

# IoT Based Automated Toll Gate Collection System Using RFID and Image Processing

[1] Battu Phalguna, [2] Jishnu Sai.M, [3] Maroju Karthavyu Kiran Kumar

[1] Electronics and Communication Engineering, Sikkim Manipal Institute of Technology, Sikkim Manipal University, Majitar, Sikkim

, [2] Electrical and Electronics Engineering, Sikkim Manipal Institute of Technology, Sikkim Manipal University, Majitar, Sikkim

, [3] Electronics and Communication Engineering, Sikkim Manipal Institute of Technology, Sikkim Manipal University, Majitar, Sikkim

[1] Phalgunabattu007@gmail.com,[2] Jishnusai99@gmail.com, [3] Karthavyumaroju1@gmail.com

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## Abstract:

Nowadays, the larger part of the roadway toll gate is physically worked in most of the countries, where an administrator collects the money from the driver and reverts with a receipt. Since, this method is excessively lagging thus we regularly experience the roads turning to parking lots at the toll gates. To overwhelm these complicated scenarios this paper introduces The Automated Toll Gate Collection System to make the toll collection process more efficient and smoother.

The Automated Toll Gate Collection System uses Radio Frequency Identification (RFID) technology which is the systemized technique used to gather the toll naturally from the moving vehicle when they pass the toll gates. In this framework, every vehicle will hold an RFID tag and it contains a unique identification number which will be consigned with the R.T.O authorities. In this automated toll gate collection system, we face a few issues. So, as to conquer these initial problems the proposed system is additionally created with an image processing technique. Thereby this system provides a faster toll collection through RFID and Image Processing. So, when the vehicle crosses the toll gate its tax sum is deducted and furthermore gets an SMS through the GSM technology about the details of the payment, where the amount will be deducted from their prepaid balance. As the vehicle doesn't need to wait in a line, it guarantees efficiency, fuel conservation and furthermore contributing in setting aside of cash. In this paper, the case making and working stream out of the framework with both the technologies were described and the information about how the trading between the drivers and toll gate authorities takes place fluently.

**Keywords:** Radio Frequency Identification, Image Processing, Global System for Mobile Communication, RFID Modules..

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## I. INTRODUCTION

These days development in transportation systems result in a better lifestyle. As India has become one of the populated countries, this led to an increase in vehicle usage among the people as many people are preferring their motor vehicles instead of using govt-public transport. So, there is a rise in the number of vehicles on road highways at toll gates which has many consequences of effects such as fuel wastage,

air pollution, and heavy traffic [1]. As initial toll collection existing system at toll gate is done by manual process, which is a time-consuming process, the passengers experience a long queue at toll gate takes a lot of journey time and wastage of fuel which in turn leads to traffic stoppage and air pollution. Because this manual process gets hold of time as it was a manual payment method at toll gate which is a time-consuming process and many labours is required at toll gates [2]. To resolve this problem of

traffic blockage at the toll gate, we proposed an IOT based electronic toll gate collection system to ensure a constant and efficient flow of traffic by collecting the toll automatically without intervene in our journey.

Functioning of IoT based electronic toll gate collection allow a more efficient electronic transaction to take place between a vehicle and toll agency. In this electronic toll collection system, we placed an RFID reader at the entry point of gate and an HD camera is placed at both entry/exit points of the gate. A UHF RFID tag is used for implementing automatic toll collection on vehicles [3]. The details of the vehicle's registration number and model will be stored in a unique ID based RFID tag linked and consigned by RTO authorities which will be placed on the windshield of the car. So, RFID reader which is placed at the gate identifies vehicle information whenever a vehicle passes through the toll gate and deducts the amount. However, the authentication of using only an RFID based system as source presents a problem that it can be misused or misplaced by someone with hostile intent. So, with the help of Optical character recognition (OCR) system we able to demonstrate away with a hybrid approach to provide a robust system and double security verification feature for the toll collection.

Optical character recognition is used for monitoring the passage of vehicles. But we use it for safety verification as the OCR system will able to read both the front and backside of vehicles' registration plates to lessen the certain errors [4]. An HD CAMERA is placed at both entry/exit of toll booths to capture the number plates of vehicle and scans the number plate which will be carryout to extract the car's registration number by image processing technique. so when a vehicle passes through the gate RFID scans the tags in car and retrieves the details of vehicles which then get authenticated with OCR system for the confirmation, For registration and crediting account balance, a user-friendly android application was developed called TOLLPAY to access these types of functions and the required amount will be

automatically deducted from user's TOLLPAY account and through GSM modem an SMS text will be sent to user's mobile regarding details of payment. If the owner is not registered, then details of the vehicle and image of the vehicle will be noted and will take the necessary action. The most profitable feature in this electronic toll gate system is that drivers didn't need to carry any sort of cash for further payment, and this technology system provides a hassle-free flow of traffic at toll gates by faster and more efficient service.

## II. EXISTING SYSTEM

Many of the toll booth in India are operated manually, Manual toll collection is the simplest form of toll collection, in which a collector operating from a booth collects the toll. And the transaction between the operators takes time and delay. It also creates a disturbance in traffic and vehicle waiting for their turn for payment may causes pollution. Another method exists in India is smart card method. A smart card is given to the person where they fill up the amount annually whenever he needed. Where here the user in place of cash he shows his card at a toll gate and amount is debited easily. As though this way of method has one good advantage over manual method. It has one disadvantage as for round up journey cannot be done in this system.

## III. RELATED WORKS

In [5] According to Khadijah Kamarulazizi and Widad Ismail, their journal implies an electronic toll collection (ETC) system using radio frequency identification (RFID) technology. These methods automated by the system and eliminate the need and inconvenience of manually paying the toll. Data information is also easily exchanged between the vehicle and the authority that is collecting the tax, thereby enabling a more efficient toll collection by reducing traffic and eliminating possible human errors. But due to limited restricted servers, these don't to all tolls gates was not attainable.

In [6], F.Don has researched his theory on an electronic toll pile system using RFID. Since 1992, his research on electronic pile toll system has been in use, during when radio frequency identification technology tags began to be broadly used in vehicles to toll automated.

In [7], the author explained about the Radio frequency identification based automatic toll gated system. The communication between an RFID system and the control system of the required frequency is 928 MHz. The C programming language and Visual Basic was used in the serial communication between the computer are programmed with microcontroller and the RFID along with the PIC. The database was developed using Microsoft Access because it can store up to 32768 records of objects.

In [8], They purposed a system by developing the electronic toll collection system using barcode laser technology. The number of plates is mounted with barcodes which are embedded of user's information. When the vehicle passes through the booth, the information will be read by the barcode reader and toll is deducted from the user's account. This system makes the payment without using the cash manually and saves time. But, the main disadvantage of this system is that it takes much of the time for sending the signal and retrieving the information from Barcode.

#### IV. PROPOSED SYSTEM

The proposed method is to provide a safe and fast toll collection of the vehicle movements at the toll stations. However, the basic model of Automated Toll Gate Collection System is developed with two levels of security verification before the payment, by using RFID technology, Image Processing Technique. To actuate the first level of security verification, each vehicle needs to hold an RFID tag given by RTO authorities. The consigned RFID tag will have the unique identification number and stores all the information of the vehicle and TOLLPAY account of the owner. However, the UHF RFID

reader will be set at the toll gate stall of the highways shown in Fig.1 which will read the RFID tags of the vehicles, At whatever point a vehicle will enter the toll gate area, the UHF RFID reader will scan the tag and fetch data from the tag. and at the same time, the second security verification will be done through an image processing technique that uses Optical Character Recognition (OCR) on images to read the vehicle licence plate number. The OCR result will counter confirm with the sent data by the RFID to recognize any error, this will guarantee that a stolen RFID card can't be utilized at any of the toll gates. Thus, for successful payment in the toll gates, one must have the right RFID tag installed on the windshield with the correct registration number, once both the security verifications confirm that the data is connected with the same vehicle. Then it will be further processed through the payment section. If the vehicle owner is having sufficient balance in the TOLLPAY account, then toll sum will be deducted automatically from the vehicle owner's TOLLPAY account corresponding the type of the vehicle. A short time later, the vehicle owner will right away get the information about the transaction by an instant message through GSM technology. Whereas if the vehicle owner is having insufficient balance in the TOLLPAY account then also the amount will be deducted and the TOLLPAY wallet balance goes to negative. Later the vehicle owner needs to add the amount in the TOLLPAY wallet. If the vehicle owner crosses the maximum negative balance in the TOLLPAY wallet, then he will be charged accordingly, and the necessary action will be taken.

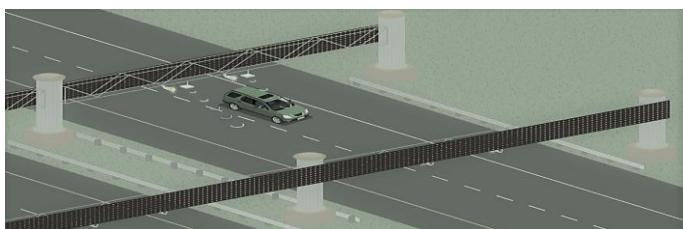


Fig.1. Proposed System with RFID and Cameras

The advantage of this system is it has been developed with android application based on IOT using android

studio which will be provided to all the vehicle owners during the vehicle registration. This application TOLLPAY app can be installed in the vehicle owners mobile. It has a unique user id and a password such the particular person having the id can only login check his/her toll statements. The toll statements include the date, time, place, remaining balance. If the consumer doesn't add credit to his/her TOLLPAY account to a long time and short credit is remain then he will receive a message of low balance by message or phone alert.

## V. SYSTEM ARCHITECTURE

Fig. 2 demonstrates the outline of the proposed system. At the point when the vehicle will go into the toll gate, the primary point is to get the information of the vehicle. For that reason, the vehicle needs to initially go through the primary gate of the system where the UHF RFID system will be there. In this system the RFID tag is detected by the UHF RFID reader & the data is stored in the temporary database of the raspberry pi. When the further vehicle is going towards the second gate the second level of verification starts through image processing. Where here the system captures the images of the car. An OCR algorithm is utilized in this system to identify the authorized number plate of the vehicle. The captured image is processed, and it extracts the number plate of the vehicle. The number of the vehicle can then be verified with the temporary database of the raspberry pi. After the confirmation, it goes to the further payment process. The toll sum is charged from the vehicle owner's TOLLPAY wallet. The use of raspberry pi in the project to process the captured image and to verify the vehicle and send the SMS through GSM module as it works on Raspbian OS which is an open-source Linux OS. It is easy to incorporate with the present system.

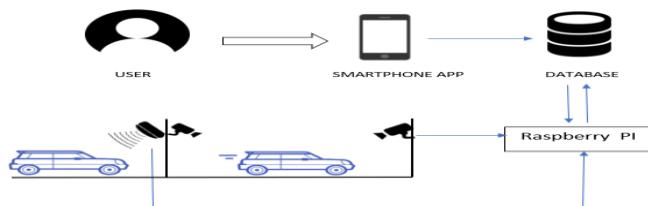


Fig.2. System Overview of Proposed System  
Using the proposed system mentioned above, the overheads of toll collection at the toll checkpoints

will be minimized. The flowchart of the presented work is given in Fig.3.

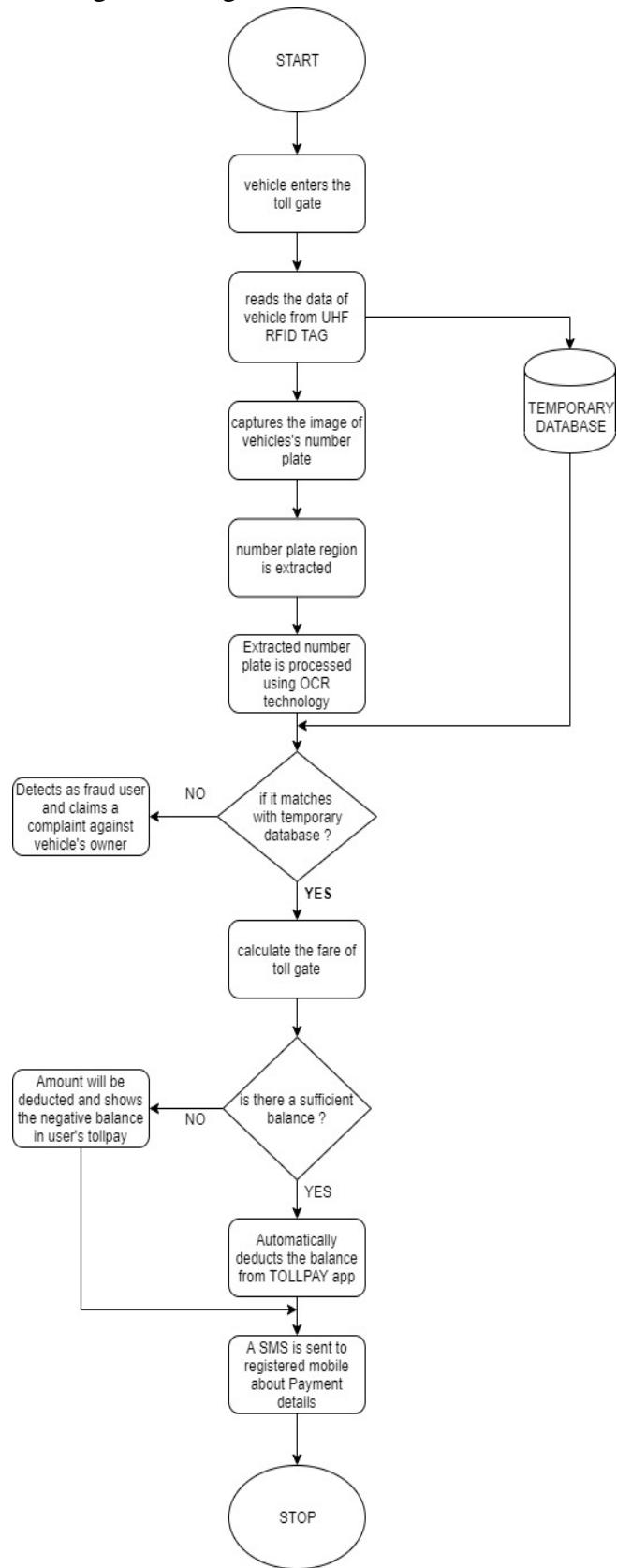


Fig.3.Flowchart of Proposed System

## A. DATABASE FRAMEWORK USED

The IOT based electronic toll collection system gates requires to get authentication with the user's data. So, the system creates data at runtime and this dynamic data needs to be stored. So, for creating DBMS, we used firebase in our system. Google based firebase comes up with diverse services with real database, authentication, storage, cloud messaging etc. The firebase provides an application programming interface for developers allows application data to be stored on firebase's cloud. The firebase can operate across android, IOS etc. After reader scans the RFID tag which has its own unique ID is converted into the string format. In Firebase software, we created a database that stores the details of registered user's vehicles. We have accorded our app and raspberry pi system to acquire the reading and writing access of firebase database. So, when a car's RFID tag gets scanned the reader returns a unique ID number gets compared dynamically and checked in the database. If the extracted number of cars gets matched with that of the details of ID of the vehicle, then we can assure that vehicle is a registered user of TOLLPAY app. After the amount gets debited and updates the new balance gets stored in Database. The databases are preserved efficiently and get updating on the TOLLPAY app of each passage of a vehicle. This way our system can intensify the existing system and has advantage of using this method in all geographical areas.

## B. HARDWARE DESCRIPTION

### i. RFID TAG:

The RFID tag is a compact package consists of a small microchip combined with an antenna. This microchip can store the specific unique ID or serial number or any other information depending upon the memory of the tag. The microchip sends and receives the data between the UHF RFID reader. Here, the functioning of the antenna which is attached to chip is to transmit the data information from a microchip to the UHF reader such as details of a vehicle. The tag is structured in a way that the tag can be easily tracked.

### ii. UHF RFID READER

The UHF RFID reader is a scanning device used for cross-examining or identifying the RFID tags. This UHF RFID reader emits the Radio waves of a set of frequencies through its antennas to transfer the data from RFID tags. When the UHF reader transmits the radio waves all tags which are within the range are contrived to respond to that radio waves frequencies. The reader scans the tags and gathers the information from tags by emitting a distinctive ID and broadcasts the results to the database. This system is designated to operate at 915 MHz. The reader consists of a radio frequency module and a decoder which can process a bulk number of tags at a time.

### iii. RASPBERRY PI:

Raspberry pi is a single-board computer which is the same size of ATM cards which can run and chain together multiple programs such as word-processing, spreadsheets or even playing games etc. The raspberry pi is a portable and low cost which is extensively used in mobile phones. It's perfect for those who require a PC for a project but don't need much of processing power and can keep the costs low, that is where this raspberry pi is effectively useful. Due to the requirement of the modern world, the device has been evolving from the previous versions in terms of memory size, do more advanced algorithms and compatibility. We use raspberry pi 3 in the system for very best use of network connectivity and remote access.

### iv. GSM MODEM:

GSM is a digital cellular-based technology widely used for transmitting the mobile voice and data services. The GSM digitizes the data or information and reduces it, then it sends down through a network with other streams of users. A limited resource is shared among the users in the radio spectrum. So, we used the GSM method to divide up the bandwidth between the many users as much as possible. The technique used in GSM is a narrowband time division multiple access (TDMA) for transmitting signals.

GSM has pretty much of improved spectrum efficiency and low-cost mobile sets and base stations.

### C. SOFTWARE DESCRIPTION

Optical Character Recognition (OCR) is a technique to help the hardware systems as a computer to recognize different characters, numbers and variables of a scanned Number plate image. There are various steps are involved in the process of OCR are a character segmentation, feature extraction and classification etc. These images are translated into a readable format. In this system, we used the Template algorithm in OCR for effective and accurate recognition of characters of number. The algorithm studies the optical image of the plate and stores the number in the format of the text file. In our system, the OCR is not consolidated in hardware, but we run on MATLAB software. The finishing output should be in the form of a string of characters. Then, it is transferred to a database where authentication of the user's car is verified in the process.

## VI. RESULTS AND DISCUSSION

In the approach of the proposed system, the vehicle has to pass the double security verification of the system. Then after the confirmation of the system, within a short time, the owner gets the SMS regarding the payment details. The results obtained of sending a message through GSM technology is shown in Fig.5.



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Fig.4. Sample Picture of Car's Number Plate from Internet

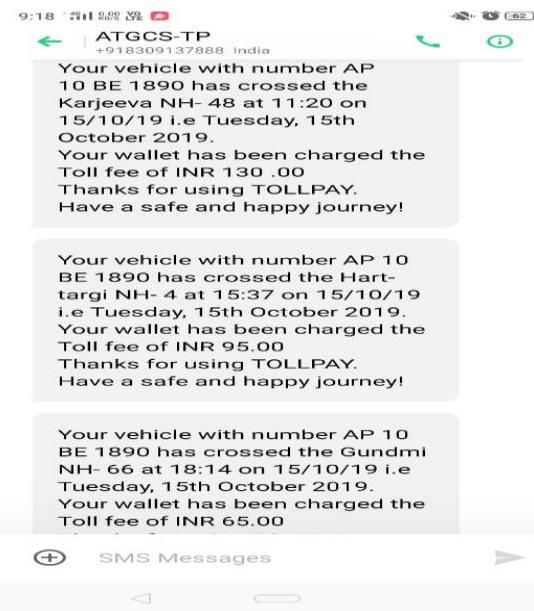


Fig.5. Result of Message Alerts.

The second level of security verification is to verify the user's details by comparing to its number plate by the image processing using the OCR technique. The process of image processing starts by placing two HD cameras at parallel toll gate to capture the front and back images of the vehicle in Fig.4 for confirming the number plate of the vehicle and the captured images of number plates are crucial so the cameras are ensured at a proper height and distance enough to detect the number plates. After capturing the plate, we had used the preprocessing techniques to enhance the number plate by noise reduction, grayscale conversion and removal of unwanted background, the result is shown in Fig.6.

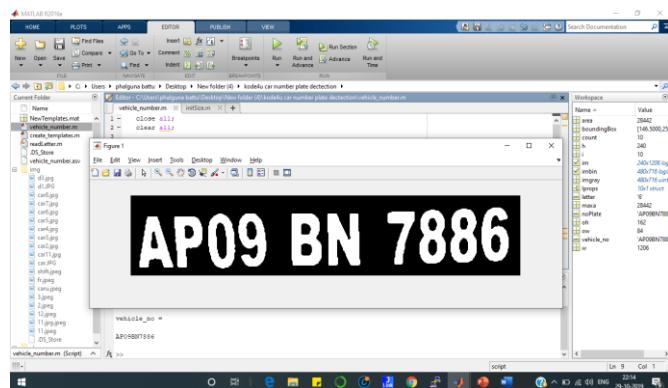


Fig.6. Result of Extracted Number Plate.

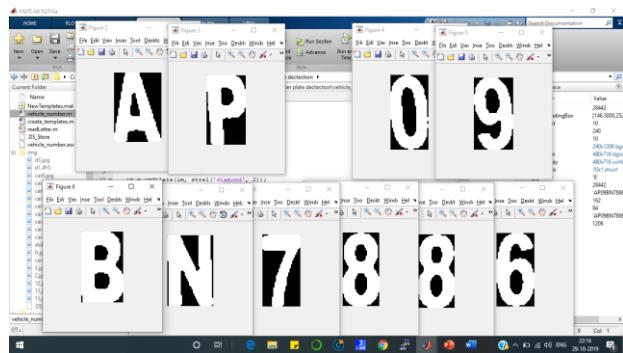


Fig.7. Result f OCR Segmentation.

Here, using the process of OCR (Optical Character Recognition) detecting each character of a number plate was achieved in Fig.7. Then those characters are arranged in a way that it gets the number plate of a vehicle. Then the extracted number plate of the vehicle will be sent for the further verification process in the system where generated image and the details of the vehicle (which is already stored in the database by scanning the RFID tag). After confirmation, it continues with the further process

The TOLLPAY mobile application is created using android studio this application is given to the owner of the vehicle which comprises of the unique user id and password as appeared in fig. 8 for the security reason, a verified client can access utilizing their login qualification. the owner can utilize the application for simple observations. After the login, the Client can see the available balance in the wallet and can screen the previous transactions as shown in Fig.8. If the client is having a low balance in the TOLLPAY wallet, then the client will be notified with a message. The client can add the balance from their respective bank accounts or e-wallets. Thus, the application gets a notification for every transaction.



Fig.8. Result of TOLLPAY App.

## V. Conclusion

In this research paper, we proposed and discussed a system called “IoT Based Automated Toll Gate Collection System” which guarantees the free flow of traffic at toll gates. The system is efficiently eliminated the major problems like traffic congestion and the possibility of any human error. This system will reduce any physical exchange and human intervention at the toll gates. The main aim of this system is to provide the most convenient toll method at low cost, highly secured and exorbitant efficiency at the toll gate. This toll gate system able to save a lot of time duration dealt at toll gate by establishing automatic payment as vehicle didn’t need to stop at toll gate in order to pay the toll, instead the toll is automatically gets deducts in our toll pay app to ensure the free flow of the vehicle at toll gates. In this way the system able to vanquish the drawbacks of the previous systems and builds an ease friendly toll gate system.

By introducing this system, we able to get advantages of the following proposed system

- It is the most efficient and effective low-cost toll gate system compared to the other toll gate systems.
- The vehicle shouldn’t be worried about the consumption of time at toll gates.
- Theft of the vehicle can be avoided by detecting the number of plates using image processing
- Toll collection without any physical exchange of cash.
- Overall managemental costs like human labour can be reduced.
- This system can allow the vehicle without any stop at a point to scan which makes ease in a speeding flow of traffic and provides benefit to the riders.
- To avoid the problem of tampering with the RFID tags we double-check the right TOLLPAY’s registered vehicle by the image processing technique.

- This system can detect multiple vehicles at a time simultaneously is possible.

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