SMART TOLL COLLECTION SYSTEM USING GPS AND GEOFENCING

Project Reference No.: *47S_BE_0197*

College ***:*** *Canara Engineering College, Bantwal*
Branch ***:*** *Department of Computer Science and Engineering*
Guide(s) ***:*** *Mr. Ajay S Shet*
Student(S) ***:*** *Mr. K Tejas Prabhu*
Mr. Anirudh Rao
Mr. Darshan N Shetty
Mr. Karthik Devadiga

Keywords:

GPS-based toll collection, On-Board Unit (OBU), Real-time vehicle tracking, Highway travel optimization, Geofencing, Automated toll payment.

Introduction:

The necessity for vehicles to stop or slow down for toll fee payment results in traffic congestion and reduces fuel efficiency. Traditional toll collection methods often involve manual processes or physical barriers, which can create bottlenecks and delays. To address these issues, a GPS-based toll collection system was developed, leveraging modern technologies to enable seamless toll payments. This system utilizes On-Board Units (OBUs) installed in vehicles and a centralized server to track vehicle movements and automatically calculate tolls based on the distance traveled. By integrating GPS technology and geofencing, this solution aims to improve traffic flow, reduce congestion, and enhance the overall travel experience for commuters. The system's design ensures that toll payments are deducted electronically without requiring vehicles to stop or slow down, thereby optimizing highway travel efficiency.

Objectives:

The primary objective of this project is to develop a smart toll collection system that automates the toll payment process using GPS and geofencing technology. Specific objectives include:

1. Implementing On-Board Units (OBUs) in vehicles to track real-time location data.
2. Developing a centralized server to manage toll gate data and transaction records.
3. Creating a seamless communication between OBUs and the server for real-time updates.
4. Ensuring secure and convenient transactions through user authentication and e-wallet management.

5. Enhancing overall travel experience by reducing congestion and improving traffic flow.

Methodology:

The Smart Toll Collection System employs a combination of hardware and software components to achieve its objectives. The On-Board Unit (OBU) is equipped with a Raspberry Pi Pico W and a NEO-6M GPS module. The GPS module continuously provides real-time location data, which the Raspberry Pi Pico processes using Python code. The OBU communicates with a central server to fetch data on nearby toll gates and determine the vehicle's entry and exit points on toll roads.

When a vehicle equipped with the OBU starts, it sends a signal to the server to retrieve the locations of nearby toll gates. As the vehicle travels, the OBU periodically updates its position and compares it with the stored toll gate coordinates. Upon entering a highway, the system records the entry point and dynamically updates the next intended checkpoints based on the vehicle's route. This information is stored in a JWT token to ensure secure processing and seamless handover of data between entry and exit points.

The server uses this data to calculate the toll amount based on the distance traveled and deducts it from the user's account. The system also includes user authentication features, OTP verification, and e-wallet management to ensure secure and efficient transactions. The modular architecture of the system allows for easy scalability and future expansion.

User Interface Flow Design

This flowchart depicts the navigation flow of a user within a mobile application. Users begin by accessing the login page to sign in to an existing one the registration page to create a new account or the login page to sign in to an existing one. After successful authentication, users are directed to the home page, where they have access to various functionalities such as viewing their profile, transaction history, and initiating payments. The "Payment UI" box likely represents the interface for processing payments, while "Vehicle Details" indicates a step for users to provide or update information about their vehicles. Users can navigate to their profile, transaction history, or initiate a payment from the home page. Additionally, there's an option to log out from any page, ensuring security and user control over their session. This structured flow guides users through the application's functionalities, facilitating smooth interaction and user experience.

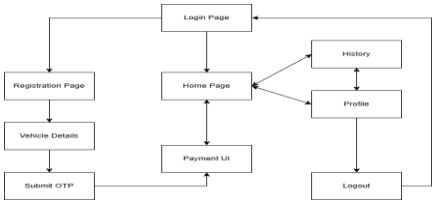


Figure 1: User Interface Flow Design

Results And Discussions:

The GPS-based toll collection system project is a streamlined, efficient, and user-friendly toll collection system that significantly enhances the toll payment process for commuters. By allowing for seamless toll payments without the need for vehicles to stop or slow down at toll booths, the system reduces traffic congestion and improves fuel efficiency. Commuters benefit from the convenience of electronic toll payments and easy access to account information through the user interface. Extensive testing, including unit testing, integration testing, manual testing, user acceptance testing, and performance testing, ensures that the system performs reliably under various conditions and meets user expectations.
One of the key advantages of the Smart Toll Collection System is its focus on enhancing user experience and convenience. By automating toll payments and eliminating the need for vehicles to stop or slow down at toll booths. Additionally, the implementation of user-friendly interfaces, such as mobile applications and electronic wallet systems, enhances the

accessibility and convenience of toll transactions for commuters. Users can easily register, manage their accounts, track toll usage, and make payments through intuitive digital platforms, thereby streamlining the entire toll collection process.

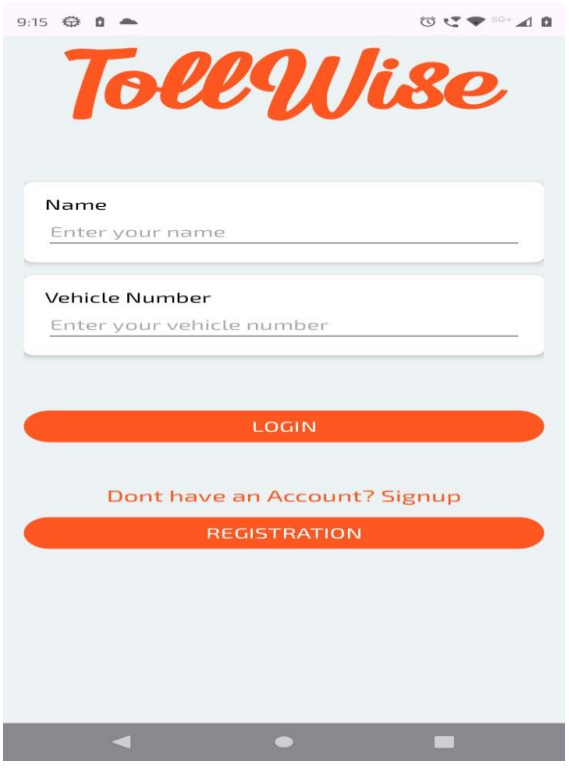
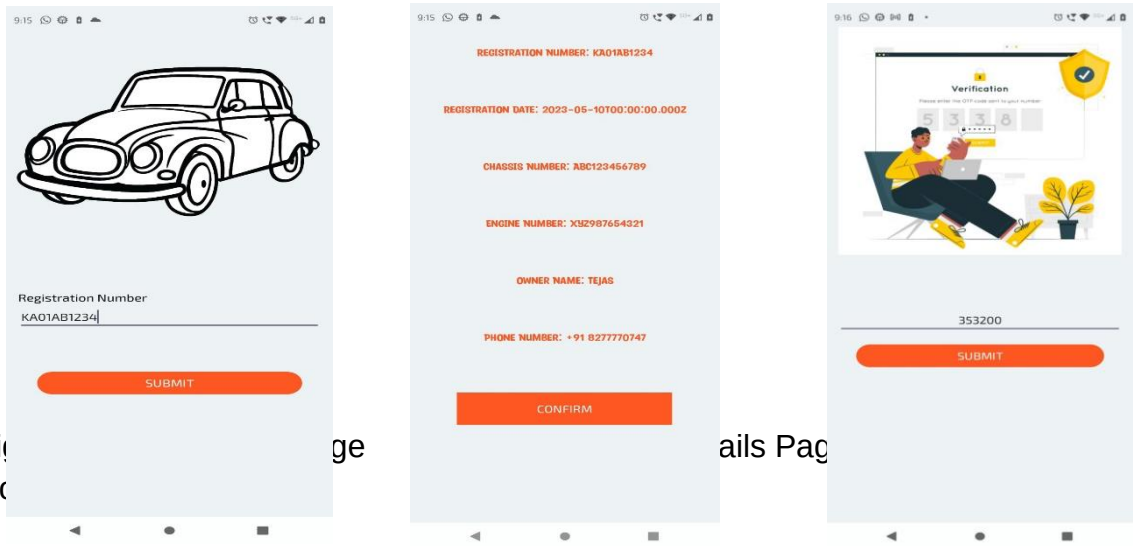


Figure 2: Login Page

Users begin by accessing the login page to sign in to an existing account using their credentials or to create a new account if the user is not already registered.



Fi ge ails Pag
C

The user can register to create a new account by entering their vehicle number then the details related to the registered vehicle will be displayed for confirmation. Once the user confirms the vehicle details to be correct the OTP is sent to the registered phone number, then user can enter the OTP. Once the user is authenticated can proceed to the app.

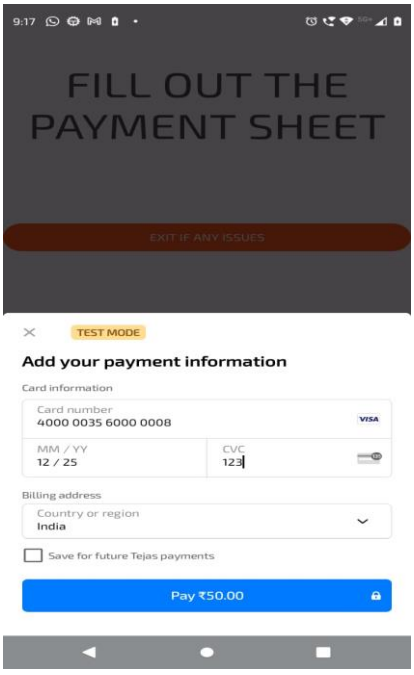


Figure 6: Initial Payment

Once the user is authenticated a payment intent is opened for adding a minimum amount to the e-wallet. User can use their debit cards for payments.

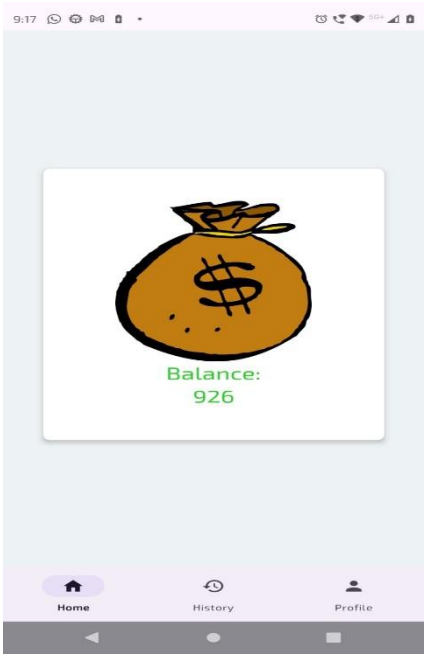


Figure 7: Balance Page

Figure 8: Transaction History

Figure 9: Profile Page

After successful authentication, users are directed to the home page, where they have access to various functionalities such as Users can navigate to their profile, transaction

history, or initiate a payment for adding funds to their e-wallet. Additionally, there's an option to log out from any page, ensuring security and user control over their session.

Conclusions and Scope for Future Work:

In conclusion, the Smart Toll Collection System using GPS and Geofencing represents a significant step forward in modernizing toll collection processes and enhancing transportation efficiency. By leveraging GPS technology and geofencing techniques, this system aims to streamline toll transactions, reduce traffic congestion, optimize fuel usage, and improve the overall user experience for commuters.

Through the implementation of user-friendly interfaces, such as mobile application, users can seamlessly register, manage their accounts, track their toll usage, and make payments. The integration of an electronic wallet system adds convenience and efficiency to toll transactions, while security measures ensure the confidentiality and integrity of user data.

Furthermore, the system's scalability and compatibility with various hardware and software components lay a strong foundation for future expansion and interoperability with existing infrastructure. Performance requirements are considered to ensure smooth operation under varying traffic volumes and database loads.

Overall, the Smart Toll Collection System not only addresses the immediate challenges associated with traditional toll booths but also sets the stage for the development of smarter, more sustainable transportation systems. By embracing technology and innovation, this project contributes to the evolution of transportation infrastructure towards a more efficient, user-centric, and environmentally friendly future.

References:

[1] Jin Yeong Tan, Pin Jern Ker, Dineis Mani & Puvanesan Arumugam | (2017) GPS-based highway toll collection system: Novel design and operation, Cogent Engineering, 4:1, 1326199, DOI: 10.1080/23311916.2017.1326199

[2] Geofencing on the Real-Time GPS Tracking System and Improving GPS Accuracy with Moving Average, Kalman Filter and Logistic Regression Analysis - Zeynep ÖZDEMİR Ankara University Computer Engineering Ankara, Turkey.

[3] A Review on GSM and GPS Based Vehicle Tracking System by Dinesh Suresh Bhadane, Pritam B. Bharati, Sanjeev A. Shukla, Monali D. Wani, Kishor K. Ambekar Lecturer, Department of E& TC, Sandip Polytechnic, Nashik.

[4] Development of a GPS-based Highway Toll Collection System Jin Yeong Tan, Pin Jern Ker*, Dineis Mani and Puvanesan Arumugam Centre for Systems and Machines Intelligence, College of Engineering University Tenaga Nasional Kajang, Selangor, Malaysia.

[5] Geofencing to Enable Differentiated Road User Charging Petter Arnesen1, Hanne Seter1, Ørjan Tveit2, and Mats Myhrvold Bjerke3.
[6] National Automatic Toll Collection System – Pilot Project (Part 1) Gabriel Nowacki, Izabella Mitraszewska, Tomasz Kamiński, Anna Niedzicka, Ewa Smoczyńska, Monika Ucińska, Thomas Kallweit and Robert Rozesłaniec.
[7] Vehicle Tracking System Using GPS Sathe Pooja1 1 Disha Institute of Management & Technology, Raipur, Chhattisgarh, India.
[8] The Pilot Project of the National Automatic Toll Collection System for Poland Gabriel Nowacki, Ewa Smoczyńska, Anna Niedzicka, Motor Transport Institute Poland.
[9] Automated Toll Collection System Using GPS and GPRS Sudheer Kumar Nagothu.
[10] A Particle Filter for Vehicle Tracking with Lane Level Accuracy Under GNSS-Denied Environments Xionghu Zhong, Ramtin Rabiee, Yongsheng Yan, and Wee Peng Tay.