GPS Toll Based Simulation Using Python

INTERNSHIP REPORT

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PROJECT TITLE:

GPS Toll Based Simulation using Python

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A special note of appreciation goes to Dr. R. Chitra, our college mentor for her academic support and for helping us connect the practical aspects of our internship with our academic pursuits. Her guidance has been invaluable in ensuring that our work remains aligned with our educational goals.

Lastly, we are grateful to our colleagues and team members who have been supportive and cooperative throughout our internship. Their willingness to assist and collaborate has made our internship experience both productive and enjoyable.

Thank you all for your encouragement, support, and guidance.

2.ABSTRACT

This report presents the development and implementation of a GPS-based toll system simulation using python. The primary objective of this project was to create a robust and efficient system that simulates the operations of a toll collection process based on GPS data, integrating a web interface for user interaction and a database for data storage.

Our project utilized python for the core simulation tasks, leveraging the Simpy library to model the toll collection process and manage the simulation events. The simulation aimed to replicate real-world scenarios, including vehicle detection, toll calculation based on distance traveled, and queue management at toll plazas.

To provide a user-friendly interface, we developed a website using html and css. This website allows users to interact with the simulation, view real-time data, and understand the workings of the gps toll system. The front end was designed to be intuitive and responsive, ensuring a seamless user experience.

For the backend, we employed MySQL to manage and store the data generated during the simulation. This database choice was driven by MySQL's flexibility and scalability, which are crucial for handling large volumes of data typical in toll systems. The data stored includes vehicle entries and exits, toll amounts calculated, and time stamps of each transaction, which can be used for further analysis and reporting.

This report details the system architecture, the design and implementation process, and the results of our simulation. The findings demonstrate the feasibility and efficiency of using gps data for toll collection, highlighting the potential for real-world application and further development.

The project not only showcases the technical aspects but also emphasizes the integration of various technologies to solve a real-world problem.

3.INTRODUCTION

This report details the development and application of a Python-based toll system simulation based on GPS. With the integration of a web interface for user interaction and a database for data storage, the project aimed to develop a reliable and effective system that mimics the workings of a toll collection procedure based on GPS data.

3.1 THE BACKGROUND OF THE STUDY

Due to its potential to increase accuracy and efficiency, gps technology has drawn a lot of attention in toll collection systems recently. Traditional toll collecting systems depend on expensive and error-prone physical infrastructure, like toll booths and sensors. With the ability to determine toll fees based on distance traveled, gps-based toll systems provide a more advanced and adaptable method.

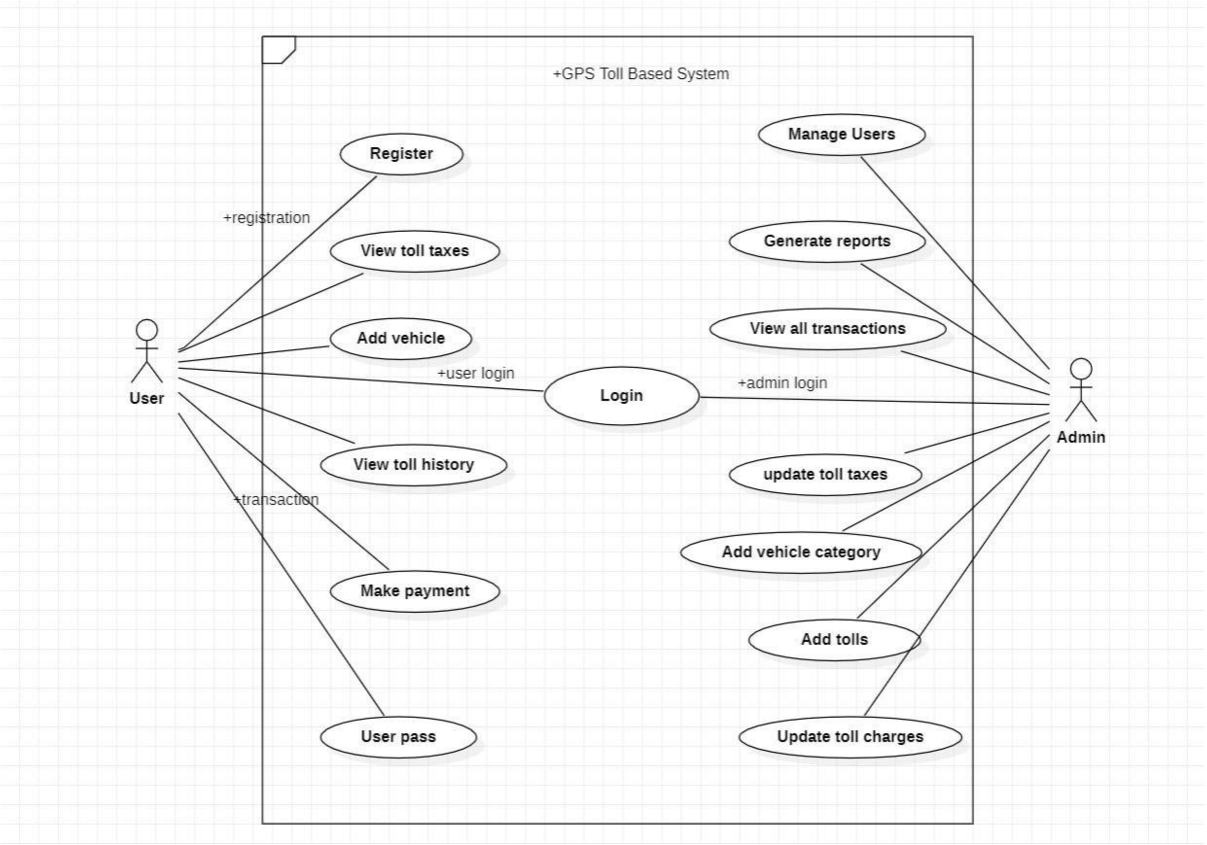
3.2 PURPOSE OF THE INTERNSHIP

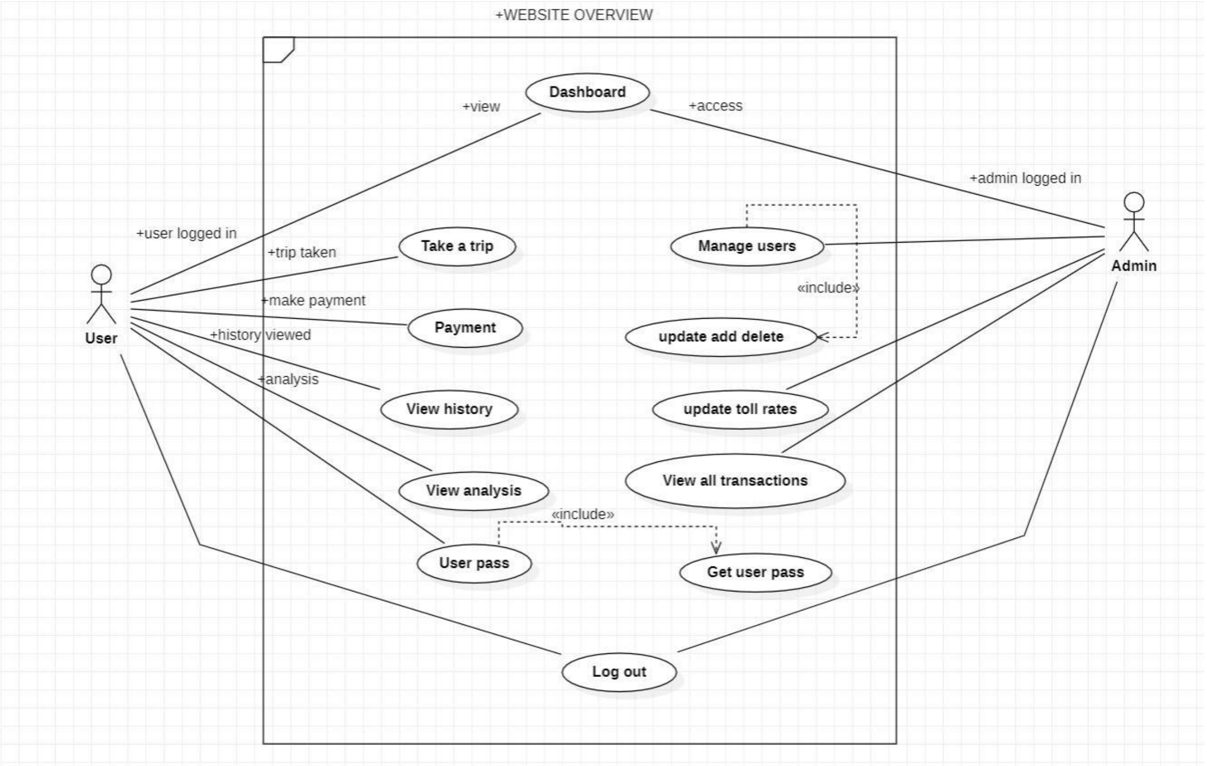
The goal of the internship was to obtain practical experience in the development of a Python GPS toll-based simulation. The following were the project's goals: Create a user-friendly interface for users to interact with the simulation and view real-time data. Design and implement a simulation that can accurately model toll charges based on GPS data. Use a database to store and manage data generated during the simulation. Showcase the viability and effectiveness of using GPS data for toll collection.

3.3 SCOPE OF THE REPORT

The following project aspects will be covered in this report: Architecture and design of the system. The simulation's implementation with Simpy and Python. Creating the web interface with CSS and HTML. Creating and implementing databases with MySQL. Results and discussion of the simulation's performance. Conclusion and recommendations for future improvements.

USE CASE DIAGRAM


+GPS Toll Based System
User
Admin
Register
+registration
View toll taxes
Add vehicle
+user login
Login
+admin login
View toll history
+transaction
Make payment
User pass
Manage Users
Generate reports
View all transactions
update toll taxes
Add vehicle category
Add tolls
Update toll charges


+WEBSITE OVERVIEW
Dashboard
+view
+access
+admin logged in
+user logged in
User
Admin
Take a trip
+trip taken
Payment
+make payment
+history viewed
View history
+analysis
View analysis
User pass
«include»
Get user pass
Manage users
«include»
update add delete
update toll rates
View all transactions
Log out

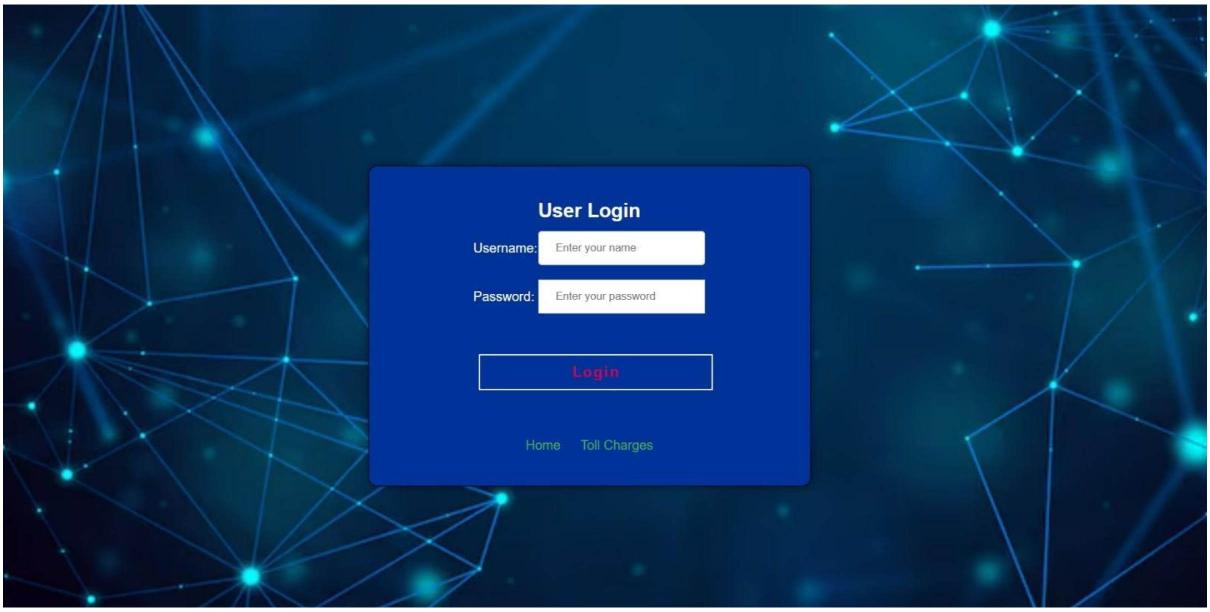
4. INTERNSHIP ACTIVITIES

4.1. Work Description

We developed a Python-based GPS toll simulation system to accurately process real-time GPS data, compute travel distances, identify toll zones, and dynamically calculate toll rates. The project involved designing the simulation system and ensuring it could handle continuous GPS data streams and adjust toll prices in real-time.

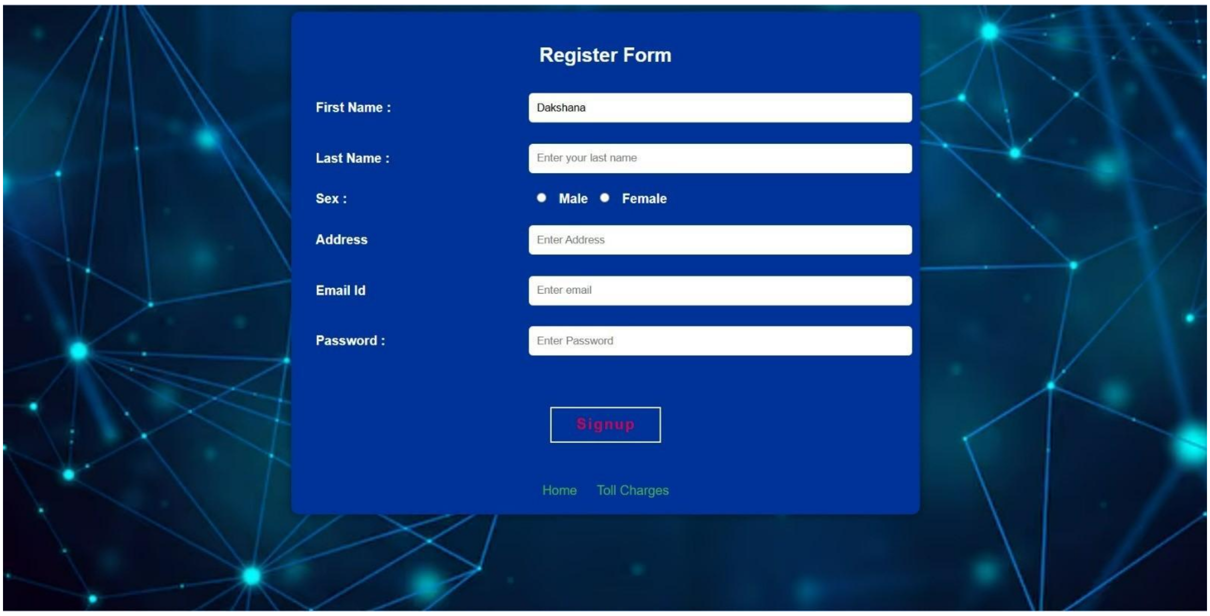
Additionally, we created a comprehensive website with a user-friendly interface for managing toll data. The site features secure login, server-verified access at each URL, and a clear structure with views for actions, models for database management, and templates for the user interface.

LOGIN:



The login page is shared by both users and administrators. The administrator is directed to their dashboard only if the username and password match the credentials stored in the database. Specifically, the screen will open for the administrator if the username is "Vaisnave" and the password is "1234567".

REGISTRATION PAGE:



Register Form

First Name : Dakshana

Last Name : Enter your last name

Sex : ● Male ● Female

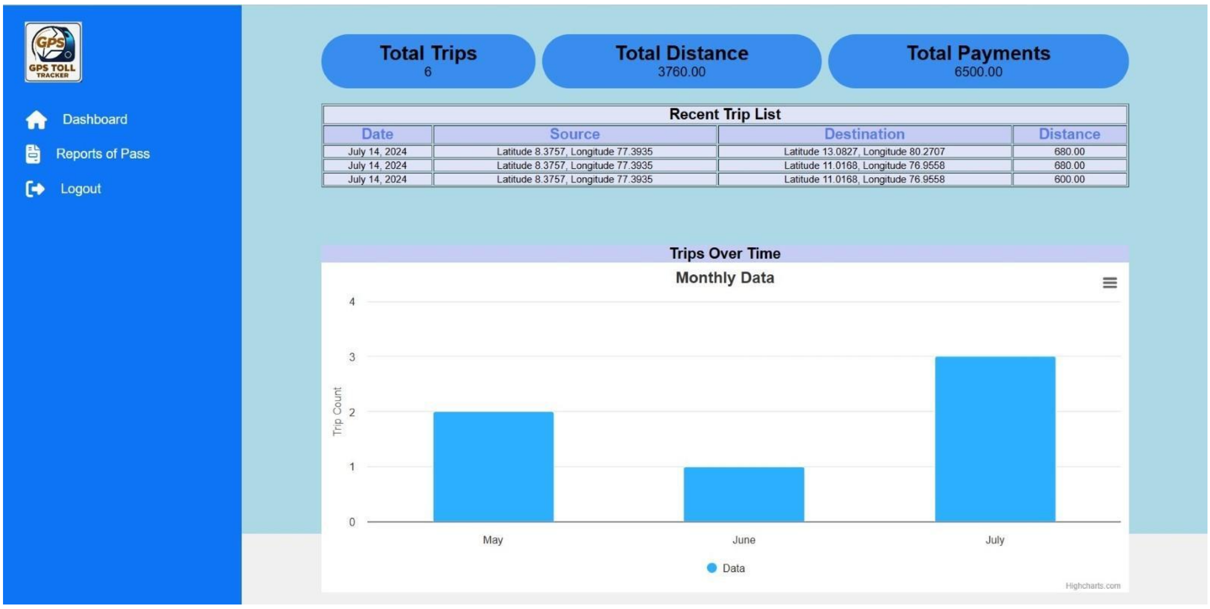
Address Enter Address

Email Id Enter email

Password : Enter Password

Users can register on the platform by providing their details and then logging in. Administrators, however, cannot register through the platform; only users can log in this way. Admin login credentials can only be modified directly in the database.

ADMIN DASHBOARD:



Total Trips 6

Total Distance 3760.00

Total Payments 6500.00

Recent Trip List

Date	Source	Destination	Distance
July 14, 2024	Latitude 8.3757, Longitude 77.3935	Latitude 13.0827, Longitude 80.2707	680.00
July 14, 2024	Latitude 8.3757, Longitude 77.3935	Latitude 11.0168, Longitude 76.9558	680.00
July 14, 2024	Latitude 8.3757, Longitude 77.3935	Latitude 11.0168, Longitude 76.9558	600.00

Trips Over Time

The pass report details display information about users who have taken a pass. Once a user obtains a pass, their information will appear in the report, including the vehicle number, vehicle category, applicant name, vehicle name, and cost. Additionally, the report will show the validity period, specifying the start and end dates. This comprehensive overview ensures that all relevant details about the pass and its holder are easily accessible and clearly presented.

USER LOGIN PAGE:

The user screen displays the total trips taken, total distance covered, and the associated cost. It also provides a summary of each trip and features a live graph representing monthly data. This data can be downloaded in various formats, including CSV, XLS, PNG, JPEG, and SVG.

SIMULATION SCREEN:

The simulation screen of the GPS toll-based system provides a dynamic interface displaying real-time data on vehicle movements, toll calculations, and queue management at toll plazas. It features interactive elements that allow users to visualize routes, monitor toll charges, and view statistical summaries of trips. The screen is designed to be intuitive, offering a seamless user experience for managing and analyzing toll operations.

The system automatically calculates toll charges based on the distance traveled from the source to the destination. For every 50 kilometers traveled, a toll is applied. This dynamic calculation ensures that tolls are accurately determined based on the total distance covered by the vehicle within the toll zones.

SIMULATION MAP PAGE:

The Simulation Map Screen visually represents real-time GPS data, displaying vehicle locations, routes, and toll zones on an interactive map. It helps users monitor vehicle movements, track entry and exit from toll zones, and view the corresponding toll charges dynamically. The screen enhances user experience by providing a clear and intuitive visual overview of the simulation, facilitating better understanding and management of toll operations.

4.2. Work Summary

Main GPS Toll-Based Simulation System:

The core project was the creation of a GPS toll-based simulation system that mimicked toll collection using real-time GPS data from moving vehicles. This project involved several critical tasks.

Real-Time GPS Data Collection and Processing:

The system handled real-time GPS data streams from vehicles, requiring efficient collection, processing, and storage. We used Python, leveraging the geopy library for accurate geospatial calculations to determine distances between coordinates.

Determining Toll Zones:

Using geopy, we defined toll zones with predefined geographical boundaries, enabling the system to detect when a vehicle entered or exited a toll zone.

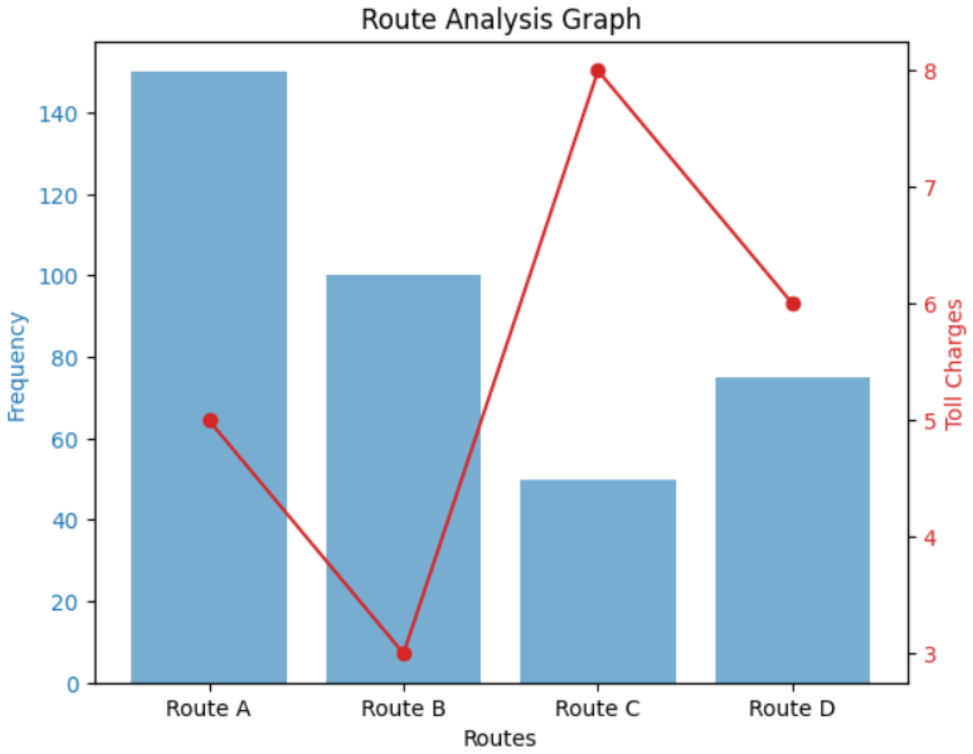


Figure: Route Analysis Graph

The Route Analysis Graph shows:

- Route A is the most used, followed by Route B.

- Route B has lower toll charges, likely contributing to its popularity.

- Routes with higher toll charges, like Route C, generate more revenue per trip.

- Insights can guide pricing adjustments and operational decisions for improved efficiency and user satisfaction.

Computing Travel Distances:

Using geopy, we accurately calculated travel distances between GPS coordinates, ensuring precise measurements even over long journeys. This included handling edge cases like route deviations and continuous vehicle tracking.

Dynamic Toll Fee Calculations:

We developed real-time algorithms to adjust toll charges based on distance traveled within toll zones, considering factors like time of day, vehicle type, and distance. Our approach allowed for flexible and scalable tolling rules and rate updates.

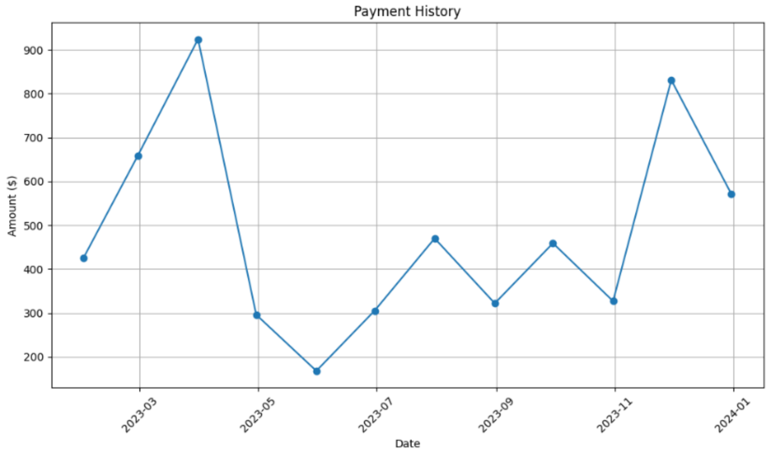


Figure: Payment Analysis Graph

The graph shows monthly payment amounts over the year 2023. It visualizes how payments vary month-to-month, providing insights into spending patterns and trends over time.

Web Application Development:

In parallel with the simulation system, we developed a comprehensive web application for accessing and managing toll data. The user interface was designed to be intuitive and user-friendly, with responsive and visually appealing HTML and CSS templates. This included designing forms for user input, tables for data display, and interactive elements for better user engagement.

Views, Models, and Templates:

- ❖ The application was built using Django, a high-level Python web framework. We designed views to handle different actions, models to manage the database schema and contents, and templates to render the HTML and CSS for the user interface.
- ❖ Views contain the action code, processing user requests, interacting with the database, and returning the appropriate responses.

- Models defined the database schema, managing data storage and retrieval operations. We used Django's Object-Relational Mapping (ORM) to interact with the database, ensuring efficient and secure data handling.
- Templates were used to render the final HTML pages, combining static HTML with dynamic content generated by the views.

4.3. Skills And Tools Used

Programming Languages and Frameworks

Python:

Python was chosen for both the simulation system and the web application due to its rich libraries and frameworks. Its readability and simplicity enabled rapid development and debugging, allowing us to focus on implementing complex functionalities efficiently.

Django:

We used Django, a high-level Python web framework, to build the web application. Its built-in features like URL routing, authentication, and ORM provided a robust, secure, and scalable structure, simplifying development and allowing us to focus on core functionalities.

Geopy:

The geopy library was essential for handling geospatial data, calculating distances between GPS coordinates, and performing spatial queries. It enabled accurate determination of vehicle locations within toll zones and precise travel distance calculations for tolls.

Web Development:

We used HTML and CSS, along with Bootstrap, to create a responsive and user-friendly interface. JavaScript added interactivity with features like form validation, dynamic content updates, and interactive data visualizations.

Database Management

MySQL and Django ORM:

We used MySQL for storing toll data and Django's ORM for simplified CRUD operations and schema management, ensuring data integrity and easy database interactions.

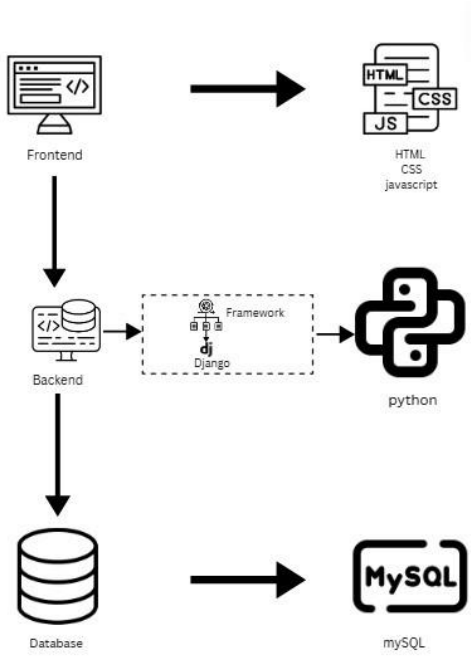


Figure: Tools Used

Version Control

Git:

We used Git for version control to track changes, collaborate effectively, and manage the project's codebase. It allowed us to maintain a history of code changes, revert to previous versions, and work on different features simultaneously through branching.

Learning Outcomes:

Algorithm Design: The algorithm for calculating toll fees had to consider the entry and exit points of toll zones, the total distance traveled within these zones, and the applicable toll rates. This required designing a flexible and efficient algorithm that could handle various scenarios and conditions.

Web Application Development

User Interface Design: We created an intuitive, user-friendly web application using HTML and CSS for responsive design, ensuring consistency across devices. JavaScript added interactivity with features like form validation, dynamic updates, and data visualizations. Secure User Login Functionality.

Security was a top priority for the web application:

Security was a top priority, with a secure login system using Django's authentication framework for password hashing, session management, and threat protection. Authorization ensured only authorized users could access specific actions and views via Django's roles and permissions.

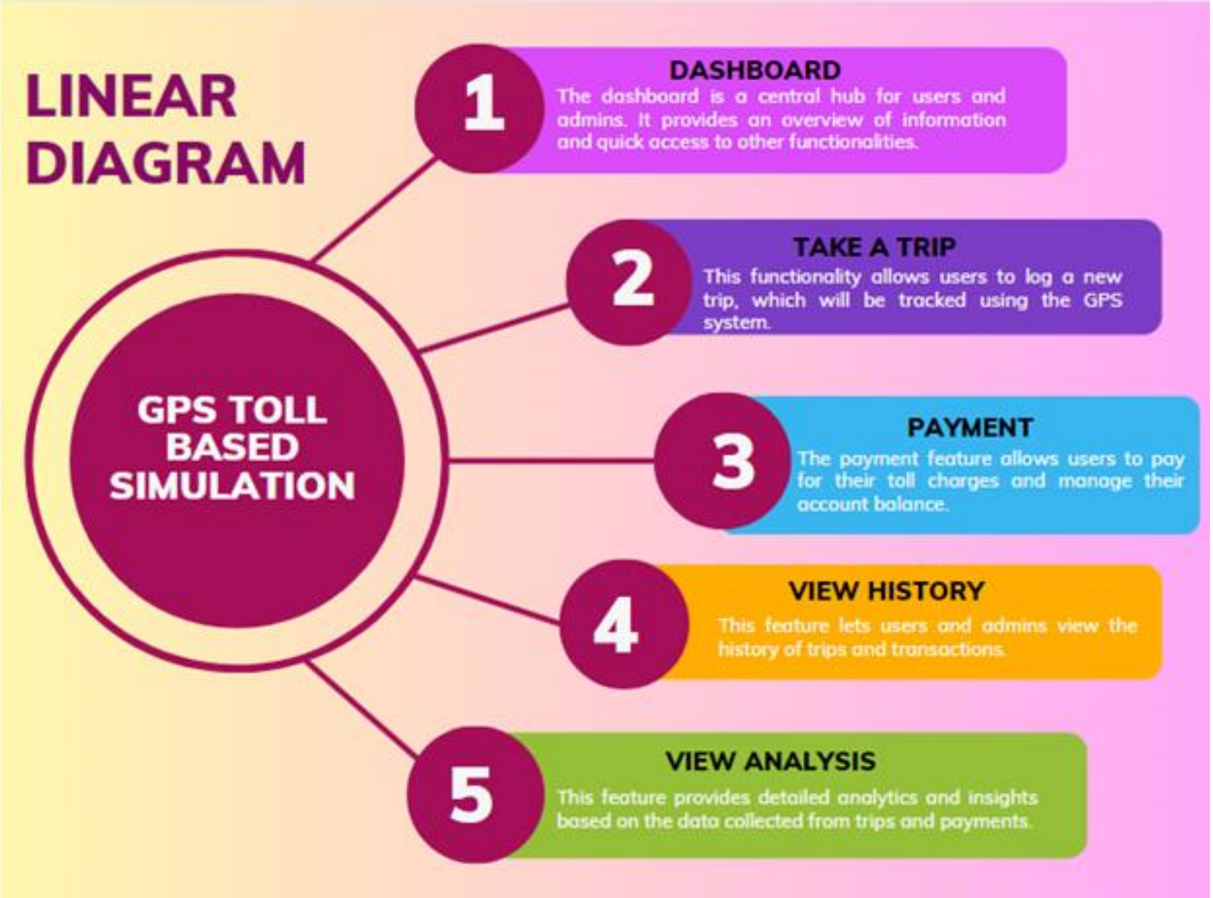
Views, Models, and Templates

The MVC (Model-View-Controller) architecture of Django was used to structure the web application:

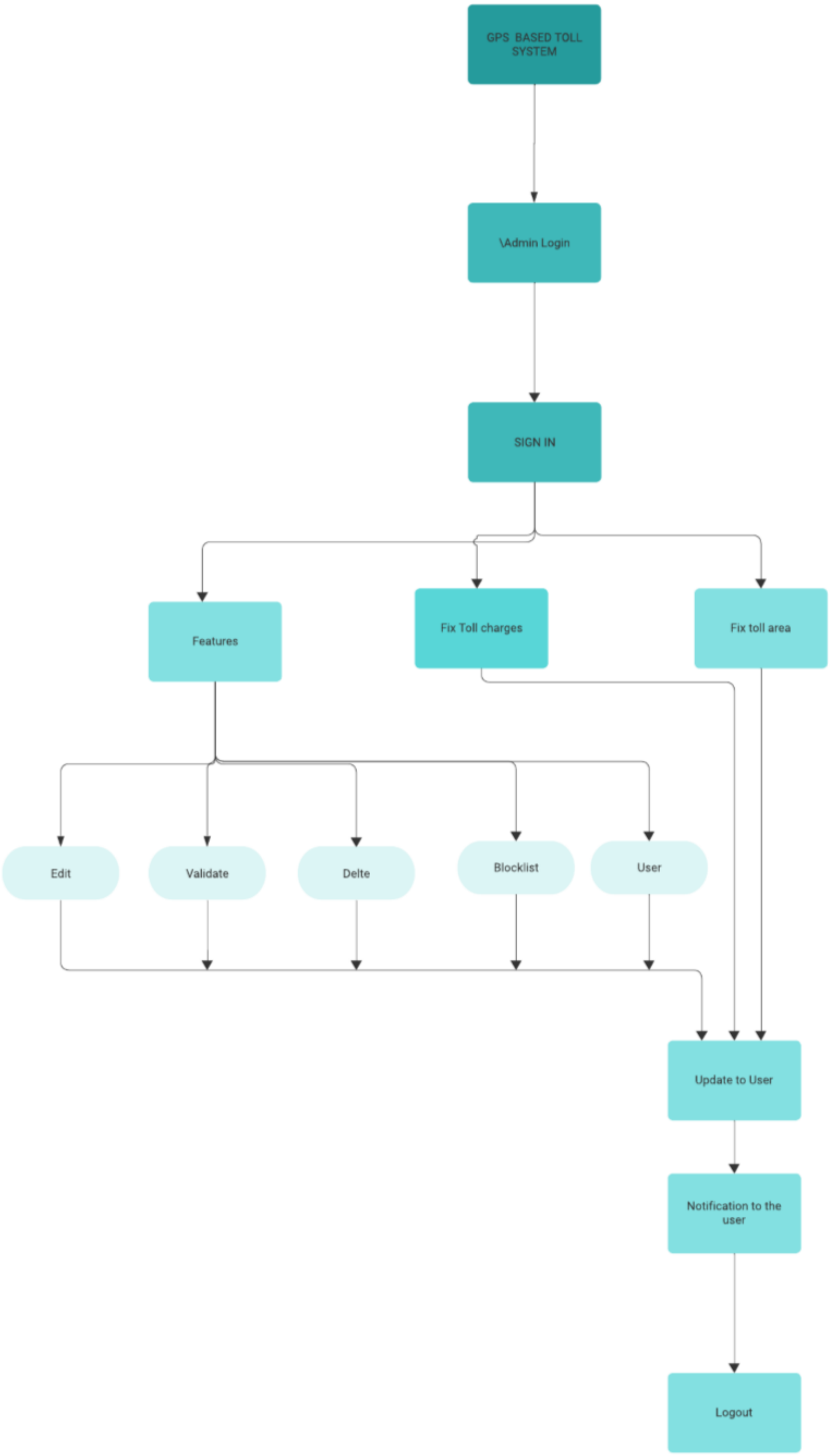
Views: Views handled user requests, performed necessary actions, and returned responses. This includes querying the database, processing user input, and rendering templates.

Models: Models defined the database schema and managed data storage and retrieval.

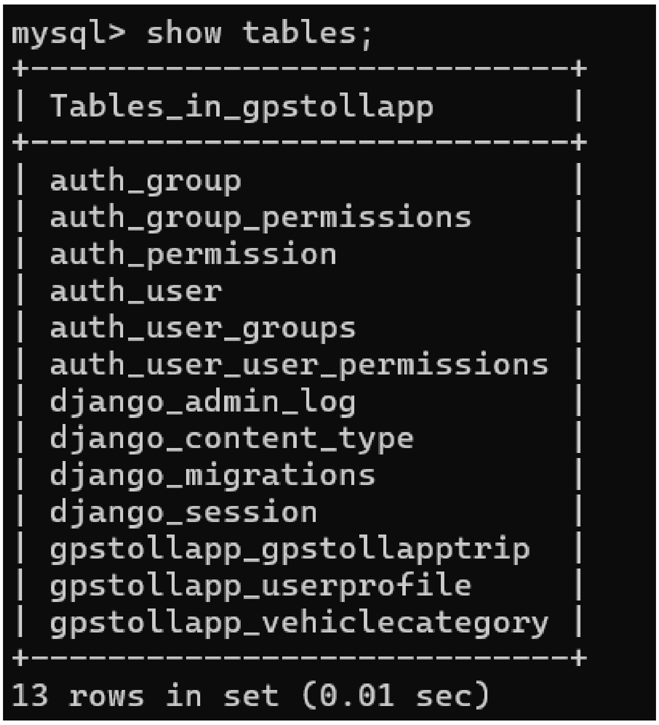
Templates: Templates were used to render the final HTML pages. We combined static HTML with dynamic content generated by the views to create responsive and interactive web pages.


LINEAR DIAGRAM
GPS TOLL BASED SIMULATION
1
DASHBOARD
The dashboard is a central hub for users and admins. It provides an overview of information and quick access to other functionalities.
2
TAKE A TRIP
This functionality allows users to log a new trip, which will be tracked using the GPS system.
3
PAYMENT
The payment feature allows users to pay for their toll charges and manage their account balance.
4
VIEW HISTORY
This feature lets users and admins view the history of trips and transactions.
5
VIEW ANALYSIS
This feature provides detailed analytics and insights based on the data collected from trips and payments.

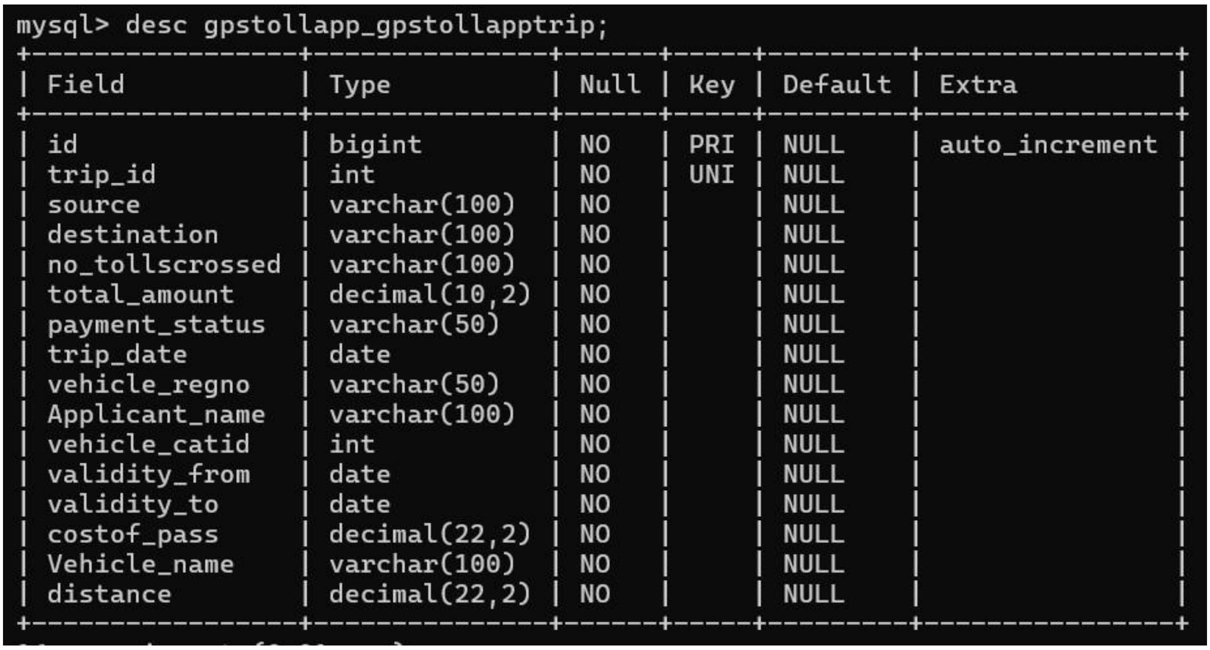
FLOW CHART


GPS BASED TOLL SYSTEM
\Admin Login
SIGN IN
Features
Fix Toll charges
Fix toll area
Edit
Validate
Delte
Blocklist
User
Update to User
Notification to the user
Logout

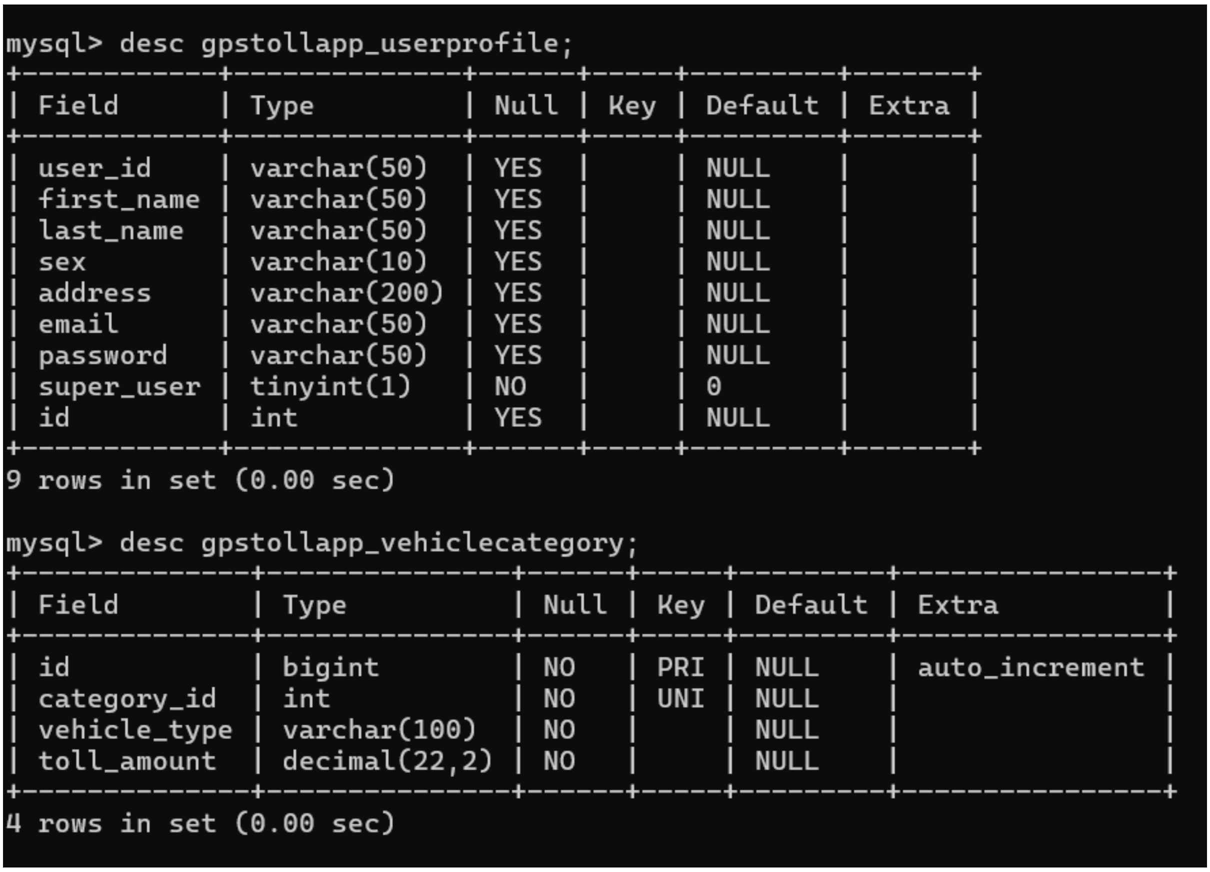
DATABASE



```
mysql> show tables;
+----------------------------+
| Tables_in_gpstollapp       |
+----------------------------+
| auth_group                 |
| auth_group_permissions     |
| auth_permission            |
| auth_user                  |
| auth_user_groups           |
| auth_user_user_permissions |
| django_admin_log           |
| django_content_type        |
| django_migrations          |
| django_session             |
| gpstollapp_gpstollapptrip  |
| gpstollapp_userprofile     |
| gpstollapp_vehiclecategory |
+----------------------------+
13 rows in set (0.01 sec)
```



```
mysql> desc gpstollapp_gpstollapptrip;
+-----------------+---------------+------+-----+---------+----------------+
| Field           | Type          | Null | Key | Default | Extra          |
+-----------------+---------------+------+-----+---------+----------------+
| id              | bigint        | NO   | PRI | NULL    | auto_increment |
| trip_id         | int           | NO   | UNI | NULL    |                |
| source          | varchar(100)  | NO   |     | NULL    |                |
| destination     | varchar(100)  | NO   |     | NULL    |                |
| no_tollscrossed | varchar(100)  | NO   |     | NULL    |                |
| total_amount    | decimal(10,2) | NO   |     | NULL    |                |
| payment_status  | varchar(50)   | NO   |     | NULL    |                |
| trip_date       | date          | NO   |     | NULL    |                |
| vehicle_regno   | varchar(50)   | NO   |     | NULL    |                |
| Applicant_name  | varchar(100)  | NO   |     | NULL    |                |
| vehicle_catid   | int           | NO   |     | NULL    |                |
| validity_from   | date          | NO   |     | NULL    |                |
| validity_to     | date          | NO   |     | NULL    |                |
| costof_pass     | decimal(22,2) | NO   |     | NULL    |                |
| Vehicle_name    | varchar(100)  | NO   |     | NULL    |                |
| distance        | decimal(22,2) | NO   |     | NULL    |                |
+-----------------+---------------+------+-----+---------+----------------+
```



```
mysql> desc gpstollapp_userprofile;
+------------+--------------+------+-----+---------+-------+
| Field      | Type         | Null | Key | Default | Extra |
+------------+--------------+------+-----+---------+-------+
| user_id    | varchar(50)  | YES  |     | NULL    |       |
| first_name | varchar(50)  | YES  |     | NULL    |       |
| last_name  | varchar(50)  | YES  |     | NULL    |       |
| sex        | varchar(10)  | YES  |     | NULL    |       |
| address    | varchar(200) | YES  |     | NULL    |       |
| email      | varchar(50)  | YES  |     | NULL    |       |
| password   | varchar(50)  | YES  |     | NULL    |       |
| super_user | tinyint(1)   | NO   |     | 0       |       |
| id         | int          | YES  |     | NULL    |       |
+------------+--------------+------+-----+---------+-------+
9 rows in set (0.00 sec)

mysql> desc gpstollapp_vehiclecategory;
+--------------+---------------+------+-----+---------+----------------+
| Field        | Type          | Null | Key | Default | Extra          |
+--------------+---------------+------+-----+---------+----------------+
| id           | bigint        | NO   | PRI | NULL    | auto_increment |
| category_id  | int           | NO   | UNI | NULL    |                |
| vehicle_type | varchar(100)  | NO   |     | NULL    |                |
| toll_amount  | decimal(22,2) | NO   |     | NULL    |                |
+--------------+---------------+------+-----+---------+----------------+
4 rows in set (0.00 sec)
```

The GPS toll-based simulation system employs MySQL to manage and store data efficiently, ensuring a robust framework for handling various aspects of toll collection. Central to this system is the User Management module, which includes the Users table for storing user credentials and personal details, and the User Sessions table to monitor login activities, thereby maintaining secure authentication and authorization processes.

The Vehicle Management module tracks vehicles through the Vehicles table, recording essential details like vehicle number and type, and linking them to their owners. The Vehicle Trips table logs each trip's specifics, such as start and end GPS coordinates, and the distance traveled, ensuring precise tracking and data integrity.

For toll calculations, the Toll Zones table delineates geographical boundaries and assigns toll rates per kilometer, allowing the system to detect when a vehicle enters or exits a zone. The Toll Transactions table captures every toll transaction, detailing the trip, toll amount, transaction time, and payment status, which is crucial for financial tracking. To support reporting and analytics, the Trip Summaries table aggregates trip data, providing insights into total trips, distances, and toll amounts for each vehicle over specified periods. The Payment

Analysis table further analyzes monthly payment patterns, helping to identify trends and optimize toll collection strategies.

This structured database design not only facilitates efficient data management and retrieval but also enhances the system's scalability and reliability. By integrating these components, the GPS toll-based simulation system offers a seamless, secure, and user-friendly experience for managing toll data and visualizing travel patterns, underscoring its potential for real-world applications.

5.CHALLENGES AND SOLUTIONS

5.1. CHALLENGES FACED

Database Connections

To address the challenges with establishing stable MySQL database connections, we implemented several strategies.

Solutions:

We implemented robust error handling with try-except blocks and automatic retry logic for managing connection drops. Connection pooling optimized high-traffic management by reusing database connections, while fine-tuned MySQL settings enhanced performance and reliability through adjusted timeout limits and buffer sizes.

Results:

Enhanced stability and reliability of database connections, reducing the risk of data loss or corruption.

Data Accuracy

Ensuring data accuracy in GPS collection and processing was addressed through a combination of hardware and software solutions:

Solutions:

We used high-precision GPS modules for accurate location readings, filtering out noise and reducing environmental errors. Data validation techniques helped filter erroneous readings, correcting outliers for precise toll calculations. Synchronization mechanisms ensured consistent data collection intervals aligned with system processing cycles.

Results:

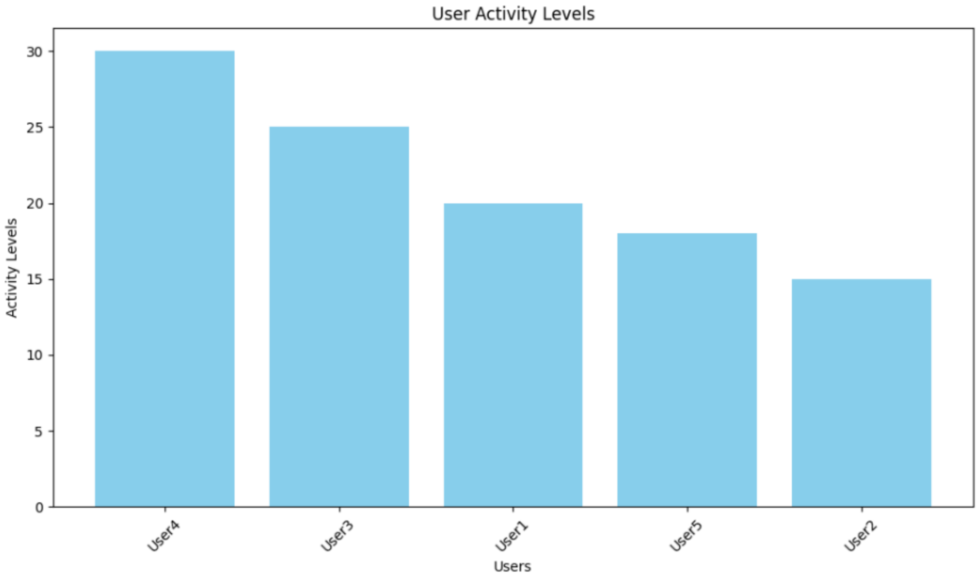
- Improved accuracy of GPS data, leading to more reliable toll calculations.
- Enhanced system integrity by ensuring consistent and validated data inputs.

Algorithm Complexity

We addressed the complexity of the toll calculation algorithm by breaking it into manageable modules, each handling specific tasks like toll zone detection and distance computation. We used efficient data structures, such as spatial indexing, for quick lookups and optimized performance through profiling, reducing computational complexity, and implementing parallel processing.

Results:

- Improved performance and accuracy of toll calculations, ensuring timely processing of real-time data.
- A flexible and scalable algorithm capable of adapting to different tolling rules and conditions.



The graph shows the activity levels of different users in a GPS toll-based simulation. Each bar represents a user, and the height of the bar indicates their level of activity within the system. It helps in comparing user engagement and identifying patterns of usage among different users.

Integration Issues

Solutions:

We conducted comprehensive testing of all components, including unit, integration, and system testing, to identify and resolve issues. Adopting an iterative approach, we refined the integration process through regular feedback and incremental updates. We also used SimPy for efficient simulation modeling, managing processes and ensuring synchronization between components.

Results:

- Seamless synchronization between the simulation system and the web application, ensuring consistent data flow and operation.

- A robust and reliable integrated system that provided a smooth user experience.

5.2. Solutions Implemented

Database Connections:

- **Robust Error Handling**: Implemented try-except blocks and automatic retry logic to manage connection drops.
- **Connection Pooling**: Optimized high-traffic management by reusing database connections.
- **MySQL Settings Fine-tuning**: Enhanced performance and reliability through adjusted timeout limits and buffer sizes.

Data Accuracy:

- **High-Precision GPS Modules**: Used for accurate location readings, reducing noise and environmental errors.
- **Data Validation Techniques**: Filtered erroneous readings and corrected outliers for precise toll calculations.
- **Synchronization Mechanisms**: Ensured consistent data collection intervals aligned with system processing cycles.

Algorithm Complexity:

- **Modular Approach**: Broke down the toll calculation algorithm into manageable modules, each handling specific tasks like toll zone detection and distance computation.
- **Efficient Data Structures**: Utilized spatial indexing for quick lookups.
- **Performance Profiling**: Reduced computational complexity and implemented parallel processing.

Integration Issues:

- **Comprehensive Testing**: Conducted unit, integration, and system testing to identify and resolve issues.
- **Iterative Approach**: Refined the integration process through regular feedback and incremental updates.
- **Simulation Modeling with SimPy**: Managed processes and ensured synchronization between components.

Security:

- **Secure User Login System**: Used Django's authentication framework for password hashing, session management, and threat protection.

- **Authorization**: Ensured only authorized users could access specific actions and views via Django's roles and permissions.

Web Application Development:

- **Intuitive User Interface**: Created using HTML and CSS for responsive design, ensuring consistency across devices.
- **Interactive Features**: Added using JavaScript for form validation, dynamic updates, and data visualizations.
- **MVC Architecture**: Structured the web application using Django's Views, Models, and Templates.

6.RECOMMENDATIONS

6.1 For The Organization

The organization should, therefore, accord prime importance to the constant evaluation of the GPS-based toll system in light of identifying areas of improvement and expansion. This may involve hardware maintenance at frequent intervals, updating software parts, and surveys by users for feedback. The company should also consider implementing the latest technology such as artificial intelligence and machine learning for the better performance and accuracy of this system.

For the protection of the data, the organization has to make a comprehensive plan that should ensure data security and privacy. It can include access controls, data backup systems, and encryption mechanisms. On the other hand, the support and maintenance department should be constituted separately by the company so as to minimize the wastage of time by ensuring the problems are sorted out as soon as possible.

The organization, therefore, needs to think of implementing a feedback mechanism that enables customers to air their views on the e-toll system for the purpose of improving it. This will assist in making informed decisions and pointing out developmental voids. The firm can maintain the lead in the transport industry by taking the continuous development and improvement of the GPS-based e-toll collection system as a priority.

6.2 For Future Interns

Any future intern coming to work on this GPS-based toll system should first develop an understanding of the goals and objectives that are set by the organization itself before the actual internship begins. This will make it easier for one to understand the background and purpose of the project, hence allowing one to contribute more effectively.

This position calls for one to really understand the GPS technology and how it is applied in toll systems. One can get this information by doing some research, attending some seminars on this topic, and consulting with colleagues who are knowledgeable. Be prepared to work individually and in a group. This will enable you to acquire the fundamental communication, problem-solving, and time management skills.

Through the internship, keep a record of all your achievements and progress. This log will help you in an internship by setting a benchmark, but also in a business organization by showing your worth. You can identify areas for improvement and career development by seeking advice and feedback from colleagues and managers. You should do this and not be afraid to.

Keep an open mentality toward new opportunities and challenges brought about through the internship. This relates to working on new projects, attending business meetings, and attending workshops related to professional development. Seize these opportunities by making good use of the learning experience in setting yourself up for professional success.

7. CONCLUSION

Our Python-based GPS toll-based simulation system effectively replicates toll collecting utilizing real-time GPS data from moving cars. Using matplotlib for data visualization and geopy for accurate geospatial calculations, we developed a reliable system that reads GPS coordinates, computes distances, identifies toll zones, and computes toll charges dynamically. Our all-inclusive website improves the system even more by giving users an easy-to-use interface to conveniently access and manage their toll data. The system runs smoothly and securely thanks to secure user login features and a well-organized backend. The project has been a useful learning experience despite obstacles including setting up database connections, guaranteeing accurate GPS data gathering, creating an effective toll calculation method, and integrating different software components.

We now possess advanced abilities in database management, web development, data visualization, geographic computation, and problem-solving. All things considered, this integrated solution provides a strong and intuitive tool for controlling toll charges based on GPS data, enabling users to efficiently manage their toll information, track their toll expenses in real-time, and visualize their travel patterns.

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