

# Database Design

```
philip306apply@cloudshell:~ (cinetravel)$ gcloud sql connect cinetravel --user=root
Allowlisting your IP for incoming connection for 5 minutes...done.
Connecting to database with SQL user [root].Enter password:
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 24
Server version: 8.0.37-google (Google)

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owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

mysql> █
```

## Part 1: 5 Tables Creation:

**Table 1:**

```
create table hotel (
    Id int primary key auto_increment,
    Hotel_Address varchar(255),
    Average_Score real,
    Hotel_Name varchar(255),
    Hotel_country varchar(255),
    City varchar(255)
);
```

```
mysql> select count(*) from hotel;
+-----+
| count(*) |
+-----+
|      1283 |
+-----+
1 row in set (0.02 sec)
```

**Table 2:**

```
create table movie_location (
    Continent varchar(255),
    Country varchar(255),
    Movie varchar(255),
    Director varchar(255),
    Locations varchar(255),
    primary key(Continent, Country, Movie)
);
```

```
mysql> select count(*) from movie_location;
+-----+
| count(*) |
+-----+
|      1348 |
+-----+
1 row in set (0.03 sec)
```

**Table 3:**

```
create table flight(
  Sched_dep_time varchar(255) not null,
  Sched_arr_time varchar(255) not null,
  Tailnum      varchar(50) primary key,
  Origin       varchar(10) not null,
  Dest varchar(10) not null,
  Time varchar(255) not null,
  Name varchar(255) not null
);
```

```
mysql> select count(*) from flight;
+-----+
| count(*) |
+-----+
|      4045 |
+-----+
1 row in set (0.02 sec)
```

**Table 4:**

```
create table airport(
  Code varchar(10) primary key,
  Name varchar(255) not null,
  Continent varchar(255),
  City varchar(255)
);
```

```
mysql> select count(code) from airport;
+-----+
| count(code) |
+-----+
|      9806 |
+-----+
1 row in set (0.04 sec)
```

**Table 5:**

```
create table movie(
  Id_movies int primary key,
  Title varchar(255) not null,
```

```
mysql> select count(id_movies) from movie;
+-----+
| count(id_movies) |
+-----+
|          1466    |
+-----+
1 row in set (0.00 sec)
```

## Advanced SQL queries 1

```
mysql> select m.Movie, count(a.code) as count_flight from airport_new a join movie_location_new ml on a.city = ml.locations group by m.Movie order by count_flight DESC limit 30;
```

Movie	count_flight
cost item create	1326
south opportunity health	1326
region	1326
seat	1326
energy give treat	1326
can case	1326
item	1326
or degree bag	844
possible	844
town	844
compare loss bag	844
forget dinner career	844
by	844
father	844
site actually	844

Total execution time: ~53.9 mseconds Estimated cost: 743434

Index 1:

CREATE INDEX idx\_airport\_city ON airport\_new(City);

```
--+
| -> Sort: count_flight DESC (actual time=104..104 rows=198 loops=1)
|   -> Table scan on <temporary> (actual time=103..103 rows=198 loops=1)
|     -> Aggregate using temporary table (actual time=103..103 rows=198 loops=1)
|       -> Nested loop inner join (cost=5734 rows=22592) (actual time=0.102..50.9 rows=97058 loops=1)
|         -> Filter: (ml.Locations is not null) (cost=96.9 rows=946) (actual time=0.0471..0.841 rows=946 loops=1)
|           -> Table scan on ml (cost=96.9 rows=946) (actual time=0.0462..0.73 rows=946 loops=1)
|             -> Covering index lookup on a using idx_airport_city (City=ml.Locations) (cost=3.57 rows=23.9) (actual time=0.00489..0.0455 rows=103 loops=946)
```

Total execution time: 104 mseconds Estimated cost: 5734

The query optimizer switched from a hash join to a **nested loop join with a covering index lookup** on the `airport_new` table. This transformation occurred after adding an index on the `airport_new.City` column (`idx_airport_city`), enabling more efficient row matching without scanning the entire table.

Index 2:

CREATE INDEX idx\_location\_city ON movie\_location\_new(Locations);

```
--+
| -> Sort: count_flight DESC (actual time=99.2..99.2 rows=198 loops=1)
|   -> Table scan on <temporary> (actual time=99..99 rows=198 loops=1)
|     -> Aggregate using temporary table (actual time=99..99 rows=198 loops=1)
|       -> Nested loop inner join (cost=5734 rows=22592) (actual time=0.0901..48.7 rows=97058 loops=1)
|         -> Filter: (ml.Locations is not null) (cost=96.9 rows=946) (actual time=0.0422..0.669 rows=946 loops=1)
|           -> Table scan on ml (cost=96.9 rows=946) (actual time=0.0413..0.584 rows=946 loops=1)
|             -> Covering index lookup on a using idx_airport_city (City=ml.Locations) (cost=3.57 rows=23.9) (actual time=0.0045..0.044 rows=103 loops=946)
```

Total execution time: 99.2 mseconds Estimated cost: 5734

After adding an index on `movie_location_new.Locations` (`idx_location_city`), the query optimizer continued to use a **nested loop join**, but with greater efficiency. The database performed a **covering index lookup** on `airport_new` using the join condition `City = Locations`, as it did in the previous run with Index 1.

Index 3:

CREATE INDEX idx\_movie\_title ON movie\_location\_new(Movie);

```
--+
| -> Sort: count_flight DESC (actual time=101..101 rows=198 loops=1)
|   -> Table scan on <temporary> (actual time=101..101 rows=198 loops=1)
|     -> Aggregate using temporary table (actual time=101..101 rows=198 loops=1)
|       -> Nested loop inner join (cost=5734 rows=22592) (actual time=0.113..50.8 rows=97058 loops=1)
|         -> Filter: (ml.Locations is not null) (cost=96.9 rows=946) (actual time=0.0463..0.829 rows=946 loops=1)
|           -> Table scan on ml (cost=96.9 rows=946) (actual time=0.0453..0.727 rows=946 loops=1)
|             -> Covering index lookup on a using idx_airport_city (City=ml.Locations) (cost=3.57 rows=23.9) (actual time=0.00485..0.045 rows=103 loops=946)
```

Total execution time: 101 mseconds Estimated cost: 5734

After creating an index on `movie_location_new.Movie` (`idx_movie_title`), the query optimizer retained the **nested loop join** strategy and continued to use a **covering index lookup** on `airport_new.City`. However, there was **no major change in the join method or overall execution plan** compared to the previous configuration.

## Advanced SQL queries 2

```
SELECT a.city, COUNT(*) AS hotel_airport_count
FROM hotel_new h JOIN airport_new a
    ON h.City = a.city GROUP BY a.city
ORDER BY hotel_airport_count DESC LIMIT 15;
```

```

Database changed
mysql> SELECT a.city, COUNT(*) AS hotel_airport_count FROM hotel_new h JOIN airport_new a ON h.City = a.city GROUP BY a.city ORDER BY hotel_airport_count DESC LIMIT 15;
+-----+-----+
| city | hotel_airport_count |
+-----+-----+
| london | 7874 |
| paris | 7812 |
| tokyo | 7350 |
| berlin | 7154 |
| toronto | 4588 |
| sydney | 4582 |
| madrid | 3864 |
| bangkok | 3650 |
| rome | 3640 |
| nairobi | 2795 |
| cairo | 1876 |
+-----+-----+
11 rows in set (0.06 sec)

```

output is less than 15 rows; 11 rows in set.

```

| EXPLAIN
|
+-----+
| -> Limit: 15 row(s) (actual time=31.3..31.3 rows=11 loops=1)
|   -> Sort: hotel_airport_count DESC, limit input to 15 row(s) per chunk (actual time=31.3..31.3 rows=11 loops=1)
|     -> Table scan on <temporary> (actual time=31.3..31.3 rows=11 loops=1)
|       -> Aggregate using temporary table (actual time=31.3..31.3 rows=11 loops=1)
|         -> Filter: (a.city = h.city) (cost=785840 rows=785700) (actual time=0.531..12.8 rows=55185 loops=1)
|           -> Inner hash join (hash=>(a.city)=hash(h.city)) (cost=785840 rows=785700) (actual time=0.528..5.8 rows=55185 loops=1)
|             -> Table scan on a (cost=0.117 rows=7857) (actual time=0.0162..1.68 rows=7956 loops=1)
|               -> hash
|                 -> Table scan on h (cost=102 rows=1000) (actual time=0.0273..0.348 rows=1000 loops=1)
|
+-----+
|
+-----+
1 row in set (0.04 sec)

```

## index1:

CREATE INDEX idx\_airport\_city ON a(city);

```

mysql> EXPLAIN ANALYZE SELECT h.city, COUNT(*) AS hotel_airport_count FROM hotel h JOIN airport a ON h.City = a.city GROUP BY h.city ORDER BY hotel_airport_count DESC LIMIT 15;
+-----+
| EXPLAIN
|
+-----+
| -> Limit: 15 row(s) (actual time=114..114 rows=5 loops=1)
|   -> Sort: hotel_airport_count DESC, limit input to 15 row(s) per chunk (actual time=114..114 rows=5 loops=1)
|     -> Table scan on <temporary> (actual time=114..114 rows=5 loops=1)
|       -> Aggregate using temporary table (actual time=114..114 rows=5 loops=1)
|         -> Nested loop inner join (cost=8211 rows=32243) (actual time=0.0639..57.5 rows=111117 loops=1)
|           -> Filter: (h.city is not null) (cost=132 rows=1283) (actual time=0.0389..0.748 rows=1283 loops=1)
|             -> Table scan on h (cost=132 rows=1283) (actual time=0.0379..0.625 rows=1283 loops=1)
|               -> Covering index lookup on a using idx_airport_city (city=h.city) (cost=3.79 rows=25.1) (actual time=0.00922..0.0385 rows=86.6 loops=1283)
|
+-----+
|
+-----+
1 row in set (0.12 sec)

```

Total execution time: 114 mseconds Estimated cost: 8211

Without **idx\_airport\_city**, the query would require full table scans on both tables, resulting in much higher I/O costs and execution time. After adding **idx\_airport\_city**, the query benefits from efficient index lookups when matching cities from the hotel table, dramatically reducing the number of rows that need to be examined in the airport table for each hotel city.

## index 2:

CREATE INDEX idx\_hotel\_city ON h(city);

[illegible]

Total execution time: 130 mseconds Estimated cost: 313793

reduced cost

With only `idx_hotel_city` but no index on `airport.city`, the query would benefit from efficient scanning of hotel cities but would still require a full table scan on the airport table for each matched city, potentially causing higher I/O costs when joining.

### index 3: with both index

```

EXPLAIN
|
|-----+
|
| -> Limit: 15 row(s) (actual time=75.3..75.3 rows=5 loops=1)
|   -> Sort: hotel_airport_count DESC, limit input to 15 row(s) per chunk (actual time=75.3..75.3 rows=5 loops=1)
|     -> Stream results (cost=11436 rows=7) (actual time=1.49..75.3 rows=5 loops=1)
|       -> Group aggregate: count(0) (cost=11436 rows=7) (actual time=1.49..75.3 rows=5 loops=1)
|         -> Nested loop inner join (cost=8211 rows=32243) (actual time=0.0648..55.7 rows=11117 loops=1)
|           -> Filter: (h.City is not null) (cost=132 rows=1283) (actual time=0.0358..0.557 rows=1283 loops=1)
|             -> Covering index scan on h using idx_hotel_city (cost=132 rows=1283) (actual time=0.0348..0.446 rows=1283 loops=1)
|               -> Covering index lookup on a using idx_airport_city (city=h.City) (cost=3.79 rows=25.1) (actual time=0.00892..0.0374 rows=86.6 loops=1283)
|
|-----+
|
| 1 row in set (0.08 sec)

```

Total execution time: 75.3 mseconds Estimated cost: 8211

With both `idx_airport_city` and `idx_hotel_city` provide an additional time performance improvement by enabling a covering index scan on the hotel table rather than a full table scan, though interestingly, the optimizer's cost estimate remains unchanged at 8211 across all configurations.

## Advanced SQL queries 3

```
SELECT f1.*
FROM flight f1
WHERE STR_TO_DATE(f1.sched_dep_time, '%H:%i') < (
    SELECT AVG(STR_TO_DATE(f2.sched_dep_time, '%H:%i'))
    FROM flight f2
    WHERE f2.origin = f1.origin
)
ORDER BY STR_TO_DATE(f1.sched_dep_time, '%H:%i')
LIMIT 15;
```

	sched_dep_time	sched_arr_time	tailnum	origin	dest	time	name
		06:50	N186US	EWR	CLT	05:00	US Airways Inc.
		06:48	N435US	EWR	CLT	05:00	US Airways Inc.
		06:48	N566UW	EWR	CLT	05:00	US Airways Inc.
		06:50	N172US	EWR	CLT	05:00	US Airways Inc.
		06:48	N152UW	EWR	CLT	05:00	US Airways Inc.
105:15		08:08	N69806	EWR	IAH	05:15	United Air Lines Inc.
105:15		08:19	N14228	EWR	IAH	05:15	United Air Lines Inc.
105:15		08:08	N68802	EWR	IAH	05:15	United Air Lines Inc.
105:15		07:55	N653UA	EWR	IAH	05:15	United Air Lines Inc.
105:17		07:57	N556UA	EWR	IAH	05:17	United Air Lines Inc.
105:25		08:20	N78506	EWR	IAH	05:25	United Air Lines Inc.
105:25		08:20	N37277	EWR	IAH	05:25	United Air Lines Inc.
105:25		08:20	N33264	EWR	IAH	05:25	United Air Lines Inc.
105:29		08:30	N24211	LGA	IAH	05:29	United Air Lines Inc.
105:29		08:28	N493UA	LGA	IAH	05:29	United Air Lines Inc.

```

-> Limit: 15 row(s) (cost=437 rows=15) (actual time=4752..4752 rows=15 loops=1)
-> Sort: str_to_date(f1.sched_dep_time,'%H:%i'), limit input to 15 row(s) per chunk (cost=437 rows=4296) (actual time=4752..4752 rows=15 loops=1)
-> Filter: (str_to_date(f1.sched_dep_time,'%H:%i') < (select #2)) (cost=437 rows=4296) (actual time=5.14..4751 rows=1948 loops=1)
-> Table scan on f1 (cost=437 rows=4296) (actual time=0.0424..4.22 rows=4045 loops=1)
-> Select #2 (subquery in condition; dependent)
-> Aggregate: avg(str_to_date(f2.sched_dep_time,'%H:%i')) (cost=93.7 rows=1) (actual time=1.17..1.17 rows=1 loops=4044)
-> Filter: (f2.origin = f1.origin) (cost=50.7 rows=430) (actual time=0.00835..1.01 rows=1371 loops=4044)
-> Table scan on f2 (cost=50.7 rows=4296) (actual time=0.0079..0.701 rows=4045 loops=4044)

```

Index 1:

**CREATE INDEX idx\_origin ON flight(origin);**

Baseline Performance:

Estimated cost 437

This index on the origin column speeds up filtering in the subquery but doesn't lower the overall cost due to the overhead of time conversion

```

-> Limit: 15 row(s) (cost=437 rows=15) (actual time=5343..5343 rows=15 loops=1)
-> Sort: str_to_date(f1.sched_dep_time,'%H:%i'), limit input to 15 row(s) per chunk (cost=437 rows=4296) (actual time=5343..5343 rows=15 loops=1)
-> Filter: (str_to_date(f1.sched_dep_time,'%H:%i') < (select #2)) (cost=437 rows=4296) (actual time=6.41..5341 rows=1948 loops=1)
-> Table scan on f1 (cost=437 rows=4296) (actual time=0.0394..4.57 rows=4045 loops=1)
-> Select #2 (subquery in condition; dependent)
-> Aggregate: avg(str_to_date(f2.sched_dep_time,'%H:%i')) (cost=238 rows=1) (actual time=1.32..1.32 rows=1 loops=4044)
-> Index lookup on f2 using idx_origin (origin=f1.origin) (cost=131 rows=1074) (actual time=0.0475..1.15 rows=1371 loops=4044)

```

Index 2:

**CREATE INDEX idx\_sched\_dep\_time ON flight(sched\_dep\_time);**

Baseline Performance:

Estimated cost 437

Creating an index on sched\_dep\_time has no effect since the query's use of STR\_TO\_DATE() prevents the index from being utilized

```

-> Limit: 15 row(s) (cost=437 rows=15) (actual time=4785..4785 rows=15 loops=1)
-> Sort: str_to_date(f1.sched_dep_time,'%H:%i'), limit input to 15 row(s) per chunk (cost=437 rows=4296) (actual time=4785..4785 rows=15 loops=1)
-> Filter: (str_to_date(f1.sched_dep_time,'%H:%i') < (select #2)) (cost=437 rows=4296) (actual time=5.18..4783 rows=1948 loops=1)
-> Table scan on f1 (cost=437 rows=4296) (actual time=0.0669..4.29 rows=4045 loops=1)
-> Select #2 (subquery in condition; dependent)
-> Aggregate: avg(str_to_date(f2.sched_dep_time,'%H:%i')) (cost=93.7 rows=1) (actual time=1.18..1.18 rows=1 loops=4044)
-> Filter: (f2.origin = f1.origin) (cost=50.7 rows=430) (actual time=0.00839..1.01 rows=1371 loops=4044)
-> Table scan on f2 (cost=50.7 rows=4296) (actual time=0.00795..0.707 rows=4045 loops=4044)

```

Index 3:

**CREATE INDEX idx\_dep\_time\_conv ON flight (**  
**(IF(sched\_dep\_time COLLATE utf8mb4\_0900\_ai\_ci REGEXP '^[0-9]{1,2}:[0-9]{2}\$',**  
**STR\_TO\_DATE(sched\_dep\_time, '%H:%i'),**  
**NULL))**  
**);**

Baseline Performance:

Estimated cost 415

The functional index on the converted time (skipping invalid formats) effectively lowers the query cost by enabling index usage on valid time values

```
| -> Limit: 15 row(s) (cost=415 rows=15) (actual time=7827..7827 rows=15 loops=1)
    -> Sort: str to date(f1.sched_dep_time,'%H:%i'), limit input to 15 row(s) per chunk (cost=415 rows=4077) (actual time=7827..7827 rows=15 loops=1)
    -> Filter: (str to date(f1.sched_dep_time,'%H:%i') < (select #2)) (cost=415 rows=4077) (actual time=7.71..7823 rows=1948 loops=1)
    -> Table scan on f1 (cost=415 rows=4077) (actual time=0.0522..7.14 rows=4045 loops=1)
    -> Select #2 (subquery in condition; dependent)
        -> Aggregate: avg(str to date(f2.sched_dep_time,'%H:%i')) (cost=89.3 rows=1) (actual time=1.93..1.93 rows=1 loops=4044)
        -> Filter: (f2.origin = f1.origin) (cost=48.5 rows=408) (actual time=0.0155..1.66 rows=1371 loops=4044)
        -> Table scan on f2 (cost=48.5 rows=4077) (actual time=0.0148..1.2 rows=4045 loops=4044)
|
```

## Advanced Query 4:

SQL:

```
SELECT LOWER(ml.Country) AS Country, ROUND(AVG(m.vote_average), 2) AS
avg_movie_rating FROM movie m JOIN movie_location_global ml ON m.title = ml.Movie
GROUP BY LOWER(ml.Country) ORDER BY avg_movie_rating ASC;
```

```
mysql> SELECT LOWER(ml.Country) AS Country, ROUND(AVG(m.vote_average), 2) AS avg_movie_rating FROM movie m JOIN movie
location_global ml ON m.title = ml.Movie GROUP BY LOWER(ml.Country) ORDER BY avg_movie_rating ASC limit 15;
+-----+-----+
| Country | avg_movie_rating |
+-----+-----+
| peru    | 5.7 |
| chile   | 5.8 |
| cambodia | 5.9 |
| brazil  | 5.9 |
| azerbaijan | 6 |
| bulgaria | 6.1 |
| panama  | 6.1 |
| tahiti  | 6.15 |
| greece  | 6.15 |
| gibraltar | 6.2 |
| queensland | 6.2 |
| kenya   | 6.25 |
| slovenia | 6.3 |
| west virginia | 6.3 |
| austria | 6.33 |
+-----+-----+
15 rows in set (0.02 sec)
```

Baseline performance:

Total execution time: ~6.12 mseconds Estimated cost: 692,852

```
| -> Sort: avg_movie_rating (actual time=6.12..6.13 rows=127 loops=1)
    -> Table scan on <temporary> (actual time=6.01..6.04 rows=127 loops=1)
    -> Aggregate using temporary table (actual time=6..6 rows=127 loops=1)
    -> Filter: (ml.Movie = m.title) (cost=692852 rows=692538) (actual time=1.34..5.01 rows=1256 loops=1)
    -> Inner hash join (<hash>(ml.Movie)=<hash>(m.title)) (cost=692852 rows=692538) (actual time=1.33..4.53 rows=
1256 loops=1)
        -> Table scan on ml (cost=0.144 rows=4724) (actual time=0.0487..2.21 rows=4724 loops=1)
        -> Hash
            -> Table scan on m (cost=150 rows=1466) (actual time=0.0922..0.814 rows=1466 loops=1)
|
```

Index 1:

```
CREATE INDEX idx_movie_title ON movie(title);
```

```
CREATE INDEX idx_movie_location_movie ON movie_location_global(Movie);
```

Total execution time: ~11.3 mseconds Estimated cost: 1,197

The query optimizer switched from a hash join to a nested loop join with an index lookup on the movie\_location\_global table. The estimated cost decreased dramatically (from 692,852 to 1,197).

```
| -> Sort: avg_movie_rating (actual time=11.3..11.3 rows=127 loops=1)
    -> Table scan on <temporary> (actual time=11.2..11.2 rows=127 loops=1)
    -> Aggregate using temporary table (actual time=11.2..11.2 rows=127 loops=1)
    -> Nested loop inner join (cost=1197 rows=2993) (actual time=0.126..10 rows=1256 loops=1)
        -> Table scan on m (cost=150 rows=1466) (actual time=0.06..0.66 rows=1466 loops=1)
        -> Index lookup on ml using idx_movie_location_movie (Movie=m.title) (cost=0.511 rows=2.04) (actual time=0.00
558..0.00618 rows=0.857 loops=1466)
|
```



Index 2:

`CREATE INDEX idx_movie_location_country ON movie_location_global(Country);`

Total execution time: ~10.8 mseconds Estimated cost: 1197

Adding an index on the GROUP BY column (Country) didn't significantly change the execution plan compared to Option 1. The query optimizer still used the index on the Movie column for the JOIN operation and didn't utilize the Country index for the GROUP BY operation. This is likely because the grouping happens after the join, and the optimizer determined that using the Movie index for the join was more beneficial.

```
| -> Sort: avg_movie_rating (actual time=10.8..10.9 rows=127 loops=1)
|   -> Table scan on <temporary> (actual time=10.8..10.8 rows=127 loops=1)
|     -> Aggregate using temporary table (actual time=10.8..10.8 rows=127 loops=1)
|       -> Nested loop inner join (cost=1197 rows=2993) (actual time=0.169..9.72 rows=1256 loops=1)
|         -> Table scan on m (cost=150 rows=1466) (actual time=0.107..0.684 rows=1466 loops=1)
|           -> Index lookup on ml using idx_movie_location_movie (Movie=m.title) (cost=0.511 rows=2.04) (actual time=0.00538..0.00596 rows=0.857 loops=1466)
|
```

Index 3:

`CREATE INDEX idx_movie_location_composite ON movie_location_global(Movie, Country);`

`CREATE INDEX idx_movie_title ON movie(title);`

Total execution time: ~10.6 mseconds Estimated cost: 1197

The execution plan for the composite index strategy looks very similar to the previous options. The optimizer is still using the index on Movie for the JOIN operation and not taking advantage of the composite index for the GROUP BY operation.

```
-----+
| -> Sort: avg_movie_rating (actual time=10.6..10.6 rows=127 loops=1)
|   -> Table scan on <temporary> (actual time=10.4..10.5 rows=127 loops=1)
|     -> Aggregate using temporary table (actual time=10.4..10.4 rows=127 loops=1)
|       -> Nested loop inner join (cost=1197 rows=2993) (actual time=0.133..9.42 rows=1256 loops=1)
|         -> Table scan on m (cost=150 rows=1466) (actual time=0.0623..0.662 rows=1466 loops=1)
|           -> Index lookup on ml using idx_movie_location_movie (Movie=m.title) (cost=0.511 rows=2.04) (actual time=0.00522..0.00575 rows=0.857 loops=1466)
|
```