Automated Toll Plaza System Using RFID and GSM Technology

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ABSTRACT

In recent times, IOT plays a major role in connecting physical devices that are accessible through internet. Cars, which were a luxury those days, have now become a necessity. This obviously increases the traffic and congestion on road. Simultaneously the number of toll booth has been increased on highways. There are thousands of vehicle crossing a single toll every hour. Collecting toll taxes manually takes lot of time since the travellers have to form queues and wait for a longer period to pay their respective taxes. In this busy life people does not have time to wait in line, stop at toll gate, take ticket and pay the taxes. This process is tedious. It also wastes time and fuel. To reduce this complexity, an alternative system must be introduced.

There are many people who developed such systems where vehicles could just pass through the toll booths without stopping. Here, drivers will not wait for paying in cash or to get a token from the toll manager to cross the toll plaza. It paves a convenient way for the vehicles on highways to pay their taxes. This system itself specifies the design with the help of unique code which is separately available for each vehicle and thereby it checks the code with the database using the tag which is already been inserted to the vehicle system. As soon as the vehicle passes, respective amount for each vehicle is deducted from the users account. Then the gate is automatically opened for the vehicle. If the vehicle which crosses the toll booth is not registered or does not have any unique code then the traditional method of manual payment is followed.

I. Introduction

A countries economy predominantly depends on the transportation system. An efficient transport system results in an efficient lifestyle of the people in the respective countries. This ultimately results in social mobility, extraordinary freedom for movement, higher rate of employment levels immense trade in manufactured goods and services. There are two methods of collecting tax presently used, first method is a traditional one which uses manual payment in highways, in which there will be a person in each toll booth to collect the money and the travellers wait in long queue to pay the taxes. The next method involves card payment system for opening the gate by simply showing the smart cards to the toll
gate system. This paper provides an innovative method to pay the taxes using unique codes which automatically recognizes the vehicle and detects the amount from the respective bank account. RFID sensors are radio frequencies used to identify and track objects remotely.

There are different types of RFID available all over the world [1,9]. RFID consists of two tags called as active and passive tags. The components embedded in the tag are reader/writer, antenna. The operating range of active tags is higher and requires low power supply like battery. Passive tag doesn’t need a battery, so the power is supplied to the reader and the range is low when compared to active tags. RFID reader is commonly known as interrogator. RFID readers are placed at every toll booth for collecting the information of the user and the vehicle with the help of RFID tag. The antennas placed at the RFID tag generate the signals and transmit to the reader. The signals are received by the reader at the receiving end which converts the signals to data. The data contains the user’s information and stored in the database. The information is also sending to the computer which contains graphical user interface. Each tag holds unique id number checks with the data available in the database and then deducts the toll tax. Once it matches, microcontroller deducts the amount which is displayed on the LCD and the gate opens.

The sensor is used for closing the gate in the negative case.

The design and development of the system is which is purely based on RFID technology, microcontroller and load cell for saving the time and provides cashless operation. The main theme behind our project is Automation. In simple words the Automation means replacing the human being from the process with the machines. In early 90’s, the toll booths were manually controlled. There will be people at the toll plazas for operating and collecting money from the travellers, opening and closing the gate and recording the data. During the year 1995, Semi Automation is introduced for opening and closing of gates and also the information is made available in computers and only two persons were required for a single booth. Now let’s see toll plazas where there will be no manual work.

Vehicle monitoring system which uses active tags has currently been deployed by Active wave Inc [2]. The products of Active wave vehicle requires 916-927 MHz for transmitting and receiving of signals and it ranges from 30 to 300 meters and receiving link also requires 433 MHz. Nowadays they are made with fixed size memory of 256 kb. And it usually weighs 14 grams with a 3v battery.

For monitoring multiple vehicles a client server model is used with sql server which involves Smart key Access. To control this system, different elementary
It performs at a frequency of 900MHz with a small range. Passive RFID tag doesn’t require additional power and operates at a maximum frequency of 13.5 MHz and it covers a distance to the maximum of 1.5 meters. It needs additional watt power to extend the reading range. For a longer time period, we can also read the tag. It is less expensive and easily available.

II. Related work

R. M. Hushangabade, S.V. Dhopte [3] proposed a system in which RFID is used to keep track of the vehicles by identifying the unique id which is embedded in the windshield of vehicles. By matching the code that is available in the database. Thereby it deducts the amount directly from the bank account. This system is widely used in the transport industry. These are the highlighting points in this paper, and other objectives also achieved which includes tracking of the vehicles and remote database connection.

Ganesh K. Andurkar, Vidya R. Ramtek [4] explained a system which is based on RFID in which they use two important things. One is RFID tag and another is RFID reader for collecting the information and for debiting the amount automatically from the account holder, thereby it reduces congestion and traffic controller. It is widely used in areas of heavy traffic and congestion. It is useful for both toll collectors as well as users.

In [4], Sachin Bhosale described the automatic toll plaza system using technology RFID. This control system uses the 8051 microcontroller. The signal is passed to PIC from PC. The main part of this system is microcontroller because the LCD display is showed as output and signal is passed to PC. To open the traffic gate, the signal is sent from microcontroller. The author also describes about the GSM modem which is used to update the information of user. SiuliRoy, Somprakash Bandyopadhyay Munmun Das, Suvadip Batabyal, Sankhadeep Pal [3] proposed a fully automatic system that reduces traffic congestion in highways to ensure traffic flow with RFID devices. Khalid Al-Khateeb, Jaiz A. Y. Johari [7] introduced RFID based toll gate system that reduces problems that are faced by manual tollgate system.

S.Nandhini, P.Premkumar [5] proposed automatic toll tax system will deduct the money from the account holders bank account and the information of the money deducted is sent to the registered mobile number linked to the account through GSM modem technology. This technology is the key to automatic toll collection in highways. This paper provides information about RFID based toll gate collection which reduces traffic. It enables automated toll collection and eliminates
possible human errors. Venkatesh Suvarna and Jeet Patalia\cite{1} explained about one of the existing automated toll collection system which uses RFID technology to collect taxes automatically.

Saurabh Narkar, Ankit Hendre, Sunil Redekar, Pranay Targe\cite{6} explained that automatic toll collection system through RFID technology is a solution for manual toll collection. The advantages of this automated toll plaza system are it increases efficiency and reduces the time consumption.

**III Proposed system**

The proposed method is to provide a fast and efficient system of tax collection in each toll gates and to control the vehicle movements automatically. The major functions of the system include vehicle theft detection, automatic tax collections, tracking over speed vehicles and signal breaking avoidance. These mechanisms are done using single RFID tag therefore saving the efforts of carrying money and records manually. As explained in the figure 1, the RFID readers which are mounted on the toll booth will notify the arrival of the vehicle. The prepaid RFID tags fixed on vehicles checks for the unique ID. If the vehicle is not registered then the tax is paid manually. If the ID is registered, it gets the details from the database and checks the balance amount and automatically deducts the required amount.

In case of insufficient balance it deducts the amount from the account holder and shows negative value. Once the transaction is completed the gate is opened.

![Figure 1 Flow Diagram of the Toll Plaza System](image)

When vehicle is stolen, it can be tracked using the unique id. The owner has to register a complaint on the website specifying its registration ID and unique RFID tag number. Now when the stolen vehicle passes by the toll plaza, the tag fixed on it is checked with the stolen vehicle's tag in the database at the toll booth. And also, if any vehicle ignores the traffic signal it can be detected using the
RFID readers which is fixed at signal crossing and will be notified to the traffic police instantly. The vehicles travelling above the speed limit can also be tracked with 100% accuracy.

IV Design and Implementation

The architecture diagram sketched below in figure 2, explains the interconnections between multiple components. The components required for gate controlling system are mentioned below

- Microcontroller
- Motor driver
- Motor
- LCD display
- GSM
- Power supply unit

Initially the RFID reader reads the information and sends the data to the microcontroller. The microcontroller is the heart of the system. The transmitter in the microcontroller is connected to the GSM receiver. The receiver in the microcontroller is connected to the RFID module. The power supply is given to the microcontroller which is linked to the DC motor for opening and closing of the gate as shown in figure 2. A RFID tag (figure 3) is a microchip combined with an antenna in a compact package. The packaging is structured to allow the RFID tag to be attached to an object to be tracked. "RFID" stands for Radio Frequency Identification. The antenna in the tag is used to receive the signals from the RFID reader or scanner.

![Figure 2 Architecture diagram](image)

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![Figure 3 RFID Tag and reader](image)

It then returns the signal, usually with some additional data (like a unique serial number or other customized information). The RFID tag can be very small – the size of a large rice grain. The GSM chooses a method which is a combination of Time and Frequency-Division Multiple Access (TDMA/FDMA)[7].
The FDMA part involves the division by frequency of the (Maximum) 25 MHz bandwidth into 124 carrier frequencies spaced 200 kHz apart. Each base station is assigned with one or more carrier frequencies. A TDMA scheme is used to divide each of these carrier frequencies in time. Burst period is the fundamental unit of time in the TDMA scheme which lasts for 15/26 ms (or approx. 0.577 ms).

A basic unit for the definition of logical channels is a TDMA frame (120/26 ms, or approx. 4.615 ms) which is a group of eight burst periods. One burst period per TDMA frame is one physical channel. The microcontroller used is the [4] PIC 16F877A 16 bit microcontroller which contains a program memory of 32-kbytes, DC operating frequency of 20MHz, data memory of 256 byte, 10bit A/D module (8 channels) and wide operating voltage range (2.2V to 5.2V). The main reasons of using PIC 16F877A is we can interface GSM and RFID in the same module. A ULN2003A driver IC is used for this system. An ULN2003A is a high-voltage, high-current Darlington transistor array features continuous load current rating to 500mA for each of the seven drivers. High output voltage is 50V. Its input is compatible with various types of logic.

Figure 4 PIC Board 16F877A

The main advantage of stepper motor is its ability to be accurately controlled in an open loop system. The advantages of stepper motor are Low cost and high reliability High torque at low speeds and a simple Rugged construction that operates in almost any environment. There are two types of stepper motor, namely, the uni polar stepper motor and bipolar stepper motor[10].

Here a unipolar stepper motor is used because its winding is made relatively simple with the communication circuit than bipolar stepper motor in open loop system. The supply voltage for motor is 12V. This motor is used to open the gate at the toll gate station. LCD (Liquid Crystal Display) used for display the present status of the system [8]. This is interface to 4 bit mode with LM016L microcontroller LCD screen consists of two lines with sixteen characters each.
V Experiment and result

The designed model of Automatic tollgate system will automatically detects the identities of the vehicles and performs the billing in accordance to the identity of each vehicle as pre-recorded in the database. Once all the test cases are passed, the system automatically opens and closes the gate as well as sends a text message to the owners of the vehicles.

These are the major goals satisfied in the project, along with the additional functionalities such as vehicle theft deduction and signal breaking avoidance. Initially there will be a RFID tag on the wind shield of the vehicle. The RFID tag is read in the toll gate using a RFID reader which will be present in each toll gate. The information of the vehicle such as owner details, vehicle number, vehicle tag number and owner bank details will be stored in database format in the microcontroller. If the vehicle number does not match with any of the details in the database the process is terminated. If the vehicle in the toll gate matches with any of the details in the database the process is further proceeded.

Based on the vehicle type, the tax amount for the vehicle will be automatically transferred from the owner’s bank account. The information will be sent to the owner’s mobile through GSM technology. The status of the vehicle will be displayed in the LCD and the gate will be opened. One additional advantage of this system is that, due to network problem, the vehicles need not wait in the queue since the toll gate opens automatically once the amount is deducted from the user’s account.

Figure 4 Output 1

The tax amount which is to be paid in the toll gate differs from vehicle to vehicle. For example, the tax for larger vehicles such as truck and buses is larger than the smaller vehicles such as cars. The vehicle type is deducted at the beginning of the process using the RFID sensors. The amount will be deducted according to the vehicle type and the message will be sent to the user as shown in the figures below.
The above figure shows the output message of money deducted for car when it passes the toll gate.

Figure 7 shows the output message of vehicle ID which is not matched with the sensor. The user has to pay the tax manually for crossing the toll gate.

Figure 6 shows the output message of money deducted for truck when it is read by the RFID tag.
As an example, a RFID tag is fixed on the car and made to pass through the toll gate. When the reader senses the tag, it identifies the vehicle and analyses the database which is already given as input. If the test cases are passes the required amount is deducted from the bank holders account and the message is sent to the card holder via GSM technology.

VI Conclusion and Future work

The automated toll plaza system is an innovative method to reduce congestion in toll gates to a great extent. The system ensures ease of toll collection on highways. It is a low cost, highly secured and efficient system which not only reduces the traffic in roadways but also improves the usage of new technology. It has very well tracking capacity than existing system. Since automation is the main principle used in this system it reduces manual work required in the collection of taxes. Automation is done through RFID technology which provides additional functions such as vehicle tracking, automatic toll collection and speed breaking avoidance. The location of the vehicle can be identified with the help of the unique id for each vehicle. The system also ensures secured bank transactions and send message to the user using GSM technology. It helps the traveller to know about the total amount spent and the status using a LCD screen. The system is supposed to provide a solution for all the traffic and tollgate problems. Reduction of congestion and inconveniences in manual payments are the main goal of this technology.

In future, different processors like QUALCOMM mobile processors can also be used for this system which provides various advanced features and network connectivity. With worldwide network connection we can access the users details directly. There are chances of security issues in accessing the users bank details. The RFID tag can be linked with the users respective government Id(Aadhar card) which holds the users bank account.

VII References

[1] VenkateshSuvarna and JeetPatalia,“A REVIEW ON VARIOUS RFID BASED AUTOMATED HIGHWAY TOLL COLLECTION SYSTEMS” Computer Engineering Department, NMIMS MPSTME, Mumbai, India


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