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Iot - Enabled RFID Web Based Toll Gate Automation with XAMPP

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Abstract: *Increasing vehicle traffic has led to congestion and delays at conventional toll plazas. It causes the blocked driving conditions, wastage of time and fuel due to the manual process or semi-automated mechanisms. This paper presents an IoT (Internet of Things) - enabled Radio Frequency Identification (RFID) based web toll gate automation system. Each vehicle is equipped with the RFID tag linked to a centralized database. An IoT-enabled controller reads the tag data and updates transactions to a web server in real time. The proposed system enables automatic toll amount deductions, secure authentication, and online monitoring of the passing vehicles through a web interface. This proposed solution uses a web portal to store the transactions, viewing user's balances, manage accounts through a web interface using XAMPP. The proposed solution eliminates the delay in toll roads, tunnels, and bridges without requiring the vehicles to stop for the payment. It also reduces traffic congestion, minimizes manual errors, and provides a low-cost and efficient toll management framework suitable for smart transportation systems.*

Key Words: *IoT, RFID, XAMPP, IoT-enabled web controller, RFID Tag*

I. INTRODUCTION

Manual toll collection and delayed processing have led to traffic congestion and long queues at toll plazas which are found in National Highways (NHAI), bridges, tunnels, etc. posing a significant concern in India. This leads to excessive wait times and wasted fuel during toll collection. Since this procedure is slow, made more traffic jams at the toll plazas on busy time. Now a day, this is replaced by Fastag technology. FASTag is the latest technology in toll plaza used by the government of India and operated by the NHAI. As the name suggests, this technology uses a system of smart tags to automate toll booths and plazas. The FASTag system uses radio waves to identify vehicles & automatically deduct toll charges. This provides many benefits over the traditional toll systems, such as creates minimum disruption to the flow of traffic and lower the fuel consumption. Even though, Fastags are better in today, but they are working with only UHF RFID Labels that are used on vehicle windshields.

The proposed system does an IoT enabled RFID web based toll gate automation with various kinds of RFID namely LF(Low Frequency) RFID labels, HF (High Frequency) RFID labels, and UHF (Ultra High Frequency)RFID labels as well as battery-powered active RFID tags[1]. RFID is a form of wireless communication that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency portion of the electromagnetic spectrum to uniquely identify an object, animal or person. Every RFID system consists of three components: a scanning antenna, a transceiver and a transponder. When the scanning antenna and transceiver are combined, they are referred to as an RFID reader or interrogator.

The RFID reader is a network-connected device that can be portable or permanently attached. It uses radio waves to transmit signals that activate the tag. Once activated, the tag sends a wave back to the antenna, where it is translated into data. The transponder is in the RFID tag itself. The read range for RFID tags varies based on factors including the type of tag, type of reader, RFID frequency and interference in the surrounding environment or from other RFID tags and readers. Tags that have a stronger power source also have a longer read range [2].

RFID FREQUENCIES AND RANGES		
FREQUENCY	**BAND**	**RANGE**
LF RFID	30-500 KHz, typically 125 KHz	Less than 3 feet
HF RFID	3-30 MHz, typically 13.56 MHz	Less than 6 feet
UHF RFID	300-960 MHz, typically 433 MHz	25+ feet
Microwave	2.45 GHZ	30+ feet

Table No 1: RFID Frequencies and their Ranges

RFID IoT solutions are cutting-edge technology solutions that combine two critical components: RFID and IoT where IoT (Internet of Things) brings together a myriad of smart devices and software, enabling communication, monitoring, and real-time control. The combination of these technologies allows for improved supply chain visibility, asset tracking, and product tracing. Through the use of RFID IoT solutions, businesses can reduce errors, save time and cut costs, ultimately leading to increased productivity and revenue. One of the greatest benefits is the ability to track and monitor inventory in real-time.

II.IOT AND RFID

A. Internet of Things

Internet of Things (IoT) is a system of interconnected objects, usually called smart devices, through the Internet. The object can be a heart monitor, a remote, or an automobile with built-in sensors.

There are 4 key components to integrate into the complete IoT:

- **Devices or sensors:** It maybe RFID, temperature Sensor.
- **Connectivity:** The sensors or devices connected to the cloud. It can be connected to the internet via cellular, WIFI, Bluetooth.
- **Data processing:** It processes the sensor's data in the cloud using certain software program.
- **User interface:** This will be the end user. It will work like an alert about the status or the situation of the devices or give the notification through texts or emails. So, in this way, IoT will work.

Communication Devices in IoT:

- Sensors
- RFID Tags
- Actuators

B. RFID Concepts

It is a method that is used to track or identify an object by radio transmission over the web. Data is digitally encoded in an RFID tag which might be read by the reader. This device works as a tag or label during which data is read from tags that are stored in the database through the reader as compared to traditional barcodes and QR codes. It is often read outside the road of sight either passive or active RFID[2,3].

There are two main types of RFID tags:

a. Active RFID. An active RFID tag has its own power source, often a battery.

b. Passive RFID. A passive RFID tag receives its power from the reading antenna, whose electromagnetic wave induces a current in the RFID tag's antenna.

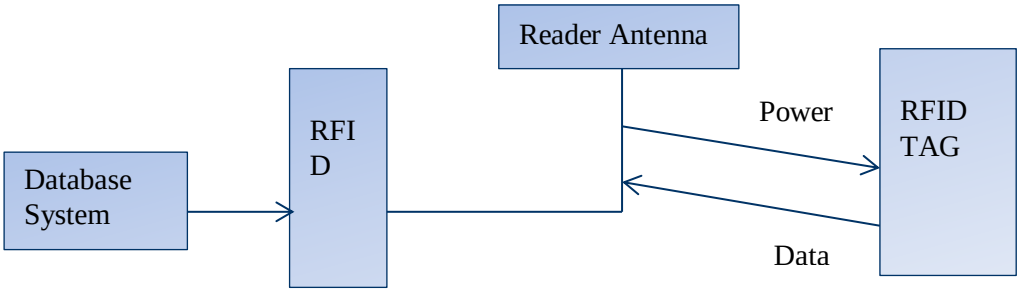


Fig. No 1. Working of RFID

The RFID system are composed of three main components namely RDIF Tag, Reader and application system.

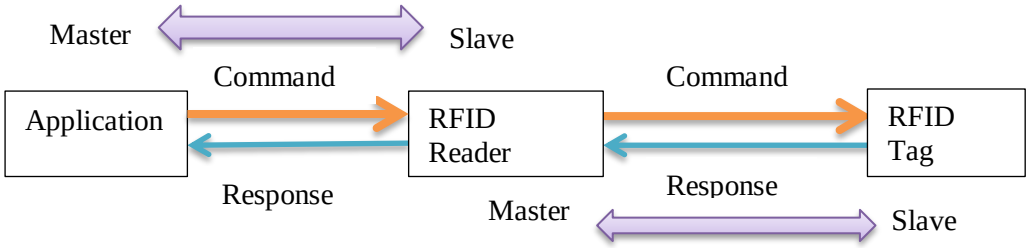


Fig. No 2. Components of a RFID System

III.RELATED WORK

The primary research conducted by Sushma Chowdary Polavarapu et al. (2018) develops an automated toll collection system using RFID technology with an Arduino MEGA2560 microcontroller that scans vehicle RFID tags, controls gate barriers via motor drivers, and communicates with GSM modules for real-time updates.

K. Shobana et al. (2010) done a research demonstrated strong consensus on system functionality and benefits that the system performs automatic vehicle identification and toll collection, allowing vehicles to pass scan points without stopping but it requires offline data uploads.

The system proposed by Shankar Dayal Pathak et al., 2021 addresses inefficiencies in manual toll collection by automating the entire process. When vehicles arrive at toll booths, RFID cards are scanned and verified against an online server that maintains user account balances. Upon validation and sufficient funds, toll amounts are automatically deducted and a motor opens the gate. The system uses a microcontroller with WiFi connectivity for real-time server communication and stores vehicle passage data for surveillance[4].

Also, 95.5% transaction success rates under heavy traffic Ramkumar G et al., 2024. The evidence consistently shows IoT-RFID integration reduces congestion and human intervention across implementations.

Kumar and Singh (2023) developed a GPS- based vehicle tracking and payment system; however, reliance on internet connectivity limited use in remote areas.

A hybrid model proposed by Priya et al. (2023) combined RFID with camera-based license plate recognition for security, though it increased hardware costs.

IV.PROPOSED SYSTEM

A. System Design

(i) Components Required

- RFID Reader – Detects vehicle tag ID
- RFID Tag – Stores vehicle and payment details
- Microcontroller (ESP32) – Handles data processing and communication
- Servo Motor – Operates toll gate barrier
- IoT – Connecting Tollbooth hardware to online server
- XAMPP – Creating Web / Server environment that stores data and provides the user interface

(ii) Role of XAMPP

XAMPP provides easy transition from local server to live server. XAMPP is an AMP stack which stands for Cross platform, Apache, MySQL, PHP, and Perl. The main advantage of using XAMPP in this paper is that it saves the cost for hosting a website live, in this case website and PHP script can be hosted on the local machine for testing at the specified port like Port 80 using TCP or UDP protocol [7].

Software components of XAMPP:

- Apache - plays the role of processing the HTTP request. It is the actual default web server application.
- MySQL - The role of database management system in XAMPP is played by MySQL. It helps to store and manage collected vehicle RFID tag data very efficiently. It is an open-source and most popular.
- PHP - Server-side scripting language. It is embedded with HTML code which interacts with the webserver. It is an open-source and work well with MySQL and has become a common choice for web developers.
- Perl - High-level programming language designed for text editing which serves purpose like web development and network programming.

B. Working of the Proposed System

The IoT enabled RFID – web based toll management automates the toll collection process. The proposed system starts by working with the issue of RFID card. The city's registration office issues RFID cards, which are one-of-a-kind identifiers, to each and every vehicle in the city. These details are stored in a MYSQL database and uploaded using XAMPP Server. The user interface can be created and viewed the details using HTML and PHP. When a vehicle has such a unique ID drives up to a toll plaza, the RFID card reader that is attached to the toll plaza will read the card and then send the unique ID of the vehicle to the micro controller[5]. The micro controller verifies the tag against the stored details in the MYSQL database.

As a direct consequence of this, the processor carries out its duties and deducts an established sum of money from the prepaid card. If the card ID being used is valid and has sufficient balance, the central processing unit will issue a command to the servo motor, instructing it to begin operating and open the gate. This will make it possible for the vehicle to move through the space. If the card is not genuine or if there is not enough money on the card, it will ask you to move the vehicle to the lane where manual tolls are collected. Along with this, this system also be integrated with SMS (Short Message Service) API allows easy and immediate communication with the registered users the toll fees deducted from their account[6,7]. These systems are often deployed on highways, bridges, and tunnels to collect payment from vehicle operators.

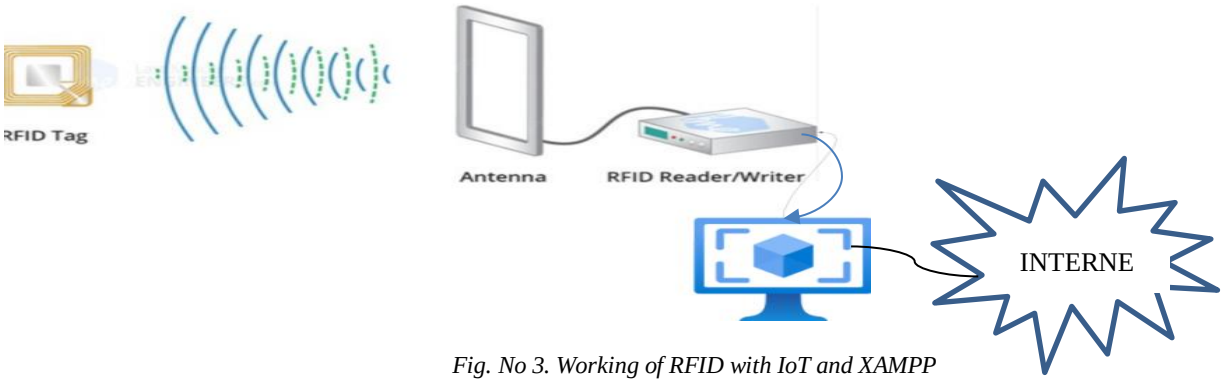


Fig. No 3. Working of RFID with IoT and XAMPP

(i) Advantages of IoT Integration

- The transaction time is very less
- Live tracking of toll transactions and vehicle log maintenance.
- Operational cost is very low.
- Scalability also improved when multiple toll booths are added.
- Reliability also achieved and maintains higher level of accuracy.

(ii) Block Diagram

The block diagram outlines the operational workflow of the smart toll system, and experimental testing confirmed its efficiency in real-world conditions.

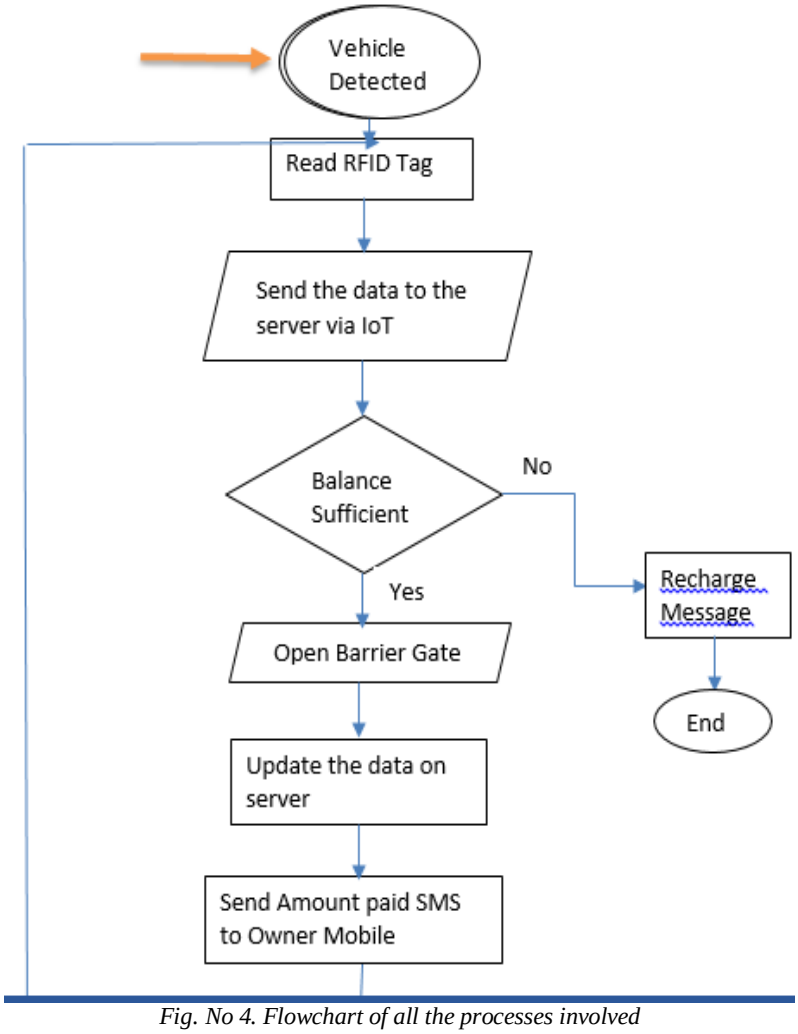
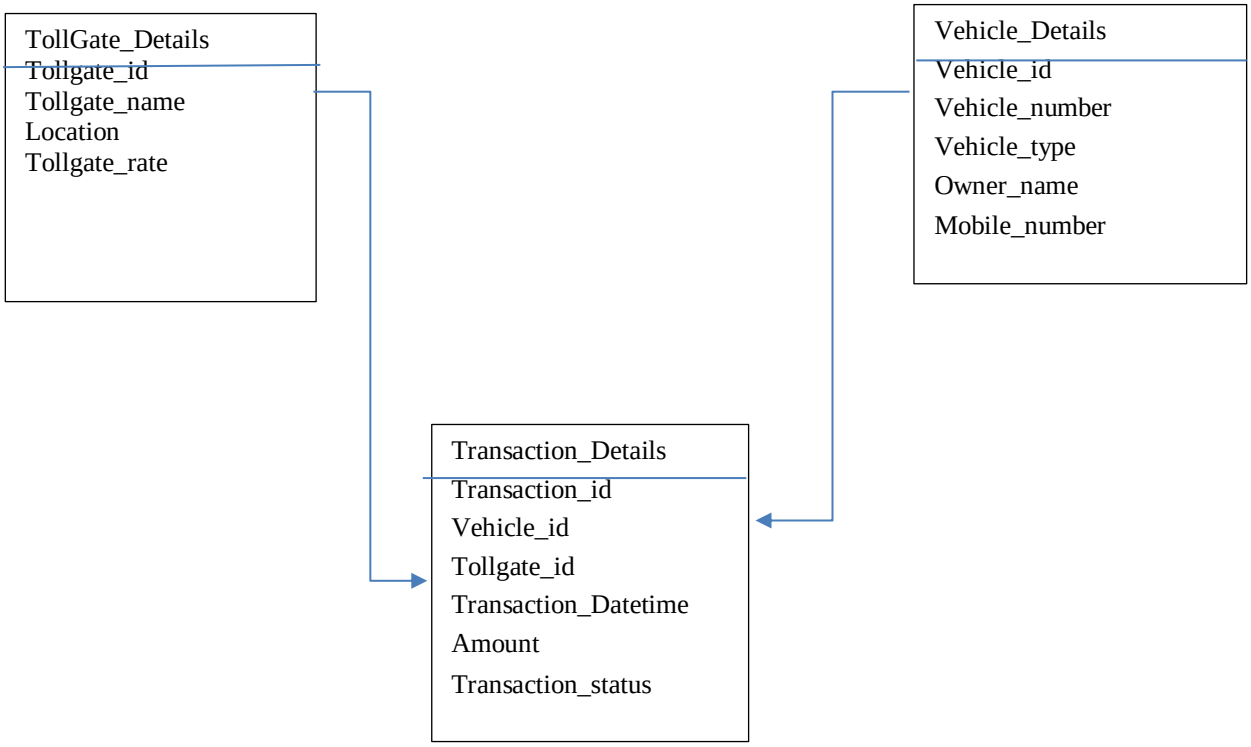


Fig. No 4. Flowchart of all the processes involved

iii) Table Structure



V.EXPERIMENTS AND RESULTS

The proposed IoT enabled RFID web based Toll automation was implemented and evaluated using XAMPP for creating User interface web application and MYSQL as backend database for updating vehicle details. When a vehicle detected, RFID reader scans the vehicle number immediately within 1 second, with 99% of accuracy across 100 test cycles[9]. The system checks for the sufficient balance, also updates the database and activates the servo motor within 2 seconds. This proposed solution ensures reliability and scalability[10,11].

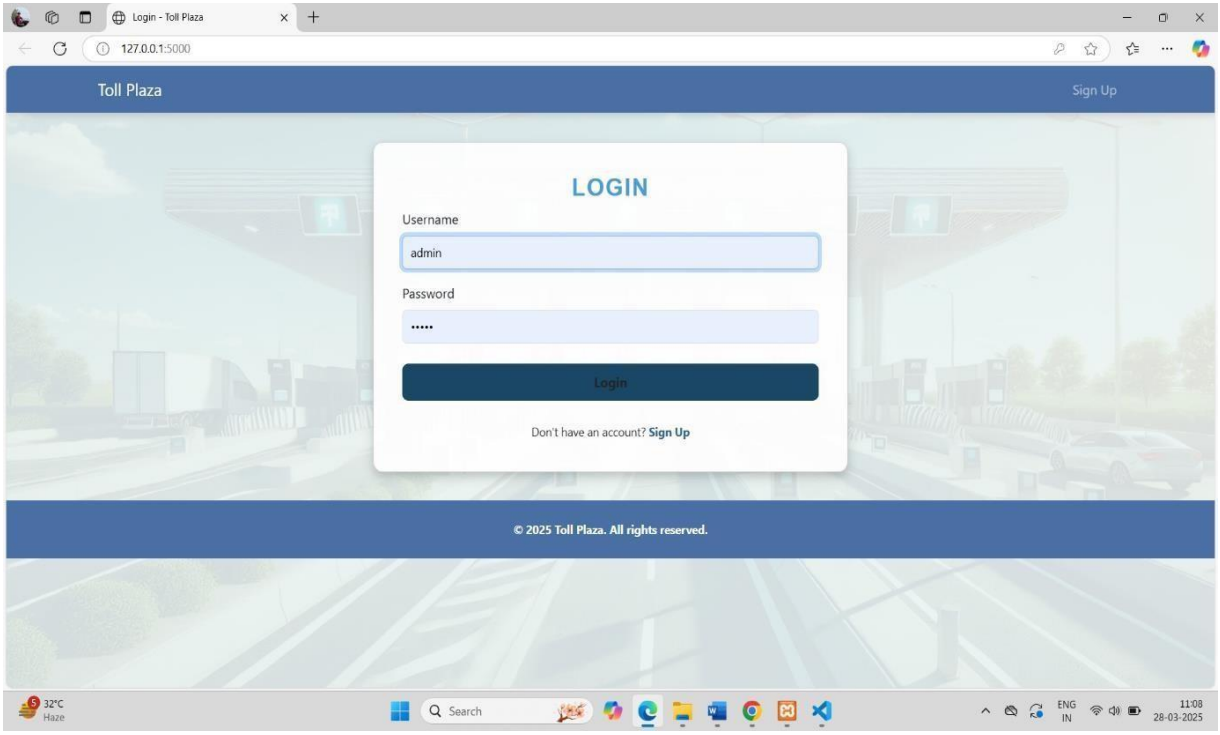


Fig. No 5. Admin Login

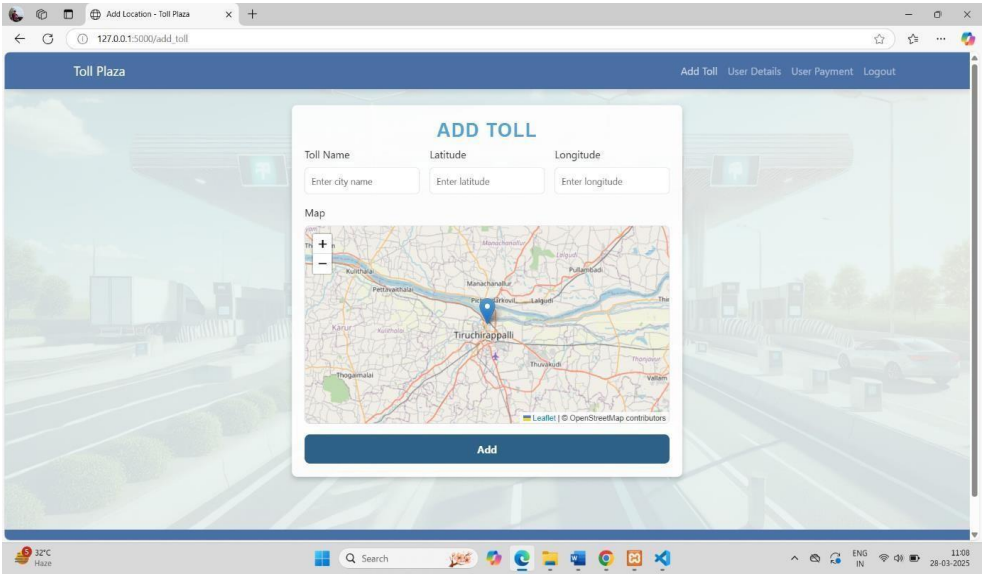


Fig No. 6. Adding Toll Details

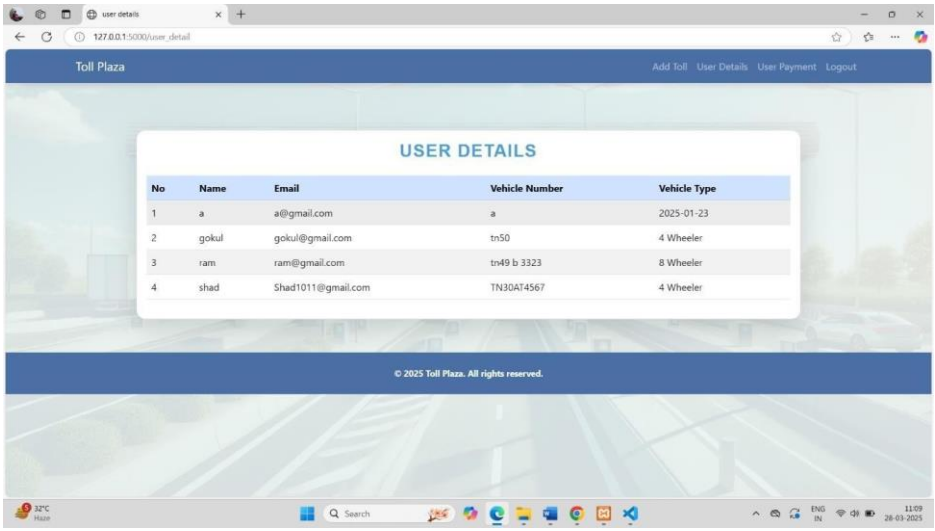


Fig. No 7. Adding Vehicle and their Owner

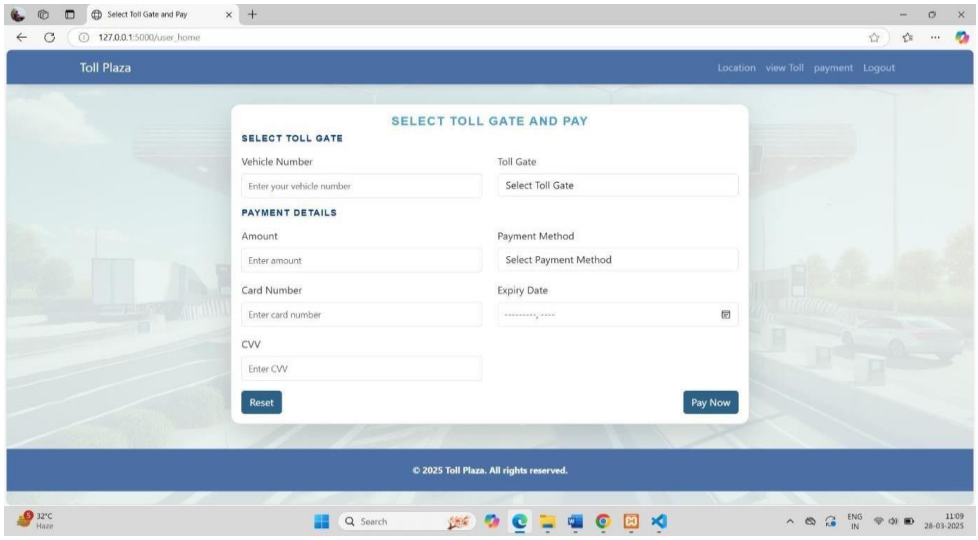


Fig. No 8. User Payment

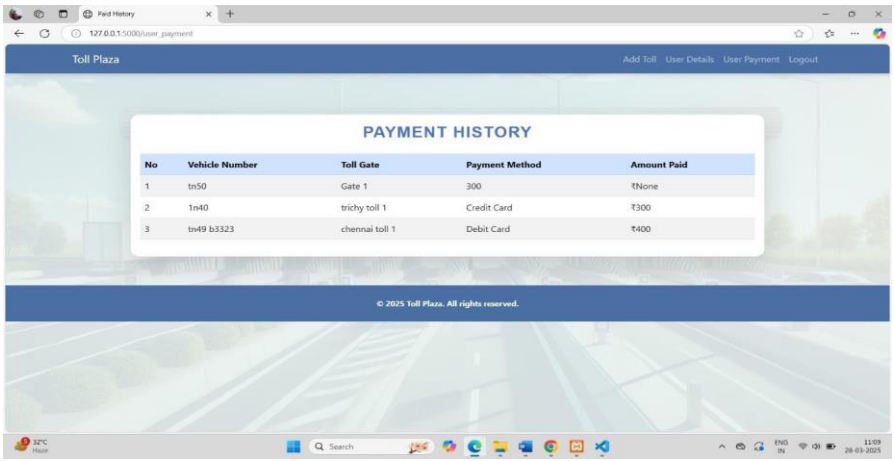


Fig. No 9. Payment History

VI.CONCLUSION

Our proposed system replaces the manual cash based toll plazas with fully automated, and 24 X 7 connected with internet. It consistently reduces manpower, time, fuel consumption, standing in a long queue and errors are made by humans. The average waiting time for vehicles at the toll plaza decreases as toll lane service rates rise. Vehicle emissions are decreased as toll plaza speeds are increased and accelerations and decelerations are minimized. Prices associated with processing toll transactions are also decreased when toll user costs are reduced. Shorter queues and reduced idling help lower fuel consumption and reduce environmental emissions.

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