CarQuest: A Student-Centric Used Car Database Solution

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I. Introduction

Reliable, economical, and environmentally friendly transportation options are in high demand in today's changing automotive market, which has resulted in a sharp increase in the appeal of used vehicles. But for prospective buyers, sorting through the wide selection of available cars can be a difficult undertaking. It might take a lot of time and energy to sort through internet listings, find reliable information, and come to a well-informed selection. Our idea aims to introduce a state-of-the-art platform into the used car industry in order to tackle this difficulty. This platform makes use of a strong database system to expedite the search procedure and give consumers an easy-to-use interface. Our goal is to improve data security, accessibility, and accuracy by switching from traditional spreadsheet-based methods to a dynamic database architecture.

II. PHASE I OVERVIEW

In the initial phase of Car Quest development, our focus was on meticulously cleaning and refining the dataset to ensure its integrity and reliability for subsequent stages. A thorough assessment for BCNF (Boyce-Codd Normal Form) compliance was conducted, a pivotal step in optimizing the database. With the data now in impeccable condition, we are prepared to advance to the next phase, which involves the implementation of SQL queries and the construction of the website. This phase marks a substantial stride toward achieving a robust and functional platform.

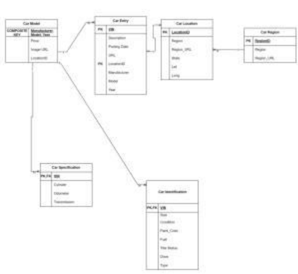


Fig. 1. ER Diagram of CarQuest

III. Database Schema

A. Car_Region Table

```
CREATE TABLE Car_Region ( RegionID
SERIAL PRIMARY KEY, Region
VARCHAR DEFAULT NULL,
Region_URL VARCHAR DEFAULT
NULL );
```

B. Car_Location Table

```
CREATE TABLE Car_Location (
LocationID SERIAL PRIMARY KEY,
RegionID INTEGER DEFAULT 0, State
VARCHAR(2) DEFAULT NULL, Latitude
DECIMAL(9,6) DEFAULT 0.0,

Longitude DECIMAL(9,6) DEFAULT
0.0,
FOREIGN KEY (RegionID) REFERENCES
Car_Region(RegionID) );
```

C. Car_Model Table

```
CREATE TABLE Car_Model (
ModelID SERIAL PRIMARY KEY,
Manufacturer VARCHAR DEFAULT
NULL,
ModelName VARCHAR DEFAULT
NULL, Year INTEGER DEFAULT 0 );
```

D. Car_Entry Table

```
CREATE TABLE Car_Entry ( VIN
VARCHAR PRIMARY KEY, Description
VARCHAR DEFAULT NULL, PostingDate
DATE DEFAULT NULL,
URL VARCHAR DEFAULT NULL,
LocationID INTEGER DEFAULT 0,
ModelID INTEGER DEFAULT 0,
FOREIGN KEY (LocationID)
REFERENCES Car_Location(LocationID),
FOREIGN KEY (ModelID) REFERENCES
Car_Model(ModelID)
);
```

E. Car Identification Table

```
CREATE TABLE Car_Identification (
VIN VARCHAR PRIMARY KEY, Size
VARCHAR DEFAULT NULL, Condition
VARCHAR DEFAULT NULL, PaintColor
VARCHAR DEFAULT NULL, Fuel
VARCHAR DEFAULT NULL, TitleStatus
VARCHAR DEFAULT NULL, Drive
VARCHAR DEFAULT NULL, Type
VARCHAR DEFAULT NULL,
FOREIGN KEY (VIN) REFERENCES
Car_Entry(VIN)
);
```

F. Car Specification Table

```
CREATE TABLE Car_Specification (
VIN VARCHAR PRIMARY KEY,
Cylinder VARCHAR DEFAULT NULL,
Odometer INTEGER DEFAULT 0,
Transmission VARCHAR DEFAULT
NULL,
FOREIGN KEY (VIN) REFERENCES
Car_Entry(VIN)
);
```

IV. Handling Query Execution using Indexing Strategies

A. Challenges Faced

1) Handling the Original Large Dataset: Since the original large dataset represented 'used car' data in a scattered manner, our goal was to simplify access for a layman user to this data. To achieve this, we classified the entire dataset into manageable smaller tables based on the region/location where the cars are available. This modularization aimed to split the large chunk of data into smaller, meaningful tables such as Car_Region, Car_Model, Car_Specification, and Car_Identification.

B. Usage of Indexing

1) Car_Region Table: In the creation of the Car_Region table, we have the implicit index column RegionID. This is a key column that is unique to each row in the table and thus helps to quickly locate and access the data.

2) Car Location Table:

- Primary Key Index: LocationID serves as the primary key, acting as an implicit index.
- Foreign Key Index: RegionID is used to refer to the Car_Region table, functioning as a foreign key index that speeds up join operations between the Car_Region and Car_Location tables.

3) Car Model Table:

- Primary Key Index: The primary key on ModelID simplifies the search for car models.

4) Car Entry Table:

- Primary Key Index: The Vehicle Identification Number (VIN) is the unique identifier for each car, ensuring effective retrieval of each car entry listing.
- Foreign Key Index: The foreign keys LocationID and ModelID reference the Car_Location and Car_Model tables, respectively.

C. Execution of Complex Queries

Fig. 2. Before Indexing

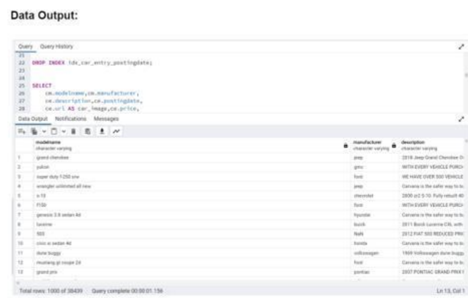


Fig. 3. Before Indexing(Observe the Query Exceution time-00:00:01.156

Prior to the implementation of indexing, the query execution time stood at 00:00:01.156 time units. This duration represents the time taken to retrieve and process data from the database without the benefits of indexing optimization. Recognizing the necessity to improve query performance, indexing concepts were adopted to enhance the efficiency of data retrieval operations. Subsequent sections will provide detailed insights into the specific indexing strategies employed and their consequential impact on reducing query execution times.

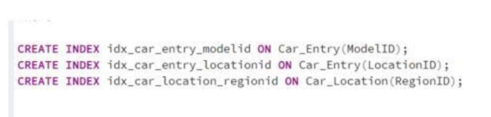


Fig. 4. Applying Indexing Bases on the complex Query seen above

Following the implementation of indexing, there was a noticeable improvement in query performance, with the execution time reduced to 00:00:01.090 time units. This signifies a positive impact on the efficiency of data retrieval operations

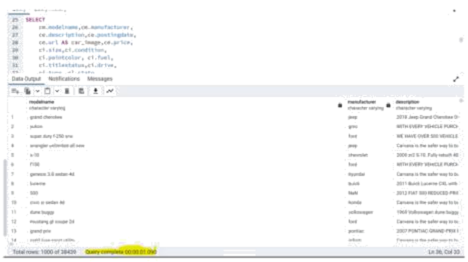


Fig. 5. Result after Applying Indexing(Observe the Reduction in Execution time)

compared to the previous duration of 00:00:01.156 time units. The optimization introduced by indexing has contributed to a more streamlined and expedited querying process, enhancing the overall responsiveness of the database.

V. Database Operations: SELECT

A. List All Cars with Their Location

```sql
--List all cars with their location
select CE.VIN, CE.Description, CL.State, CR.Region
from Car_Entry CE
join Car_Location CL on CE.LocationID=CL.LocationID
join Car_Region CR on CL.RegionID=CR.RegionID
```

Fig. 6. All Cars with their Locations

1) Explanation: This SQL query employs the JOIN operation to retrieve information about cars along with their respective locations. It involves three tables: Car_Entry (CE), Car_Location (CL), and Car_Region (CR). The query links entries in the Car_Entry table to their corresponding locations using the LocationID column and then associates the locations with their regions through the RegionID column. The result includes columns such as Vehicle Identification Number (VIN), Description, State, and Region for each car.

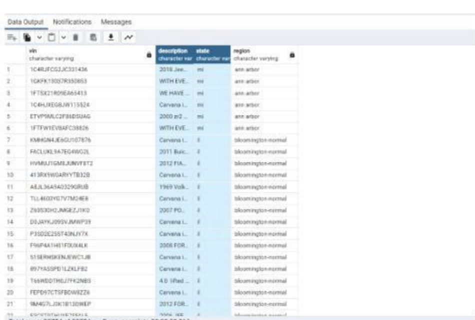


Fig. 7. Results of All Cars with their Locations

B. Find Cars with Specific Manufacturer in a Given Region

1) Explanation: This SQL query retrieves information about cars with a specific manufacturer (in this case, 'ford') located in a given region (in this case, 'albany'). It involves

```sql
--Find cars with specific manufacturer in a given region
select CE.VIN, CM.Manufacturer, CM.ModelName, CR.Region
from Car_Entry CE
join Car_Model CM on CE.ModelID=CM.ModelID
join Car_Location CL on CE.LocationID=CL.LocationID
join Car_Region CR on CL.RegionID=CR.RegionID
where CM.Manufacturer='ford' and region='albany'
```

Fig. 8. Find Cars with Specific Manufacturer in a Given Region

joining four tables: Car_Entry (CE), Car_Model (CM), Car_Location (CL), and Car_Region (CR) to link car entries with their models, locations, and regions. The WHERE clause filters the results based on the specified manufacturer and region, providing a targeted list of cars meeting these criteria.

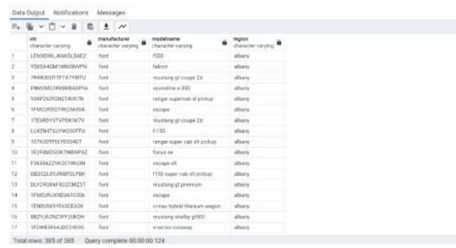


Fig. 9. Results for Cars with Specific Manufacturer in a Given Region

C. Average Price of Each Car Model

```sql
--Average Price of Each Car Model
SELECT CM.Manufacturer, CM.ModelName, round(AVG(CE.Price),2) AS AveragePrice
FROM Car_Entry CE
join Car_Model CM on CE.ModelID=CM.ModelID
GROUP BY CM.Manufacturer, CM.ModelName;
```

Fig. 10. Find Average Price of Each Car Model

1) Explanation: This SQL query calculates the average price for each car model by joining the Car_Entry (CE) and Car_Model (CM) tables based on the ModelID. The AVG function is used to compute the average price, and the result is rounded to two decimal places using the ROUND function. The GROUP BY clause ensures that the calculation is performed for each unique combination of manufacturer and model name, providing a summary of average prices for different car models.

D. Top 5 Expensive Car Models in Each Region

1) Explanation: This SQL query retrieves the top 5 most expensive car models in each region. It utilizes the ROW_NUMBER() window function to assign a rank to each car entry based on its price within each region. The outer query then filters the results to include only the top 5 expensive car models in each region, ordered by region and price in descending order.

E. Finding Cars with Specific Color and Condition

1) Explanation: This SQL query retrieves informa-tion about cars with a specific color ('blue') and

	manufacturer character varying	modelname character varying	averageprice numeric
1	NaN	JT2bg22k5y0513201	3950.00
2	bmw	7 series	23711.43
3	nissan	altima 2.5 4dr sedan	12149.50
4	volvo	c30 t5 2dr hatchback	12500.00
5	ford	econoline e150	8750.00
6	volkswagen	passat s	6270.00
7	NaN	64 Hawk	18500.00
8	toyota	scion	5225.00
9	NaN	Mobility Ventures MV-1 SE Wheel	20900.00
10	ford	transit wagon xl	28995.00
11	volkswagen	passat 2.0t	3000.00
12	porsche	panamera sedan 4d	34990.00
13	NaN	avana Cargo Van	23995.00
14	gmc	terrain awd 4dr sle	24502.00
15	bmw	z4 2.5i	7500.00
16	gmc	yukon xl slt 1500	18995.00
17	ford	f-450 platinum	112500.00
18	subaru	legacy 2.5i sedan 4d	20290.00
19	volvo	s80	6190.71

Total rows: 1000 of 7326 Query complete 00:00:00.124

Fig. 11. Results for Average Price of Each Car Model

```sql
--Top 5 Expensive Car Models in Each Region
SELECT Region,Manufacturer,ModelName,Price
from
(SELECT
        CR.Region,
        CM.Manufacturer,
        CM.ModelName,
        CE.Price,
        ROW_NUMBER() OVER (PARTITION BY CR.Region ORDER BY CE.Price DESC) as rn
    FROM Car_Entry CE
    JOIN Car_Model CM on CE.ModelID = CM.ModelID
    JOIN Car_Location CL ON CE.LocationID = CL.LocationID
    JOIN Car_Region CR ON CL.RegionID = CR.RegionID) as RankedCars
where rn<=5
order by Region,Price DESC
```

Fig. 12. Find Top 5 Expensive Car Models in Each Region

Data Output Notifications Messages

	region character varying	manufacturer character varying	modelname character varying	price numeric
1	abilene	jeep	wrangler	135000
2	abilene	NaN	HUMMER HI	119500
3	abilene	NaN	2015 Peterbuilt Glider Kit	115000
4	abilene	NaN	Man Test	100000
5	abilene	NaN	Man Test	100000
6	akron / canton	chevrolet	corvette	106999
7	akron / canton	chevrolet	corvette	91000
8	akron / canton	jeep	grand cherokee srt	69900
9	akron / canton	chevrolet	corvette	69850
10	akron / canton	gmc	sierra 2500hd	61743
11	albany	ferrari	360 modena	58900
12	albany	chevrolet	corvette z06	86000
13	albany	chevrolet	corvette z06	82500

Total rows: 245 of 245 Query complete 00:00:00.188 Ln 232, Col 1

Fig. 13. Results for Top 5 Expensive Car Models in Each Region

```sql
--Find Cars with Specific Color and Condition
SELECT CE.VIN, CM.ModelName, CE.Description, CI.PaintColor, CI.Condition
FROM Car_Entry CE
JOIN Car_Identification CI ON CE.VIN = CI.VIN
JOIN Car_Model CM on CE.ModelID=CM.ModelID
WHERE CI.PaintColor = 'blue' AND CI.Condition = 'new';
```

Fig. 14. Finding Cars with Specific Color and Condition

condition ('new'). It involves joining the Car_Entry, Car_Identification, and Car_Model tables to link car entries with their identification details and model information. The WHERE clause filters the results based on the specified paint color and condition.

F. Cars with Mileage Over 100,000 by Manufacturer

```sql
--Cars with Mileage Over 100,000 by Manufacturer
SELECT CM.Manufacturer, COUNT(*) AS HighMileageCars
FROM Car_Entry CE
join Car_Model CM on CE.ModelID=CM.ModelID
JOIN Car_Specification CS ON CE.VIN = CS.VIN
WHERE CS.Odometer > 100000
GROUP BY CM.Manufacturer;
```

Fig. 16. Results for Cars with Mileage Over 100,000 by Manufacturer

1) Explanation: This SQL query counts the number of cars with mileage exceeding 100,000 by manufacturer. It involves joining the Car_Entry (CE), Car_Model (CM), and Car_Specification (CS) tables to link car entries with their models and specifications. The WHERE clause filters for cars with an odometer reading over 100,000 miles. The COUNT function is then used to tally the number of high-mileage cars for each manufacturer, providing insights into the distribution of cars with significant mileage.

	manufacturer character varying	highmileagecars bigint
1	chevrolet	2533
2	mazda	164
3	audi	113
4	acura	120
5	nissan	625
6	mini	44
7	mercedes-benz	239
8	chrysler	237
9	ram	640
10	kia	239
11	bmw	282
12	pontiac	143
13	infiniti	109
14	volkswagen	205
15	NaN	581
16	ford	3047
17	harley-davidson	3
18	jaguar	18
19	fiat	2

Fig. 17. Results for Cars with Mileage Over 100,000 grouped by Manufac-turer

G. Latest Models Available in Each State

```sql
--Latest Models Available in Each State
SELECT CL.State, MAX(CM.Year) AS LatestModelYear
FROM Car_Model CM
join Car_Entry CE on CE.ModelID=CM.ModelID
JOIN Car_Location CL ON CE.LocationID = CL.LocationID
GROUP BY CL.State;
```

Fig. 18. Results for Latest Models Available in Each State

1) Explanation: This SQL query identifies the latest car models available in each state by joining the Car_Model (CM), Car_Entry (CE), and Car_Location (CL) tables. The MAX function is applied to the Year column to determine the latest model year for each state. The GROUP BY clause ensures that the aggregation is performed for each unique

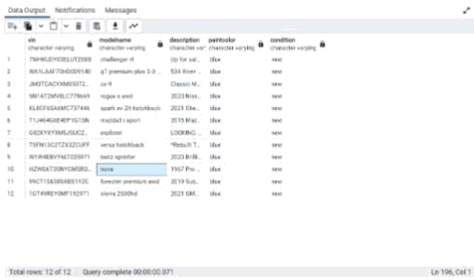
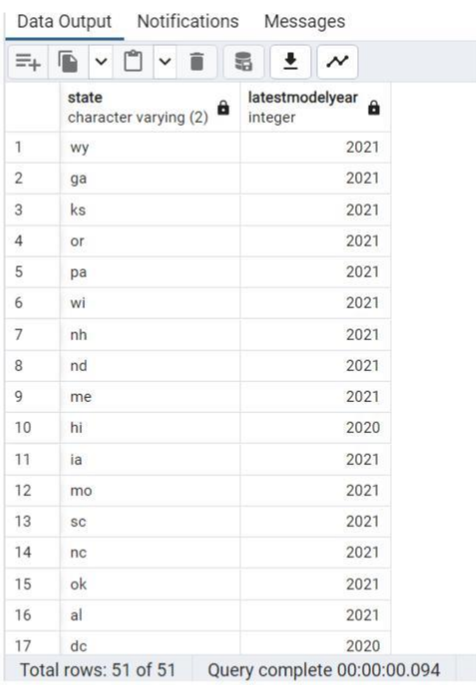


Fig. 15. Results for Cars with Specific Color and Condition

state, providing valuable information about the most recent car models present in various locations.



	state character varying (2)	latestmodelyear integer
1	wy	2021
2	ga	2021
3	ks	2021
4	or	2021
5	pa	2021
6	wi	2021
7	nh	2021
8	nd	2021
9	me	2021
10	hi	2020
11	ia	2021
12	mo	2021
13	sc	2021
14	nc	2021
15	ok	2021
16	al	2021
17	dc	2020

Total rows: 51 of 51 Query complete 00:00:00.094

Fig. 19. Results for Latest Models Available in Each State

VI. Database Operations: Insertions

A. Inserting Data into Car_Region Table

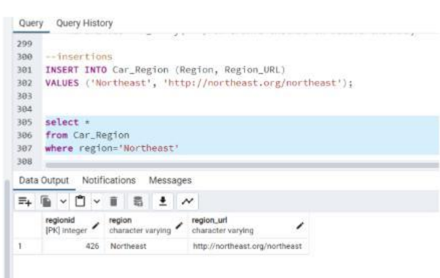


Fig. 20. Inserting Data into Car Region Table

1) Explanation: The first query inserts a new region, 'Northeast,' along with its corresponding URL into the Car_Region table. The second query is used to verify the successful insertion by retrieving all rows where the region is 'Northeast.'

B. Inserting Data into Car_Location Table

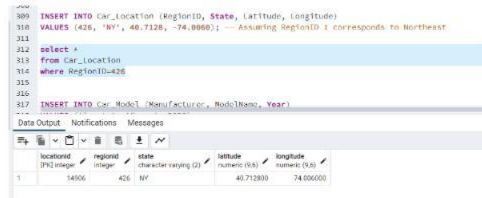


Fig. 21. Inserting Data into Car Location Table

C. Explanation

The first query inserts a new location data into the Car_Location table with the specified RegionID, State, Latitude, and Longitude. The second query is used to verify the successful insertion by retrieving all rows where the RegionID is 426.

D. Inserting Data into Car_Model Table

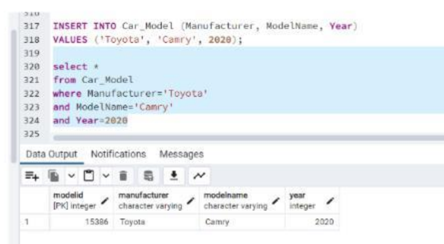


Fig. 22. Inserting Data into Car Model Table

1) Explanation: The first query inserts a new car model, 'Toyota Camry 2020,' into the Car_Model table. The second query is used to verify the successful insertion by retrieving all rows matching the specified Manufacturer, ModelName, and Year.

E. Inserting Data into Car_Entry Table

Fig. 23. Inserting Data into Car Entry Table

1) Explanation: The first query inserts a new car entry with specific details into the Car_Entry table. The second query

is used to verify the successful insertion by retrieving all rows where the VIN matches the specified value.

F. Inserting Data into Car_Identification Table

Fig. 24. Inserting Data into Car Identification Table

1) Explanation: The first query inserts identification details for a specific car into the Car_Identification table. The second query is used to verify the successful insertion by retrieving all rows where the VIN matches the specified value.

G. Inserting Data into Car_Specification Table

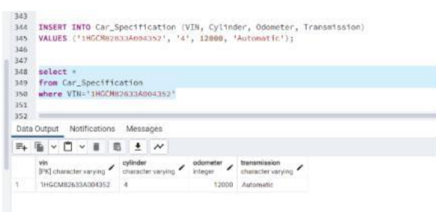


Fig. 25. Inserting Data into Car Specification Table

1) Explanation: The first query inserts specific specifications for a car into the Car_Specification table. The second query is used to verify the successful insertion by retrieving all rows where the VIN matches the specified value.

VII. Database Operations: Updates

A. Updating Car_Region Table with Cascaded Update

Fig. 26. Updating Car Region Table with Cascaded Update

1) Explanation: The update query modifies the RegionID in the Car_Region table from 426 to 500. This table is configured with a cascaded update setting, so we will verify if the update is reflected in the Car_Location table.

Fig. 27. Car Location table automatically gets updated as a result of Cascaded Update.

VIII. Cascade delete operations

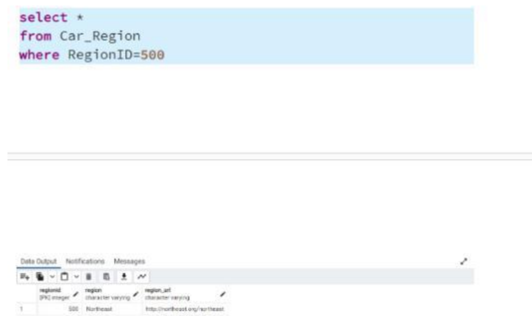


Fig. 28. Cascade delete

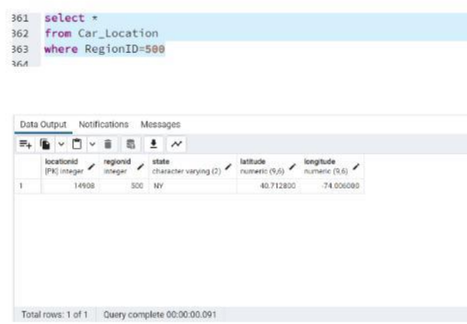


Fig. 29. Cascade delete Operation

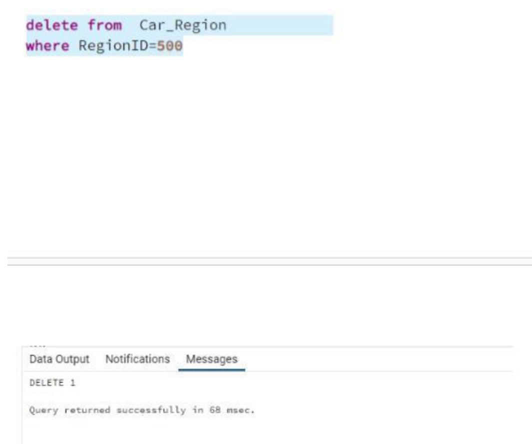


Fig. 30. Cascade delete Operation

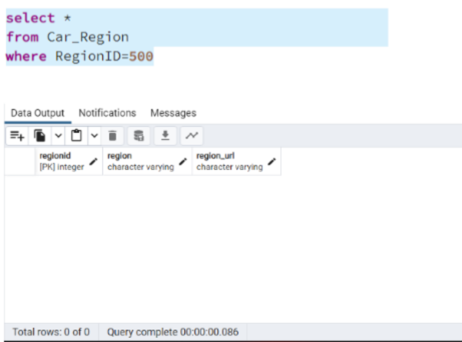


Fig. 31. Cascade delete Operation

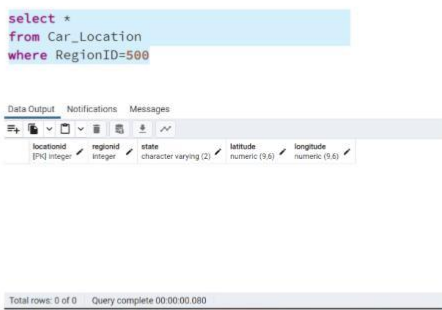


Fig. 32. Cascade delete Operation - We can see here that the Deletion operation in the Car Region table also Deletes the particular row from the Car Location table

From the above figures DELETION is also cascaded, as we see that RegionID deletion from Car Region Table deletes it from Car Location as well.

IX. Query Execution Analysis: Identifying Performance Bottlenecks

A. Problematic Query 1

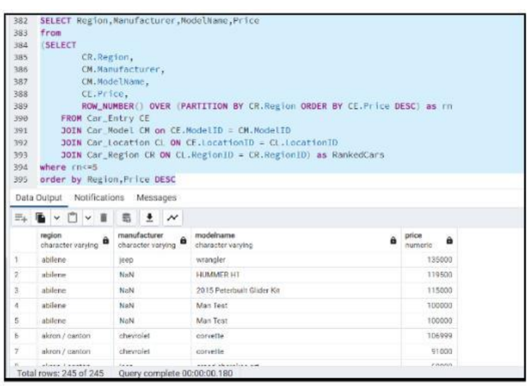


Fig. 33. Before Indexing : Observe the Query Execution Time

Result of Explain:

"Subquery Scan on rankedcars (cost=7042.35..8204.97 rows=38754 width=38)"
" -> WindowAgg (cost=7042.35..7817.43 rows=38754 width=46)"
" Run Condition: (row_number() OVER (?) <= 5)"
" -> Sort (cost=7042.35..7139.23 rows=38754 width=38)"
" Sort Key: cr.region, ce.price DESC"
" -> Hash Join (cost=920.09..4088.89 rows=38754 width=38)"
" Hash Cond: (cl.regionid = cr.regionid)"
" -> Hash Join (cost=905.53..3971.59 rows=38754 width=30)"
" Hash Cond: (ce.locationid = cl.locationid)"
" -> Hash Join (cost=460.16..3424.47 rows=38754 width=30)"
" Hash Cond: (ce.modelid = cm.modelid)"
" -> Seq Scan on car_entry ce (cost=0.00..2862.54 rows=38754 width=14)"
" -> Hash (cost=267.85..267.85 rows=15385 width=24)"
" -> Seq Scan on car_model cm (cost=0.00..267.85 rows=15385 width=24)"
" -> Hash (cost=259.05..259.05 rows=14905 width=8)"
" -> Seq Scan on car_location cl (cost=0.00..259.05 rows=14905 width=8)"
" -> Hash (cost=9.25..9.25 rows=425 width=16)"
" -> Seq Scan on car_region cr (cost=0.00..9.25 rows=425 width=16)"

Fig. 34. EXPLAIN tool Results

1) Original Query: The execution plan for the Top 5 Expensive Car Models in Each Region query provides insights into potential areas for optimization:

- Sequential Scans: The plan reveals sequential scans (Seq Scan) on the tables Car Entry, Car Model, Car Location, and Car Region. Sequential scans can be less efficient than index scans, particularly for large tables.
- Window Function: The WindowAgg operation indicates the use of a window function. Window functions can introduce overhead, especially when dealing with a large number of rows.
- Nested Loops and Hash Joins: The query plan involves hash joins (Hash Join) between multiple tables. The efficiency of these joins depends on the size of the tables and the presence of indexes.

The sequential scans, absence of index scans, and the cost associated with the window function suggest potential areas for improvement. To enhance performance, consider the following strategies:

1) Create Index:

- Index the foreign key columns used in joins.
- Index the 'RegionID' column in the 'Car Location' table.
- Index the 'Manufacturer', 'ModelName', and 'Price' columns, as they are frequently used.

Implementing these indexing strategies can significantly enhance the query performance.

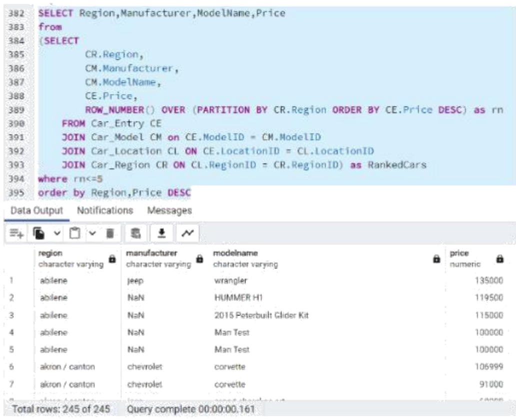


Fig. 35. After Indexing Results : See the improvement in Execution time

2) Query Optimization Results: After implementing index-ing strategies, we observed a notable improvement in query performance for the Top 5 Expensive Car Models in Each Region query.

- Before Indexing: The query execution time was 00:00:00.180 seconds.
- After Indexing: With the introduction of appropriate indexes, the execution time reduced to 00:00:00.160 seconds.

This optimization resulted in a improvement, showcasing the effectiveness of the indexing strategies. Further refinements in indexing and query structure could potentially yield addi-tional performance gains.

B. Problematic Query 2

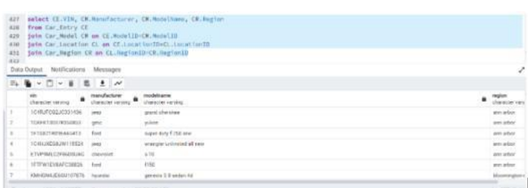


Fig. 36. Before Indexing : Observe the Query Execution Time

```
Output:
"Hash Join  (cost=920.11..4088.93 rows=38755 width=49)"
"  Hash Cond: (cl.regionid = cr.regionid)"
"  ->  Hash Join  (cost=905.55..3971.63 rows=38755 width=41)"
"        Hash Cond: (ce.locationid = cl.locationid)"
"        ->  Hash Join  (cost=460.19..3424.50 rows=38755 width=41)"
"              Hash Cond: (ce.modelid = cm.modelid)"
"              ->  Seq Scan on car_entry ce  (cost=0.00..2862.55
rows=38755 width=25)"
"              ->  Hash  (cost=267.86..267.86 rows=15386 width=24)"
"                    ->  Seq Scan on car_model cm  (cost=0.00..267.86
rows=15386 width=24)"
"        ->  Hash  (cost=259.05..259.05 rows=14905 width=8)"
```

Fig. 37. EXPLAIN tool Results

1) Query Execution Plan Analysis: Our query in-volves multiple joins between four tables: Car_Entry, Car_Model, Car_Location, and Car_Region. The ex-ecution plan is using Hash Joins to combine these tables, indicating the use of a hash-based method, often efficient for larger datasets.

a) Sequence of Joins:: First, Car_Entry is joined with Car_Model on ModelID, then the result is joined with Car_Location on LocationID, and finally, that result is joined with Car_Region on RegionID.

b) Sequential Scans (Seq Scan):: The plan includes several sequential scans (Seq Scan) on the Car_Entry, Car_Model, Car_Location, and Car_Region tables. This suggests that using index scans could be more efficient, especially for larger datasets.

c) Hash Operations:: The plan involves building hash tables on smaller tables and then probing these tables using rows from the larger table. The cost and row estimates for these operations provide insights into the resources required to build these hash tables.

d) Optimization:: Consider indexing columns used in join conditions (ModelID, LocationID, RegionID) and in WHERE clauses (if any). Composite indexes covering mul-tiple columns might improve performance.

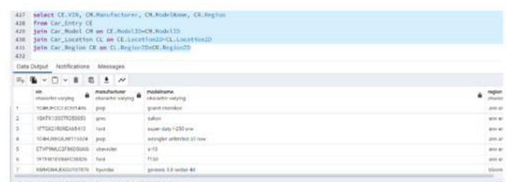


Fig. 38. After Indexing Analysis Results - Observe the improveemnt in Execution time

2) Query Performance Improvement: The query execution time has been significantly improved after indexing. Before indexing, the query took approximately 00:00:00.151 seconds, and after implementing proper indexing, the execution time reduced to 00:00:00.130 seconds. This marks a notable im-provement in the efficiency of the query.

a) Analysis:: The performance enhancement can be at-tributed to the creation of suitable indexes on key columns involved in join conditions and filtering. Indexing allows the database engine to quickly locate and retrieve the relevant rows, reducing the need for sequential scans.

b) Conclusion:: Optimizing queries through indexing is a crucial practice to enhance database performance, especially when dealing with large datasets. The observed reduction in execution time demonstrates the positive impact of thoughtful indexing strategies on query efficiency.

C. Problematic Query 3

```
--Average Price of Each Car Model
SELECT CM.Manufacturer, CM.ModelName, round(AVG(CE.Price),2) AS AveragePrice
FROM Car_Entry CE
join Car_Model CM on CE.ModelID=CM.ModelID
GROUP BY CM.Manufacturer, CM.ModelName;
```

Fig. 39. Before Indexing Results - Observe the Execution Time

```
"HashAggregate  (cost=5233.34..5289.90 rows=5656 width=25)"
"  Group Key: cr.region, ci.type"
"  ->  Hash Join  (cost=1773.89..4942.69 rows=38754 width=17)"
"        Hash Cond: (cl.regionid = cr.regionid)"
"        ->  Hash Join  (cost=1759.33..4825.38 rows=38754 width=9)"
"              Hash Cond: (ce.locationid = cl.locationid)"
"              ->  Hash Join  (cost=1313.96..4278.26 rows=38754 width=9)"
"                    Hash Cond: ((ce.vin)::text = (ci.vin)::text)"
"                    ->  Seq Scan on car_entry ce  (cost=0.00..2862.55 rows=38755 width=21)"
"                    ->  Hash  (cost=829.54..829.54 rows=38754 width=22)"
"                          ->  Seq Scan on car_identification ci  (cost=0.00..829.54 rows=38754 width=22)"
"              ->  Hash  (cost=259.05..259.05 rows=14905 width=8)"
"                    ->  Seq Scan on car_location cl  (cost=0.00..259.05 rows=14905 width=8)"
"        ->  Hash  (cost=9.25..9.25 rows=425 width=16)"
"              ->  Seq Scan on car_region cr  (cost=0.00..9.25 rows=425 width=16)"
```

Fig. 40. EXPLAIN Tool Results

1) Query Analysis and Optimizations: The execution plan reveals several aspects of the query execution:

a) HashAggregate:: The HashAggregate operation is utilized to implement the GROUP BY clause, grouping records by CR.Region and CI.Type and then counting them. The average size of the output rows is indicated as width=25.

b) Hash Operations:: Before each join, a hash table is constructed for one of the joining tables. This is a common approach in hash joins, where one table is hashed and then probed with the other.

c) Optimizations:: To enhance performance, it is recommended to ensure that columns used in join conditions (VIN, LocationID, RegionID) are properly indexed. Indexes can significantly expedite join operations by minimizing the need for full table scans. Specifically, having an index on VIN in both Car Identification and Car Entry tables could be particularly beneficial.

d) Conclusion:: Optimizing query performance involves thoughtful indexing, especially on columns used in join operations. The identified optimizations aim to reduce the reliance on sequential scans and improve the efficiency of hash joins.

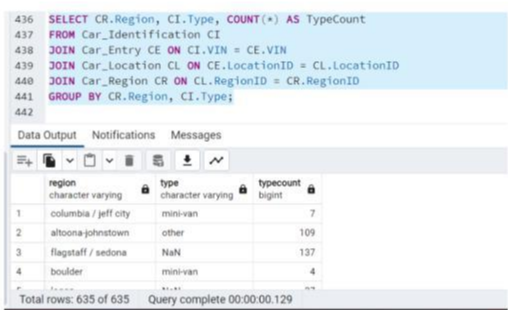


Fig. 41. After Indexing Results - Observe the Improvement in Execution Time

e) Performance Improvement:: After implementing the recommended indexes, a significant improvement in performance was observed. The query execution time reduced from 00:00:00.140 seconds to 00:00:00.120 seconds, indicating the effectiveness of indexing in query optimization.

f) Conclusion:: Optimizing queries involves a careful consideration of indexing strategies, particularly on columns involved in join operations. The observed improvement in per-formance underscores the importance of thoughtful indexing for efficient database queries.

X. CarQuest Website: Revolutionizing Used Car Search

CarQuest, our online tool, redefines the used car search experience. With an intuitive and user-friendly interface, Car-Quest aims to provide a seamless and efficient way for users to explore, compare, and discover used cars. Leveraging a com-prehensive database. CarQuest ensures that users can find the perfect vehicle that meets their preferences and requirements.

A. Key Features

- Extensive Database: CarQuest boasts a large database of used cars, categorized by regions, models, and specifi-cations, offering users a diverse selection to choose from.
- Search Capabilities: Users can search with model name and location to get the data about the cars matching the criteria.
- Detailed Car Information: Each car listing on CarQuest provides comprehensive details, including specifications, condition, location, and pricing, empowering users with the information needed to make informed decisions.
- User-Friendly Interface: CarQuest prioritizes user expe-rience with an intuitive interface, making navigation and exploration of the website seamless and enjoyable.

Fig. 42. CarQuest Main UI

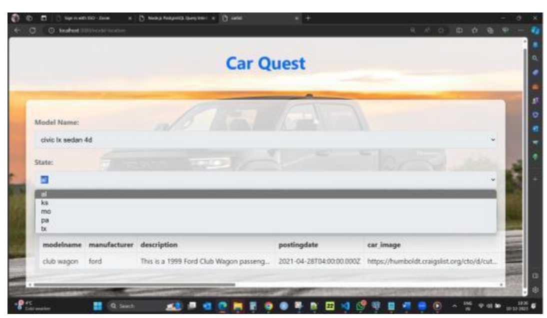


Fig. 43. CarQuest Main UI

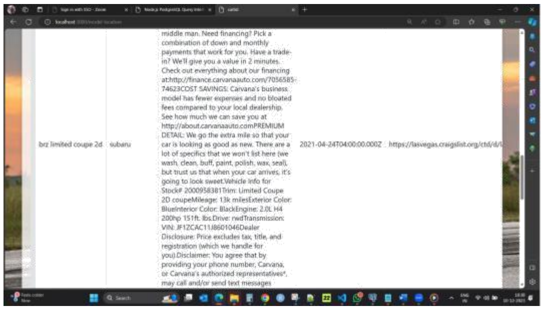


Fig. 44. CarQuest Main UI

Fig. 45. CarQuest SQL Query Interface

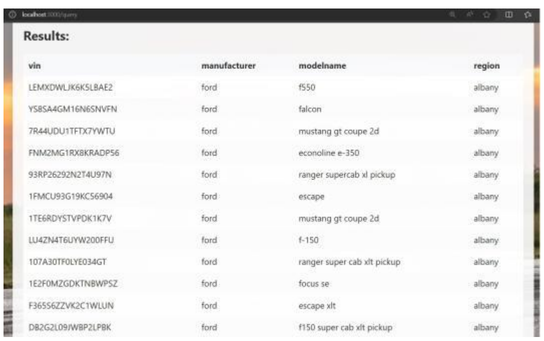


Fig. 46. CarQuest SQL Query Results

The visual appeal of the website enhances the overall user experience, making the process of searching for a used car both enjoyable and efficient. With carefully crafted layouts, clear call-to-action buttons, and a harmonious color scheme, the CarQuest web UI ensures that users can seamlessly interact with the platform.

XI. Conclusion

CarQuest: A Robust Foundation for a User-Friendly Used Car Platform

Significant progress has been made in the CarQuest project, establishing a solid foundation for a comprehensive used car platform. The achievements in this phase can be summarized as follows:

1) Database:
   - Developed a well-organized database schema for efficient used car data management.
   - Created essential tables to store and organize vehicle information.
   - Implemented optimized SQL queries for efficient data retrieval and analysis.
   - Employed indexing strategies, leading to a signifi-cant improvement in query performance.
2) Web Interface:
   - Created a user-friendly website to complement the underlying database functionality.
   - Designed an intuitive and visually appealing inter-face for searching and browsing used cars.
   - Elevated the user experience with a dynamic and interactive web platform.
3) Synergy:
   - Seamlessly integrated the database with the web UI for a cohesive user experience.
4) Moving Forward:
   - Transitioning from the foundational database setup to a user-centric web platform.
   - Committed to continuously refining and expanding CarQuest to meet evolving user needs.
5) Overall:
   - This phase marks a major milestone in the CarQuest project.
   - Successfully established a robust foundation and created a user-friendly interface.
   - Paving the way for a comprehensive and user-focused used car platform.

XII. Contributions

A. Dataset Exploration and Project Discussion

- Arjun and Sai Teja: Dataset decision, Data Cleaning, Basic Project Discussion, Project Report

B. Dataset Exploration and Project Discussion

- Sai Teja: Determination of Dataset
- Arjun and Sai Teja: Dataset decision, Data Cleaning, Basic Project Discussion, Project Report

C. Database Schema Design

- Balaji and Arjun: Determination of Tables, Primary key, Foreign key Determination

D. Database Implementation

- Arjun: Creation of Database in PostgreSQL including create table queries

E. Data Insertions

- Arjun and Balaji: Insertion of Data into Tables

F. Web UI Development

- Balaji: Web UI development

G. Web UI Changes

- Arjun: Web UI requirement changes

H. Preparation of Video

- Sai Teja, Arjun, Balaji: Preparation of video

I. Preparation of SQL Dump file

- Sai Teja Preparation of SQL Dump file

References

[1] Link to the Dataset. https://www.kaggle.com/datasets/austinreese/craigslist-carstrucks-data

[2] PostgreSQL Documentation. https://www.postgresql.org/docs/

[3] Web UI. https://nodejs.org/en/download