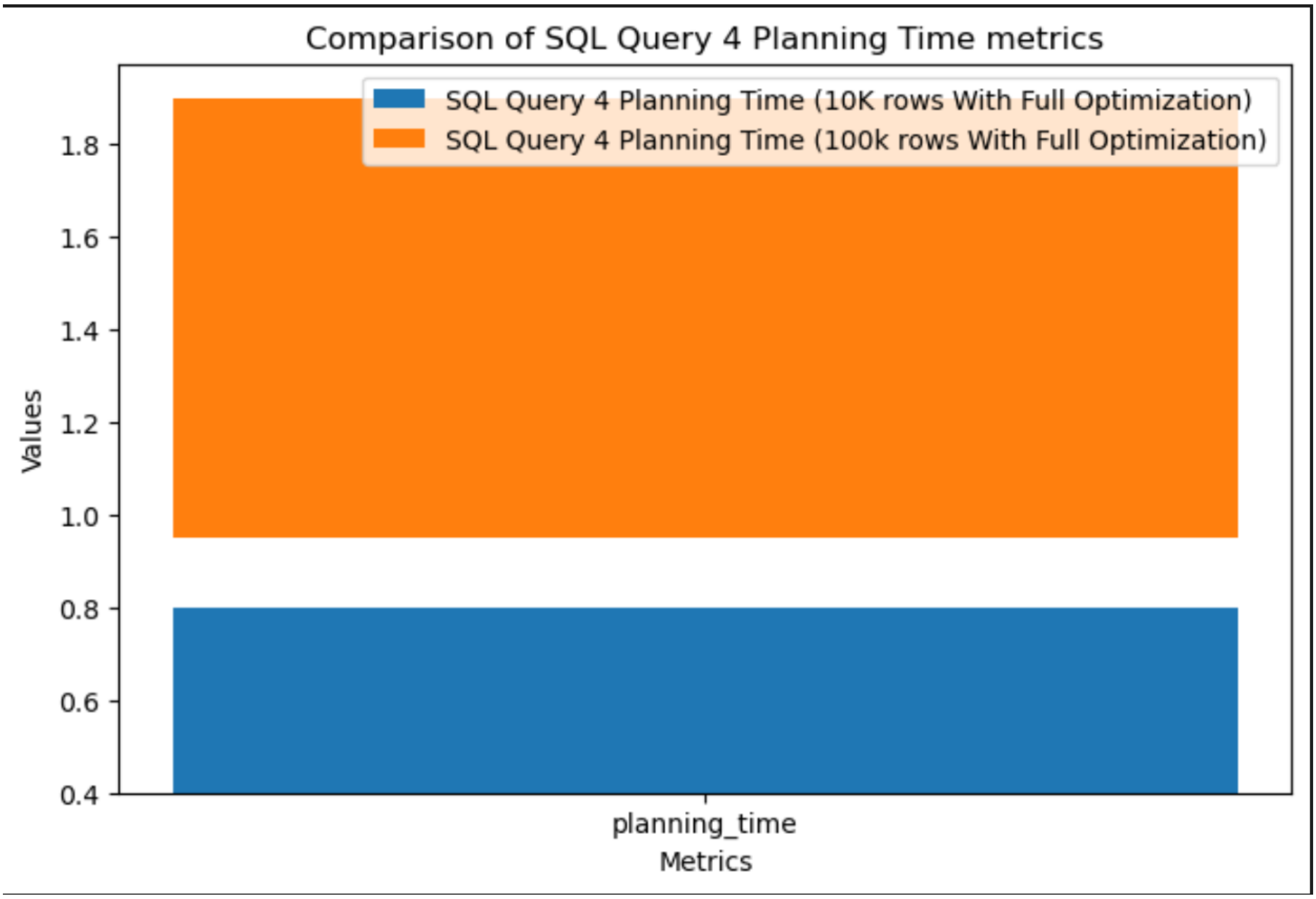
Query 3


Comparison of SQL Query 3 Execution Time metrics
🟦 SQL Query 3 Execution Time (10K rows With Full Optimization)
🟧 SQL Query 3 Execution Time (100k rows With Full Optimization)
200
175
150
125
100
75
50
Values
execution_time
Metrics


Comparison of SQL Query 3 Planning Time metrics
🟦 SQL Query 3 Planning Time (10K rows With Full Optimization)
🟧 SQL Query 3 Planning Time (100k rows With Full Optimization)
5
4
3
2
1
Values
planning_time
Metrics

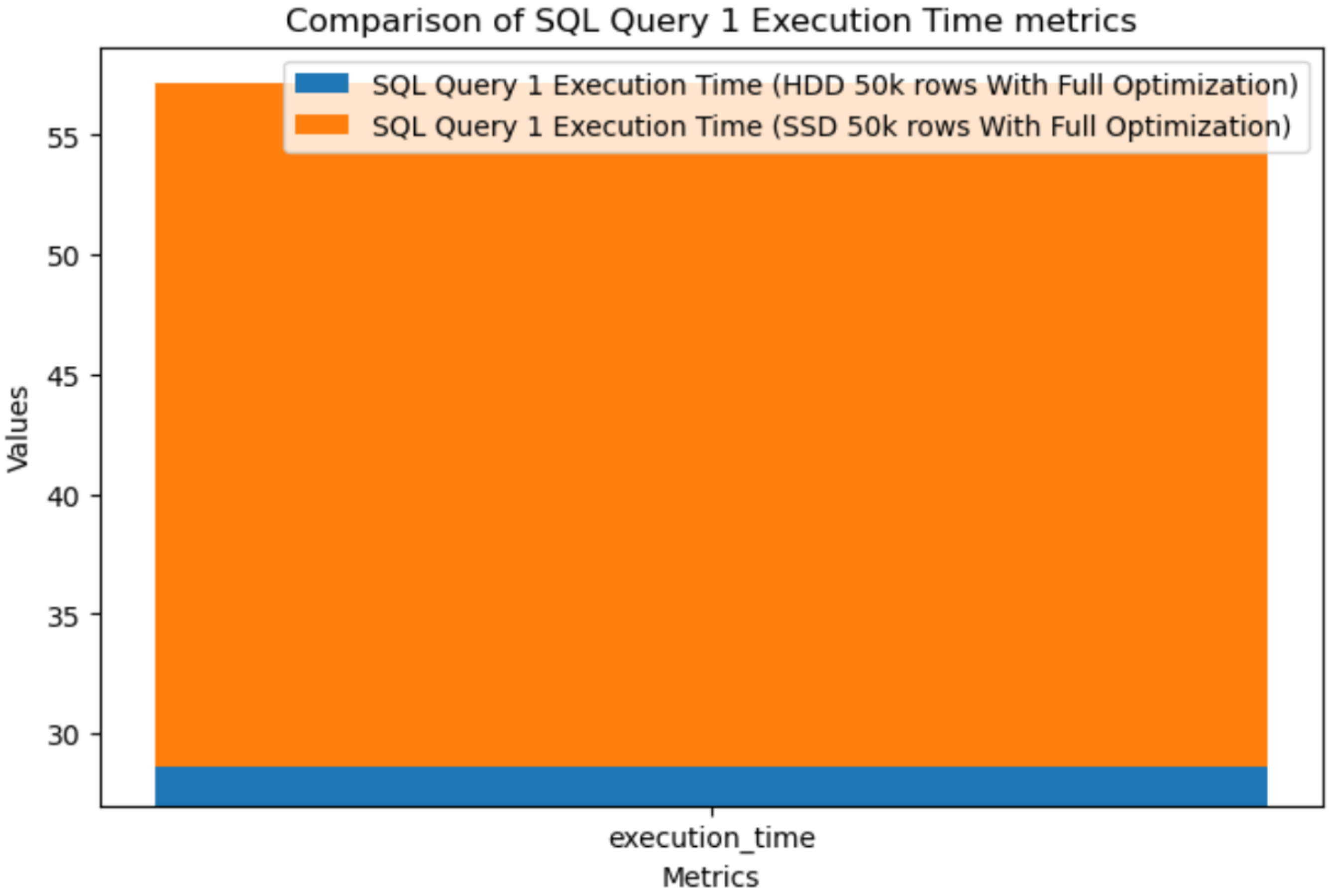
Query 4

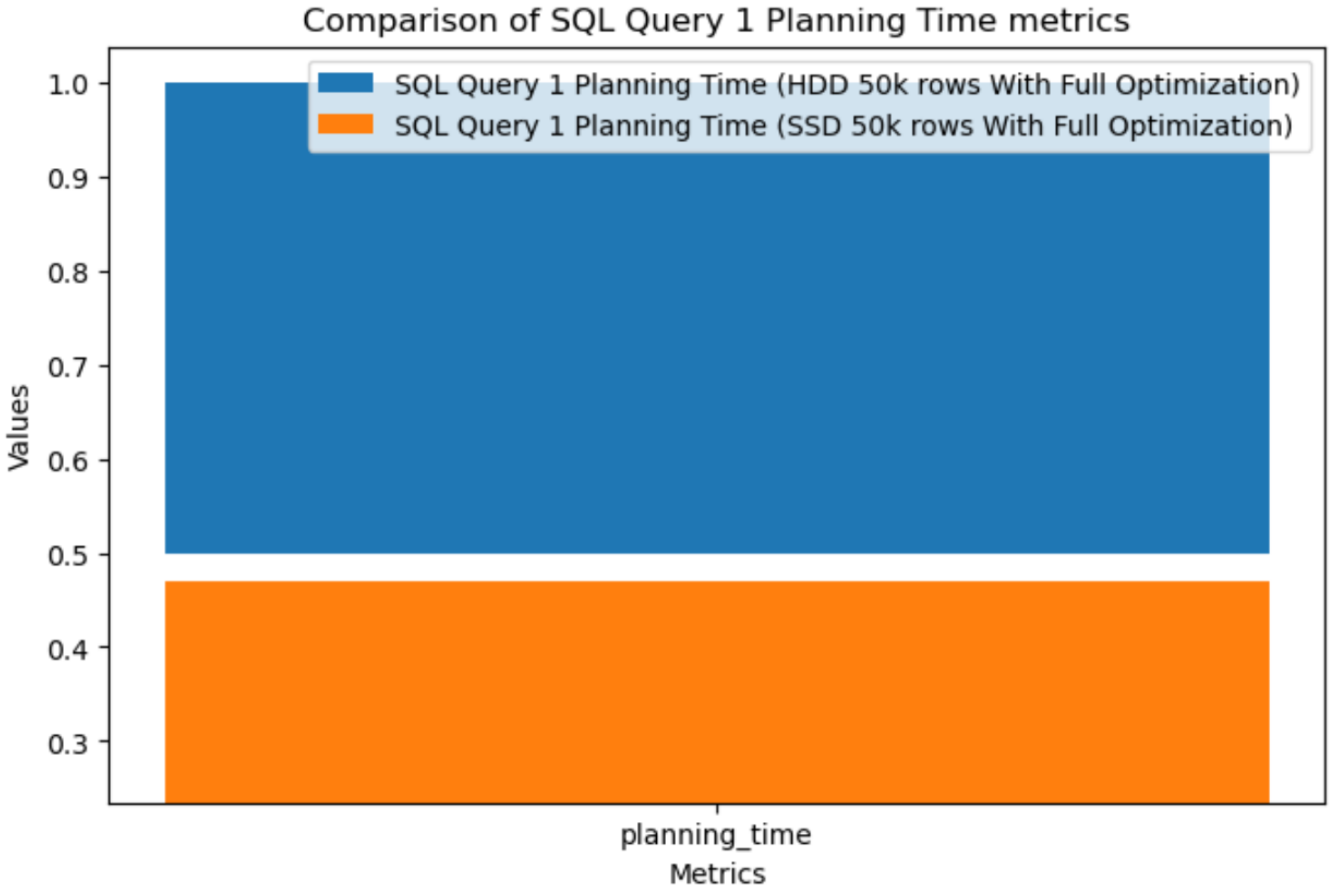




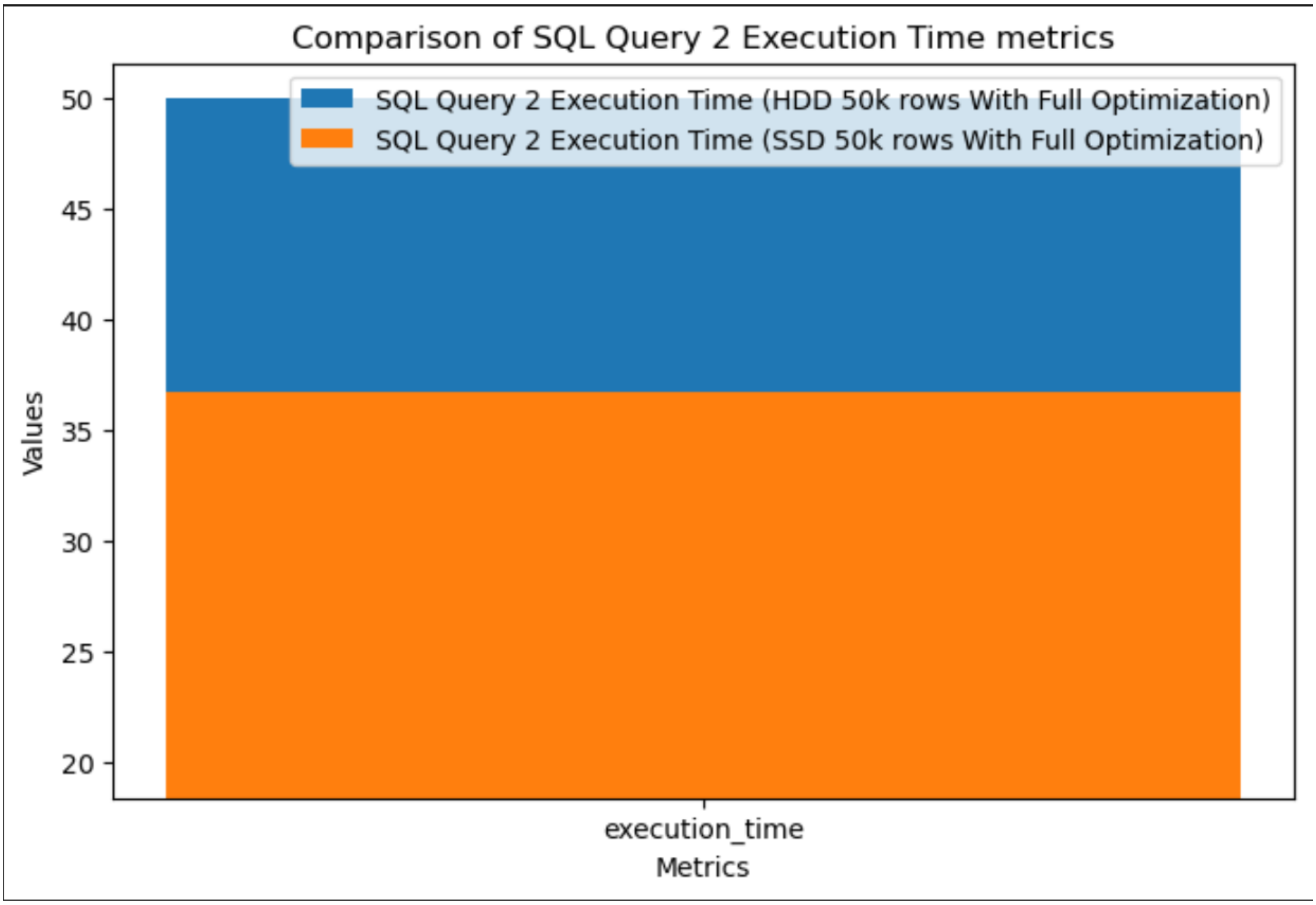
Comparison of the plan and execution times for the queries with different disks(HDD VS. SSD).

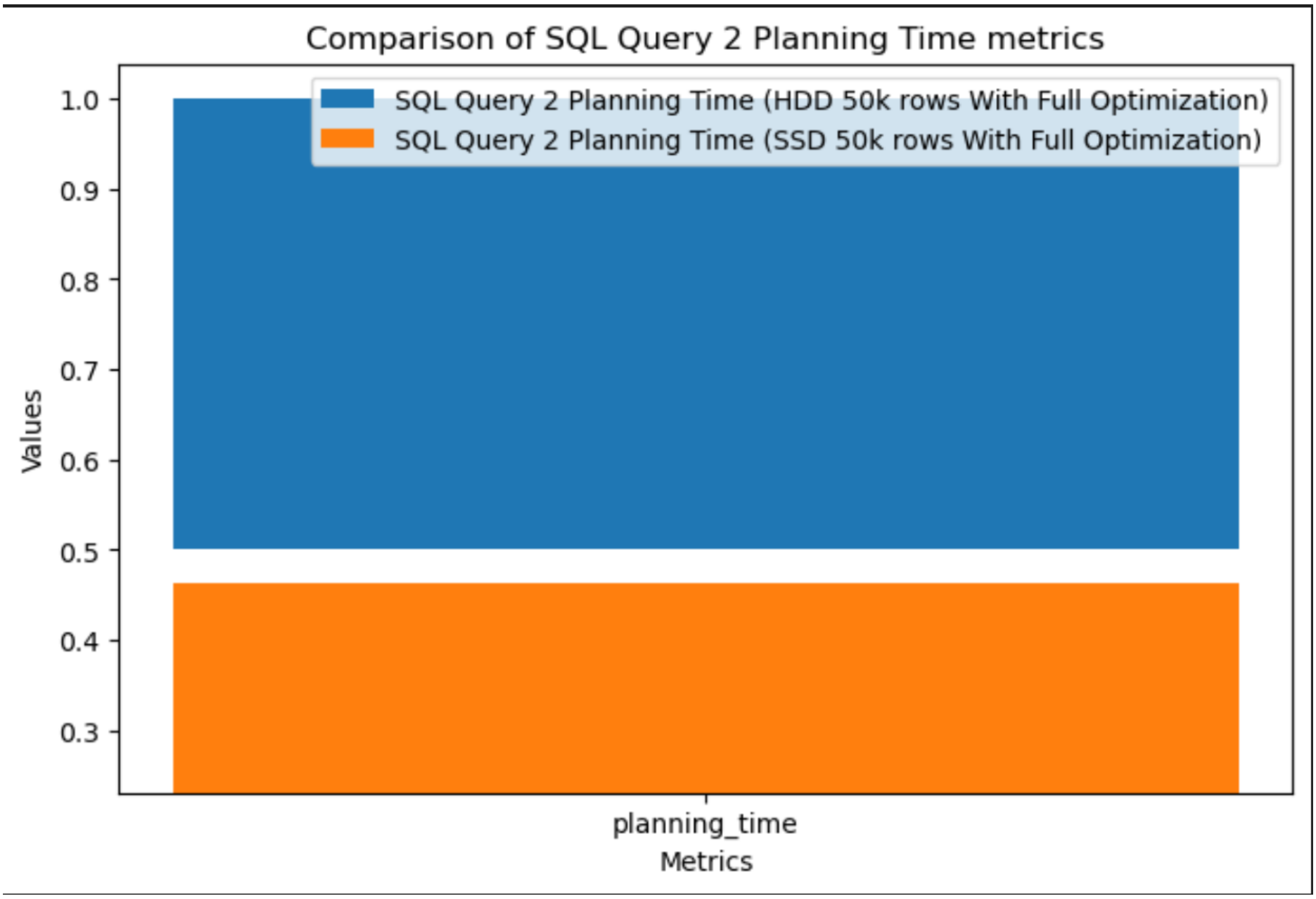
Query 1


Comparison of SQL Query 1 Execution Time metrics
SQL Query 1 Execution Time (HDD 50k rows With Full Optimization)
SQL Query 1 Execution Time (SSD 50k rows With Full Optimization)
Values
55
50
45
40
35
30
execution_time
Metrics

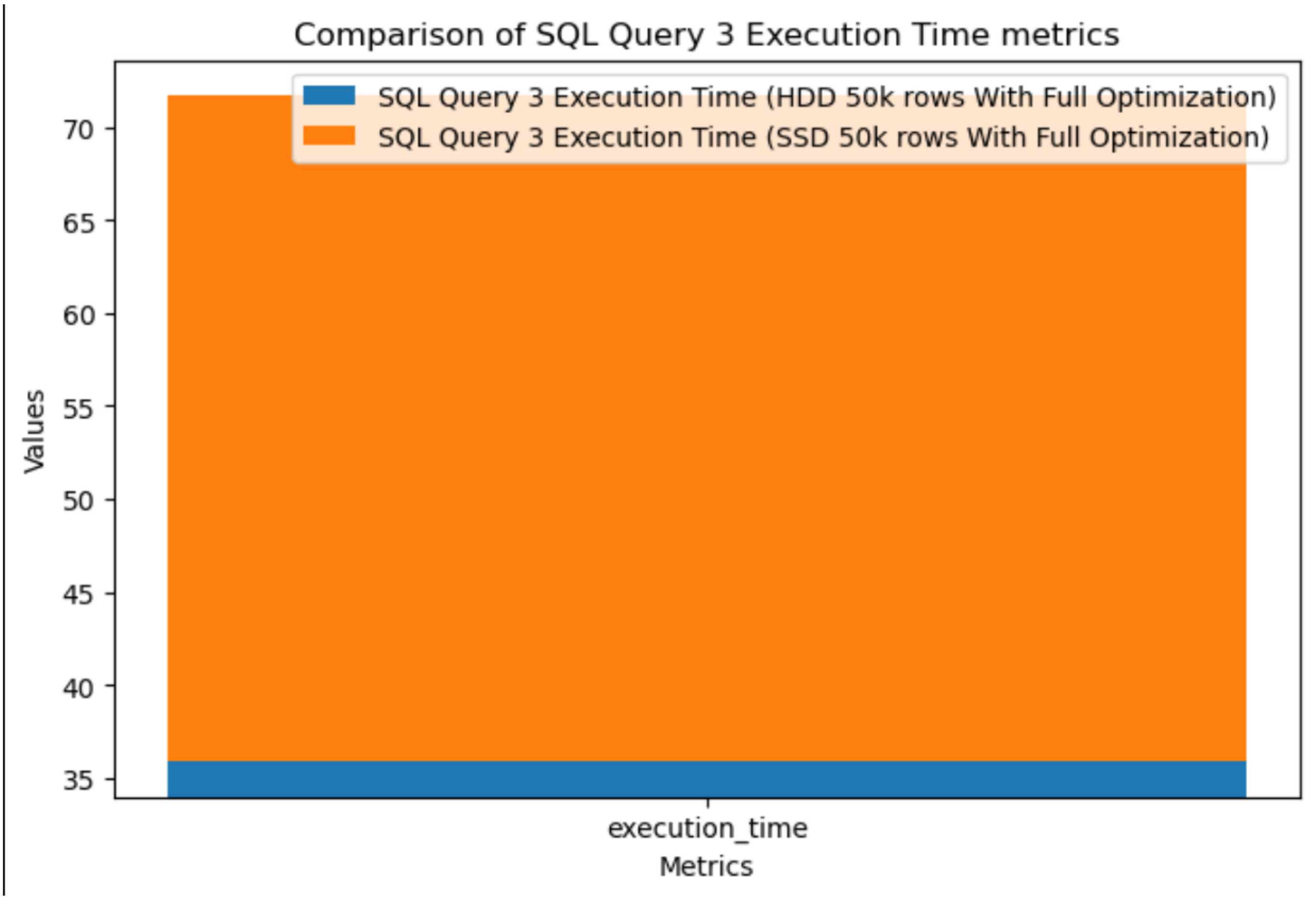

Comparison of SQL Query 1 Planning Time metrics
SQL Query 1 Planning Time (HDD 50k rows With Full Optimization)
SQL Query 1 Planning Time (SSD 50k rows With Full Optimization)
Values
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
planning_time
Metrics

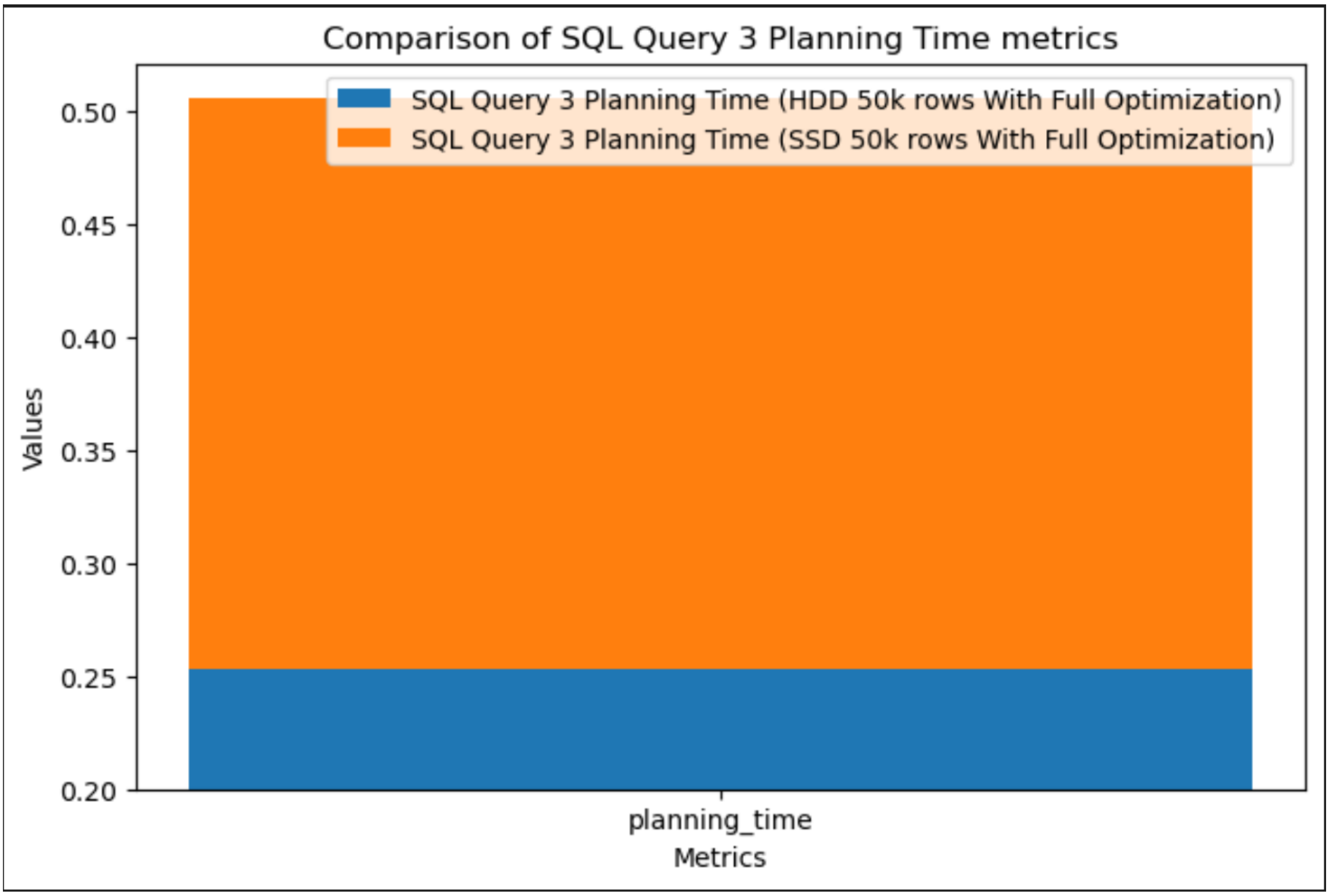
Query 2


Comparison of SQL Query 2 Execution Time metrics
🟦 SQL Query 2 Execution Time (HDD 50k rows With Full Optimization)
🟧 SQL Query 2 Execution Time (SSD 50k rows With Full Optimization)
Values
50
45
40
35
30
25
20
execution_time
Metrics

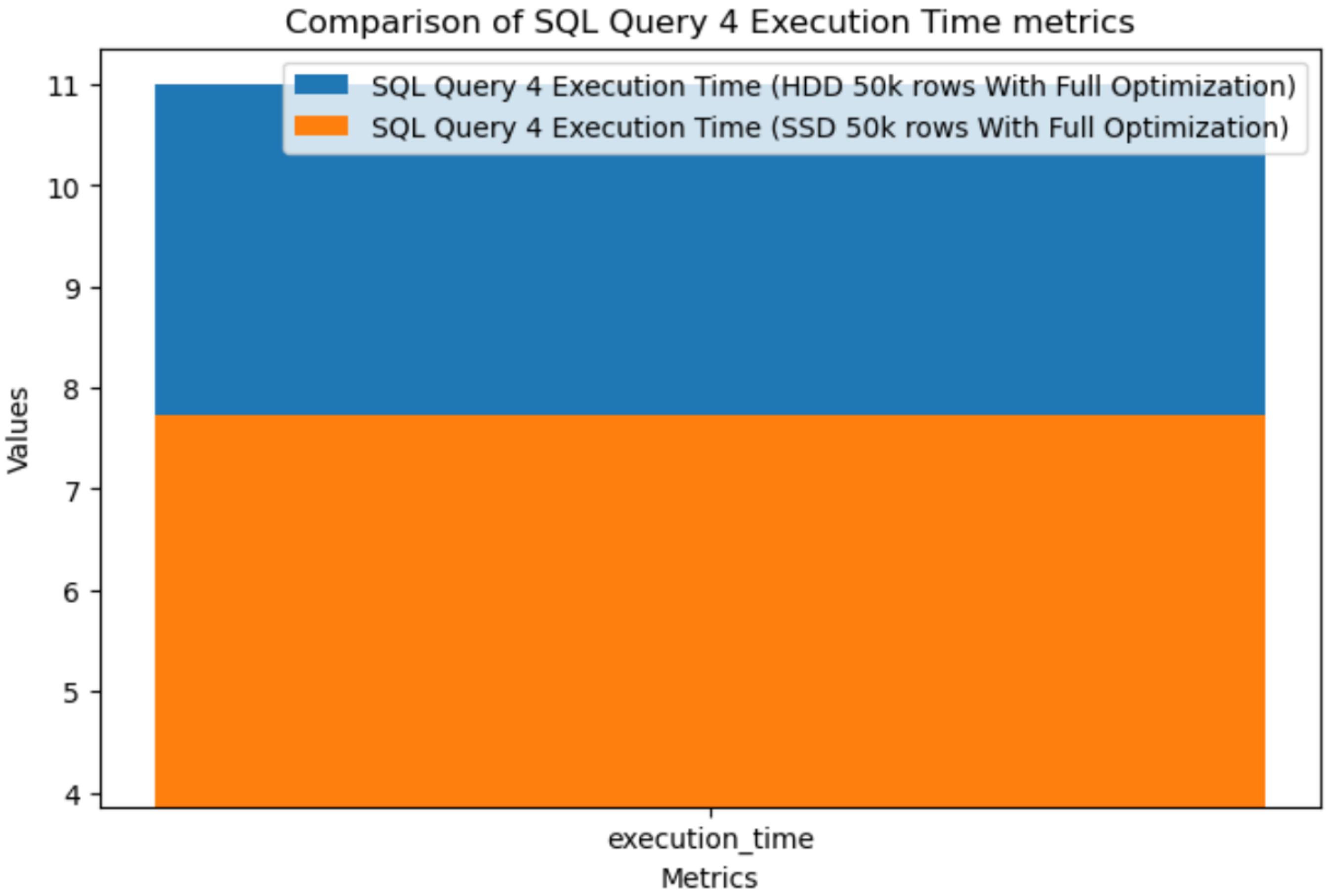

Comparison of SQL Query 2 Planning Time metrics
🟦 SQL Query 2 Planning Time (HDD 50k rows With Full Optimization)
🟧 SQL Query 2 Planning Time (SSD 50k rows With Full Optimization)
Values
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
planning_time
Metrics

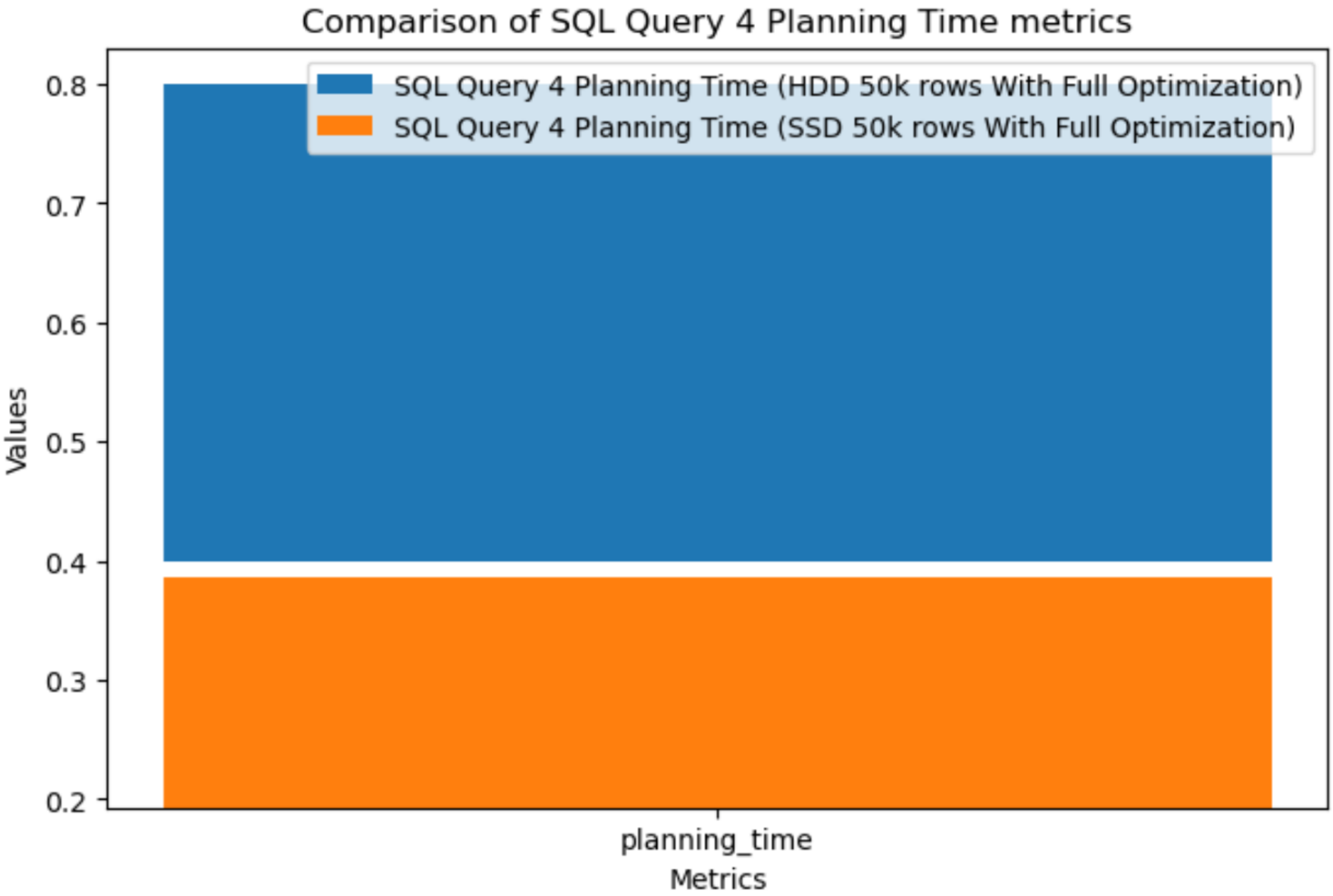
Query 3


Comparison of SQL Query 3 Execution Time metrics
SQL Query 3 Execution Time (HDD 50k rows With Full Optimization)
SQL Query 3 Execution Time (SSD 50k rows With Full Optimization)
Values
70
65
60
55
50
45
40
35
execution_time
Metrics


Comparison of SQL Query 3 Planning Time metrics
SQL Query 3 Planning Time (HDD 50k rows With Full Optimization)
SQL Query 3 Planning Time (SSD 50k rows With Full Optimization)
Values
0.50
0.45
0.40
0.35
0.30
0.25
0.20
planning_time
Metrics

Query 4





System Specifications

Name	Version

Name	Version
OS	Ubuntu 22.04 LTS
CPU1	Intel(R) Core(TM) i7-1087H CPU @ 2.20GHz
CPU2	AMD Ryzen™ 7 5800 @ 2.20GHz
Disk1	HDD 1 TB
Disk2	SSD 1 TB
RAM	16 GB

Developer Guide

How to run?

1. Run `docker-compose up`.
2. You will see a message whether the creation was `Okay` or `Not Okay`.
3. Exec into the container.
4. Populate the data by running with the required size `./mnt/scripts/populate_data.sh 10k`.
5. Run the query using `./mnt/scripts/run_queries.sh query1`.
6. Don't forget to stop the container after you are done.
7. Run `docker-compose down --volumes` to delete the volumes.

how to copy and paste file in bash script?

```
cp /mnt/scripts/queries/query1.js /mnt/scripts/queries/query1.js.bak
```

For NOSQL

1. Run `docker-compose up mongodb`
2. Container will create collections upon startup also it will insert dummy data into them
3. Use **connect_db.sh** to exec into container
4. Run the following commands

```
    mongosh
    use admin
    db.auth("root","pass12345")
    use social
```

5. The container starts initially with 10k data for each collection , to change this
   - Open a shell in the container using connect_db.sh
   - change the number fo dummy data using `export DUMMY_SIZE=1000000`
   - run `mongosh`
   - Authenticate yourself using step 4 commands

    - load the script again using `load("./insert_dummy.js")`

How can you contribute?

1. Create queries in the `queries` folder.
2. Add the queries to the `run_queries.sh` file.

How to add data?

1. Add a new script in the `dummyData` folder.
2. Add the new size of the data in the `populate_data.sh` file.

> > You can find the schema of the database in the `DDL` folder.

Helpful mongo commands

1. Note that mongo command should be installed on the computer. On Linux this should be install `mongodb-org-shell` package.
2. Connect to MongoDB server `mongo admin -u root -p pass12345` It will connect to localhost port 27017.
3. Show databases: `show dbs`
4. Create new non-existent database: `use mydatabase`
5. Show collections: `show collections`
6. Show contents/documents of a collection: `db.your_collection_name.find()`
7. Save a data to a collection: `db.your_collection_name.save({"name":"Sony AK"})`
8. Show database version: `db.version()`
9. Show database status: `db.stats()`