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REAL-TIME AUTOMATED TOLL COLLECTION SYSTEM USING SEAMLESS PAYMENT GATEWAY

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Abstract: Automated Toll Collection System has gained significant momentum in recent years due to its ability to streamline and optimize toll payment processing for highways and bridges. This advanced system utilizes Global Positioning System (GPS) technology to accurately track vehicle locations and enable electronic toll collection without manual transactions. The system boasts high accuracy, offering customization to accommodate different vehicle types and toll fees. It is also highly flexible and scalable, making it capable of adjusting to fluctuating traffic volumes and changing toll rates. In this system, a GPS device is installed on the vehicle, which communicates with a centralized server. This server calculates the toll based on the real-time distance travelled by the vehicle using the Haversine formula. The toll is then automatically deducted from a pre-loaded digital wallet or charged to a designated seamless payment gateway linked to the vehicle owner's account. By eliminating the need for cash transactions and toll booth stoppages, this system offers improved convenience for drivers, reduces traffic congestion, and contributes to lower environmental impact compared to traditional toll collection methods. Embracing this technology has the potential to revolutionize toll management and enhance overall transportation efficiency, improving user experience and reducing delays.

Keywords: Raspberry Pi, LCD Display, GPS Technology, Distance Travelled, Payment Gateway Web App.

I. INTRODUCTION

Toll collection has traditionally been done manually at toll booths, causing delays and inefficiencies. With advancements in technology, automated systems using Radio Frequency Identification (RFID), Dedicated Short Range Communication (DSRC), GPS, and Automatic Number Plate Recognition (ANPR) have emerged to improve efficiency and reduce congestion. Recent innovations, such as Near Field Communication (NFC), blockchain, and cloud computing, further enhance security, scalability, and tolling efficiency.

Our project, the Real-Time Automated Toll Collection System Using Seamless Payment Gateway, aims to integrate GPS-based toll collection with a seamless payment gateway. Using a Raspberry Pi, Arduino, GPS modules, LCD installed in the system(Vehicle) will accurately track vehicle locations and enable seamless payments via mobile devices or linked accounts. This solution eliminates toll booths, reduces traffic congestion, and offers a more eco-friendly and cost-effective approach to tolling, improving overall driver experience and operational efficiency.

II. LITERATURE REVIEW

The tax system has evolved dramatically over the years, from a single border and narrow road to a vast system of taxation that plays a vital role in revenue generation and even city or state transportation if much of the population travels in ways even with roads However, traffic control became a requirement and a legal process.

As per S.Nandini and P.Premkumar, tollgate systems around the world make use of Dedicated Short-Range Communication (DSRC). Here, a mobile application is used for sending transaction details. An automated toll gate system is present in this system. Here message is sent to the vehicle owner. In this proposed system make use of GPS. Automated toll collection has always helped in improving traffic flow's efficiency. This has also been proven to be the easiest way to clear traffic.

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Every owner should have his/her bank account registered with the RFID, in the present system. AN amount is automatically deducted from the account. This is not based on the distance the traveller travelled, but is based on preset amounts. And as per the research of Widad Ismail and Khadijah Kamarul Azizi, their work again talks about RFID usage in toll collection.

"Automated Toll Tax Collection System" - Sujata Eresimi, Jayashree R, Priyanka T, Sushanth Sagar S R, Varna K N explained the project uses RFID technology and an Arduino to create an automated toll collection system. It replaces manual toll collection, reducing traffic congestion and wait times. When a vehicle with an RFID tag passes through, the system reads the tag, deducts the toll, and opens the gate, improving efficiency and reducing fuel waste and emissions.

"Automatic Toll Plaza Using RFID" - M. Siva Ganga Prasad, D. Pranitha, V. C. Chakra Rao, V. R. V. S. S. Pavankumar & and G. Sandeep have revolutionized urban traffic management in this RFID-based automatic toll collection system. They replace manual toll collection, reducing time and costs for drivers. RFID readers streamline the process, reducing queues, and providing benefits like shorter wait times and postpaid options for motorists. Toll operators also gain cost savings and better audit control. This technology minimizes the drawbacks of traditional methods, enhancing efficiency and tax collection accuracy with minimal infrastructure changes.

"Automatic Toll Tax Collection Using GSM" - P. Mahalakshmi, Viraj Pradip Puntambekar, Aayushi Jain & Raunak Singhania, this Automatic toll tax collection using GSM (Global System for Mobile Communications) is a modern technology that streamlines the process of collecting tolls on highways and bridges. This system uses mobile communication networks to facilitate toll collection without needing physical toll booths or manual transactions. Each vehicle is equipped with a GSM module or a compatible communication device. This module is connected to the vehicle's account and communicates with the toll collection infrastructure.

III. METHODOLOGY

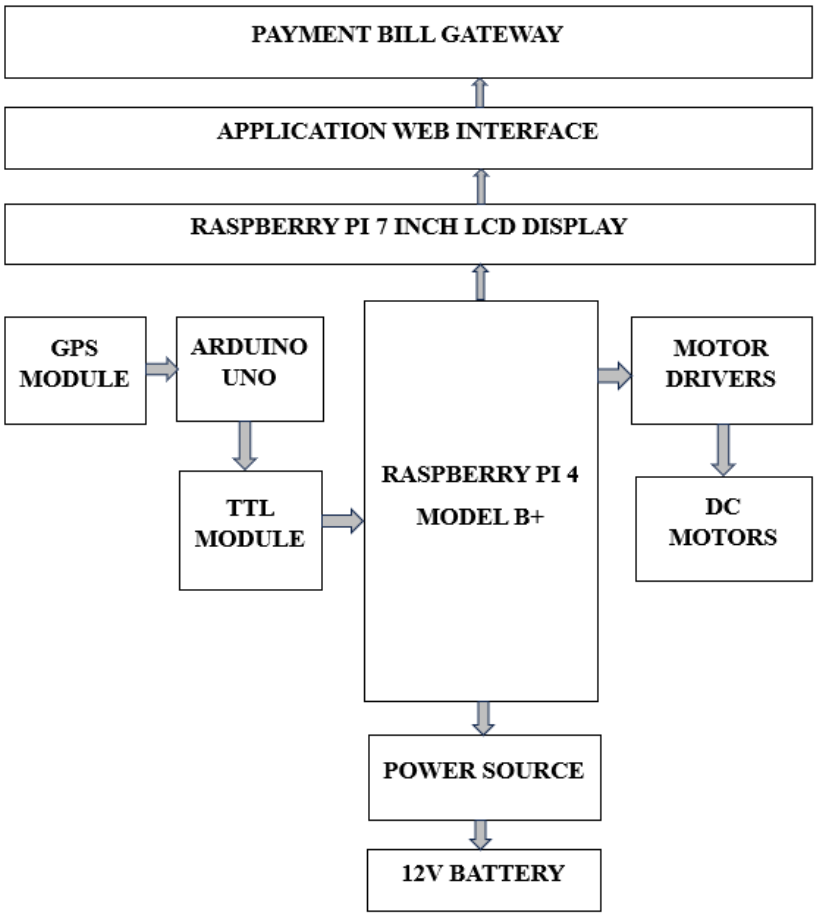

Fig 1: Block diagram of Real-Time Automated Toll Collection System Using seamless Payment Gateway

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The Real-Time Automated Toll Collection System Using Seamless Payment Gateway integrates hardware and software components for efficient toll automation. The system begins with a GPS module that provides the vehicle's location (latitude and longitude) as it approaches the toll plaza. This data is sent to an Arduino UNO, which processes it and controls various system components. The Arduino is connected to a TTL module, enabling communication with the Raspberry Pi 4 Model B+ by converting data signals. The Raspberry Pi acts as the central processing unit, receiving location data, calculating toll fees using Haversine formula in the backend of web app, and managing other system functions. It controls motor drivers for the movement of vehicle when payment is made. The Raspberry Pi is powered by a main power supply and backed up by a battery in case of power loss.

For user interaction, the Raspberry Pi connects to a 7-inch LCD display which shows the web app interface in the on-board unit for toll fee, payment status, vehicle tracking, Balance, Recharge, transaction history, Vehicle emergency issues and other relevant information about vehicle. The system also features a Web Interface, allowing remote monitoring and control by toll operators and administrators. This interface provides real-time data on transactions and vehicle movement. The system includes a Payment Bill Gateway for secure, seamless toll fee payments. Upon confirmation of payment. This combination of hardware and software enhances toll collection efficiency, ensuring real-time processing and seamless payment.

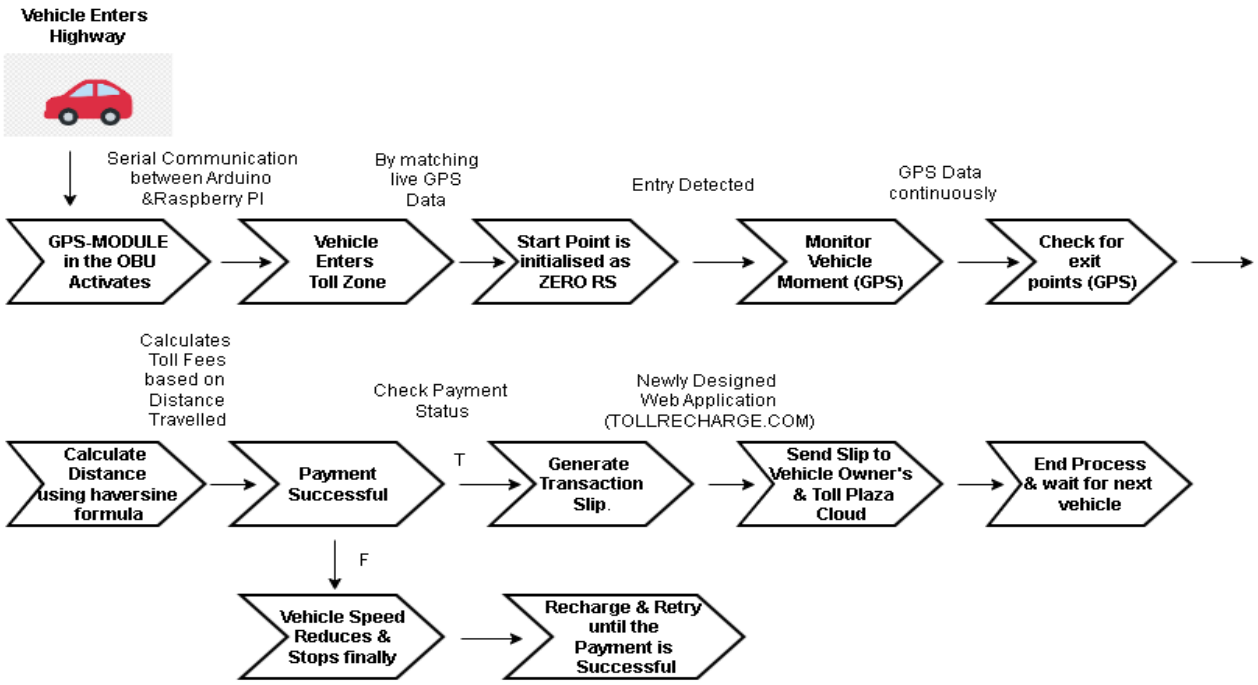

Fig 2: System Flow of Real-Time Automated Toll Collection with Payment Gateway Integration

IV. HARDWARE AND SOFTWARE IMPLEMENTATIONS

HARDWARE IMPLEMENTATION:

Raspberry pi 4 model B+: The Raspberry Pi 4 Model B+ acts as the central processing unit, managing GPS data from vehicles to determine toll charges based on their location. Additionally, the Raspberry Pi handles communication with the backend server to update payment statuses and store transaction records, ensuring an efficient and automated toll collection process.

TFT LDC Display: The TFT LCD Display is used to provide real-time visual feedback to drivers regarding their toll transaction status. The display shows relevant information such as the current toll amount, the vehicle's location, payment status, and any notifications or errors. The Raspberry Pi 4 Model B+ controls the TFT LCD display, updating it dynamically based on data from the GPS system and payment gateway to ensure drivers receive clear and timely information throughout the process.

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GPS Module: The GPS Module is used to track the real-time location of vehicles as they move along designated toll routes. The Raspberry Pi 4 Model B+ interfaces with the GPS module to receive latitude and longitude coordinates, which are used to calculate the appropriate toll charges based on the vehicle's location. The GPS data is then processed to determine when a vehicle enters a toll zone, and the system automatically triggers the toll calculation and payment process via the seamless payment gateway.

Arduino Uno: The Arduino Uno serves as a microcontroller that interfaces with various hardware components, such as the GPS module, sensors, and the TFT LCD display. It controls the TFT LCD Display to show real-time information, such as toll charges or vehicle status, providing drivers with updates during their journey.

We have also used the Car Chassis & Frame which provides the structural base for the system, supporting all components. DC Motors & Drivers enable movement and control within toll zones, while the Power Supply ensures stable operation. Active Cooling Fans prevent overheating of critical components, and the 12V Battery powers the entire system, allowing for autonomous operation. These components work together to ensure efficient and reliable functioning of the automated toll collection system.

SOFTWARE IMPLEMENTATION:

- Front End - HTML, CSS, Java
- Back End - Python
- Framework - Flask
- Database - SQLite

V. RESULTS

Fig 3: Working Model

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Fig 4: User Sign-Up Process for Seamless Toll Payments on TollRecharge.com

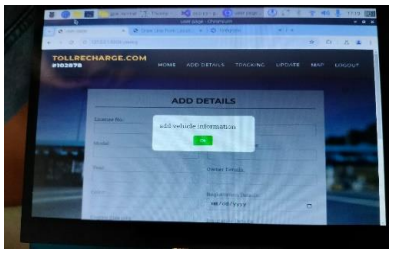

Fig 5: Adding Vehicle Details for Accurate Toll Payment Processing

Fig 6: User Dashboard for Monitoring Balance and Recharging

Fig 7: Toll Exit Notifications with Travel Distance on Dashboard

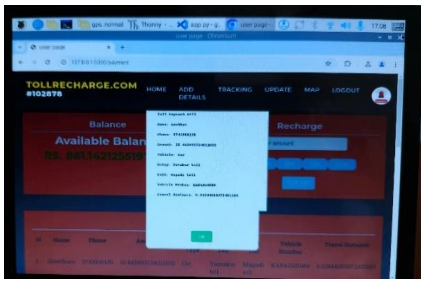

Fig 8: Transaction Receipt with Driver Details

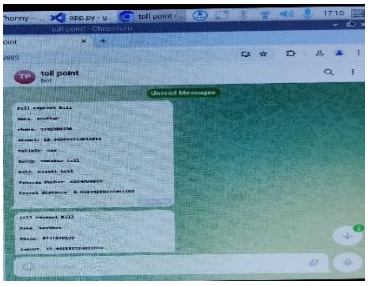

Fig 9: Transaction Receipt for User and History Sent to Toll Management System

The proposed system is implemented to calculate the toll fee automatically based on the distance travelled by the vehicle. The "Real-Time Automated Toll Collection System Using Seamless Payment Gateway" automates toll collection, eliminating manual intervention. When a vehicle enters the highway, the GPS module sends real-time location data to the Arduino, which is transmitted to the Raspberry Pi for continuous monitoring. Upon entering the toll zone, the system checks the vehicle's position to ensure it reaches the entry point. The toll amount is initially set to zero and only calculated after the vehicle exits the zone. The Haversine formula calculates the shortest distance between two points on the surface of a sphere given their latitudes and longitudes. The formula is

$$a = \sin^2\left(\frac{\Delta \text{lat}}{2}\right) + \cos(\text{lat}_1) \cdot \cos(\text{lat}_2) \cdot \sin^2\left(\frac{\Delta \text{lon}}{2}\right)$$

The system then checks the payment status via a seamless gateway. For experimentation purposes, It is set an amount of 5 rupees per kilometre. In other words, for every kilometre travelled, an amount of rupees 5, will be deducted from the traveller’s account, after the traveller has finished travelling. If successful, a receipt is sent to the driver through a Telegram bot. If payment fails, the vehicle's speed is reduced until payment is completed. The system ensures only vehicles with successful payments proceed, preventing toll evasion.

This helps a traveller pay proportionally to the distance of travel and not any random amount set by the government. It is found that the amount spent for toll gates would be decreased by a great amount. Since there is no physical toll gate, congestion at these points is also avoided.

It is very crucial to focus on the amount set for one kilometre. The total amount paid might increase, above the existing amount, if it is set high. The proposed system reduces the time delay and the variation in the toll fee of the existing systems. This process integrates GPS tracking, serial communication, distance calculation, and real-time payment validation, improving toll collection efficiency and reducing congestion.

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VI. CONCLUSION

The proposed idea can permanently eliminate the need to have toll gates and ease the payment process. It ensures transparency, safety, and reliability. The driver can ensure continual travelling without any kind of pause. The driver can add money to his wallet balance and money gets automatically deducted. In future, designers can include some parameters like over-speed detection and prevention. Also, it is possible to track cars in the event of an emergency or accident. The methodology, proposed above, was implemented and is used to find the distance that the vehicle travelled, thereby deducting the amount proportionally. By using a Seamless Payment Gateway presents a significant advancement in tolling infrastructure by leveraging modern technologies such as GPS tracking, cloud computing, and digital payment systems. This system not only simplifies the toll collection process by automating it, but it also reduces the need for physical toll booths, minimizing traffic congestion and travel delays. The seamless payment process, integrated with the payment gateway, ensures that tolls are paid quickly and securely, providing a convenient experience for drivers. Additionally, the system's ability to monitor vehicle entry and exit points in real-time guarantees accurate toll fee calculation, eliminating human error and disputes. By offering a fully automated, efficient, and user-friendly solution, this system enhances operational efficiency for toll operators while providing a hassle-free experience for motorists. Ultimately, this system lays the foundation for a future where toll collection is faster, more secure, and more efficient, contributing to smoother traffic flow and smarter transportation networks.

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