National Journal of Multidisciplinary Research and Development
ISSN: 2455-9040
Impact Factor: RJIF 5.22
www.nationaljournals.com
Volume 3; Issue 1; January 2018; Page No. 691-695

Automated toll booth management system using UID (AADHAR)

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Abstract
The population of India is growing rapidly because of which the number of vehicles is also increasing. This has led to a lot of commotion on the roads. One such example is the congestion caused by the large queues of vehicle on the toll booth. Hence, a system that enables user to pay the toll without waiting for a long time, through a UID is proposed. The objective of this project is to design an optimal toll system that uses a web interface which will provide all the information related to the car by scanning the QR Code present on the windscreen of the car. The user can then select the route he wants to travel i.e. single way or double way based on which the UID – AADHAR Card is scanned. Since all bank accounts of Indian citizens are linked with their respective Aadhaar card they can pay the amount by authenticating their fingerprints. The payment gateway is encrypted to ensure security. The receipt will then be sent to the registered mobile number with the bank account. With this system, we propose a system with dedicated sensors using microcontroller Arduino UNO R3. The system is coded in Arduino IDE. A perfect tradeoff between accuracy and cost of the system is accomplished by choosing appropriate sensors which are QR Code scanner, BAR CODE reader and, R305 (Fingerprint sensor). A sensor is applied in every signal, to dig up the time at which the vehicle has passed the toll. These details can be used for further actions. Thus this system reduces the manual labor of the toll authorities, saves time and effort.

Keywords: arduino UNO R3, fingerprint sensor, barcode reader, QR code, toll collection

1. Introduction
In our daily life we often visit the toll plaza. The major problem we face is waiting in the large queue for our turn, wastage of time and fuel. To overcome this, the design of the toll plaza must be improved. Thus, to reduce this commotion we use UID based toll booth. The processing time required for UID based toll booth is less than the manual toll booth. The manual toll system may lead to human error [1]. This can thus be avoided by the UID based toll system.
RFID uses Radio Frequency waves to track objects. It is preferred as it is low cost and convenient. This RFID can be easily scanned by the tag reader. A software program running on the computer retrieves the vehicle details from the vehicle database. The user is then allowed to select the route he wants to travel. Since the Aadhar card is linked with the bank account that makes the transactions secure and fast. Depending on this, the appropriate amount is deducted from the owner's account and the receipt is send on their registered mobile number. If the balance in the owner's account is insufficient, then the amount will be deducted from their account when sufficient amount is available.
Thus we need a system that is capable of handling the long queues of vehicle in less time. The payment gateway for paying the toll is secured.
The UID based toll system aims to reduce the time that the vehicle waits at the toll plaza. By implementing it their also will be less accident rate that is caused by the vehicles changing lanes in order for faster clearance. Once, the vehicle arrives at this toll plaza the information about it is recorded as the RFID is scanned so it also helps in theft detection.

2. Background
The toll plazas in India are maintained by the Government. The main objective of the toll booth is to collect tolls from the vehicles in order for the maintaining that road. The most common approach for gathering tolls was to have the vehicle halt and pay the toll to the toll collector sitting at the toll booth. The toll collector collects the amount of toll to be paid by each vehicle based on the route the vehicle wants to travel [2]. Another approach is, the daily user of the toll booth is given a smart card where the person has to scan the smart card at the system installed, depending upon the validity of which the toll gates opened. These approach causes congestion of lanes. To overcome this, the design and implementation of toll plaza must be improved. Besides, the optimization method the operational efficiency must also be improved.

3. Related Work
The existing systems have proposed the idea of Automated Toll Management System,
K. Gowrisubadra *et al.* [3] proposed a system for controlling the overloaded vehicles and controlling the vehicles driving without proper documents, in order to overcome the limitations in toll gates.

Arokiyanathan. P *et al*. [4] connects RFID to car number and gives the driver, the authority to make payments for the toll gates the car will pass in advance.
Sana Said Al-Ghawi *et al*. [5] requires a dedicated account with every user passing through the toll gate and the use of infrared sensors in the proposed system can be inefficient due to intervention of light and other sources.
Akshay Bhavke *et al*. [6] proposed a system for the detection of vehicles collision. When the vehicles collide, their tags given to them using RFID gets exchanged which helps in detecting accidents. The theft detection system is not implemented in the proposed system.
Jin Yeong Tan, Pin Jern Ker *et al*. [7] proposed a system for toll collection developed using raspberry pi. It eliminates delay in travel and uses SQL for database management. It also enhances the car security.
Sudheer Kumar Nagothu *et al*. [8] proposed a system where each car is identified by the sim of the GPRS to save time. There can be a lot of limitations due to poor networks issues. The intervention of private agencies may increase the cost required for the installation of toll gates.

4. Proposed System

The proposed system eliminates the traffic at the toll booth. It also reduces the manual process that interrupts the mobility of the vehicle by using RFID scanners. This system includes a 3-protocol layer as shown in fig.1 where each layer contributes and when combined a successful system is achieved. The base layer contains the RFID on the vehicle, connections required among the sensors and the Arduino board such that efficient data is collected from the user. This layer is followed by network layer and application layer. The network layer explains the networking between the cloud/internet and the web interface. The Byte Rotation Algorithm and Advanced Encryption Algorithm is used in this layer to maintain security and efficiency of the data when payment is done by the user. The top layer is the application layer that contains the database of the vehicle and the Aadhar card of the user. So this data can be retrieved whenever required. The fig.1 shows the flow of the process when a vehicle arrives at the toll plaza.

Benefits of the system

- Smaller lines at the toll booth
- More organized system
- Faster and efficient
- Ability to make payments with card
- Use of postpaid toll stations
- Better audit control by centralized user account
- Less possibility of accidents
- Theft detection of vehicles

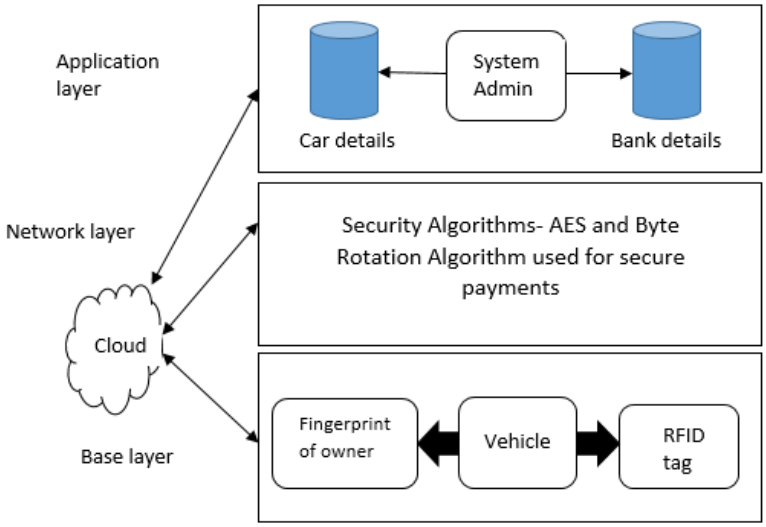

Fig 1: Components of the system

5. System Architecture

The system architecture is divided into two major segments,

- Hardware Segment
- Software Segment

5.1 Hardware Segment

The hardware segment has a microcontroller Arduino UNO R3, temperature sensors, a pulse rate sensor and a respiratory sensor and an ESP8266 Wi-Fi shield.

i) Arduino UNO R3

Arduino Uno is a computer hardware which is basically a microcontroller board based on ATmega328. The Arduino Uno has 14 digital I/O pins out of which 6 can be used as PWM outputs, 6 analog inputs, a 16MHz ceramic resonator, a USB connection, a power jack and a reset button. It operates at 16MHz clock speed. It has an SRAM of 2KB and EEPROM of 1KB. Arduino has a flash memory of 32KB out of which 0.5KBis used by bootloader. In addition to this, the arduino Uno can be easily coded by using Arduino IDE.

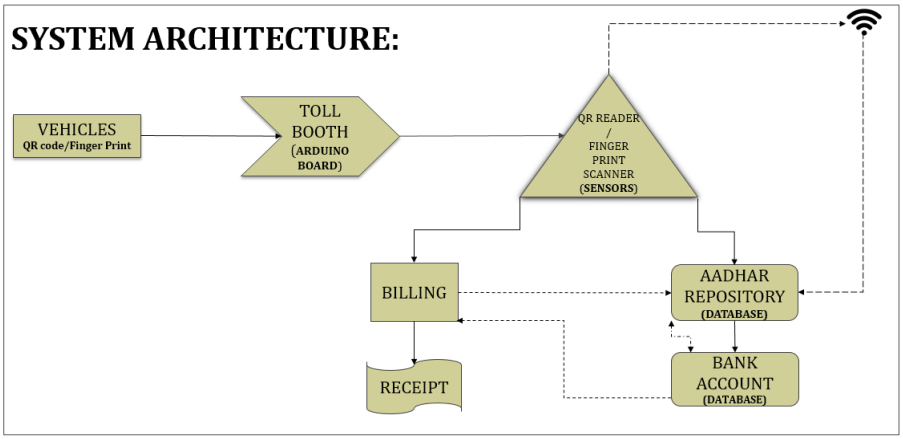

Fig 2: Schematic Diagram of System

ii) R305- Fingerprint scanner

The R305-Finger Print sensor has an integrated image collecting algorithm and chip which is responsible for faster and better bio-metrics collection. The sensor can conduct secondary development ad this can be embedded into different systems. The power consumption is very low which overshadows the cost effectiveness concern and its compact and small size makes it apt for a feasible usage at the automated toll collection center. The image processing capabilities are good and it can capture image resolution up to 500 dpi. The life span of the sensor is 100 million times. The highest concern with the bio-metric sensors is the security, and the R305 has a level 5 security which is highest among the levels. The working environment are optimal and thus, it is best suited for the automated toll management system.

Fig 3: R305 Fingerprint sensor

iii) Webcam based QR Code reader

Quick Responsive code is a two-dimensional bar code. Being attached to information about items, marks its height in readability and fast storing segment. As soon as the horizontal and vertical derived code is scanned, the standard encoding modes displays the information stored with the QR code. It is scanned using image sensors instead of beam(s) of lights. The data storage capacity of the QR code depends on its versions (Ranging from version 1 to 40) and types. The characters are coded with the help of this formula:

$$V=C1*45+C2r$$

5.2 Software Segment

i) Arduino IDE

Arduino IDE is an Integrated Development Environment for Arduino driven processing. Arduino IDE is user-friendly and efficient for development of programs. It acts as an interface between all the hardware components of the system. It is compatible with a wide range of programming languages. It is a powerful base for any developmental processes which includes Arduino and are carried out by Researchers, Development Professionals, and programmers. It is an open source software which can be used to work on Windows, Linux, or Mac Operating System. The Arduino IDE takes the readings of sensors from Arduino board and displays it to the user. Various algorithms can be applied using IDE and programming languages to make health predictions.

ii) Cloud Storage

Cloud Storage space is used to collect data from Sensors and store it. The data is stored using Bite Rotation Algorithm and can be retrieved anywhere using AES Algorithm which enables only an authorized user to access data using a unique identification and password technique. Variously paid cloud storages are available, such as AWS, IBM Bluemix, Google Cloud, iCloud by Apple Inc.

iii) AES and BR – Algorithm

a) Byte Rotation Algorithm: Byte Rotation Algorithm (BRA) is used for secure data transfer. It enhances the data security. It supports OS concept of multi-threading. A thread is a small block of a program/execution unit. It allows execution of multiple threads within a single process. It is a symmetric Key Block Cipher Algorithm. It has each block size is of 16 bytes. The size of the key matrix is 16 bytes, and the values of the key matrix are randomly selected which ranges from 1 to 26. It follows Monoalphabetic substitution concept. The BR Algorithm takes less time to create a new thread than a process. The termination of the thread as well as the time to switch between threads is also less. Threads within same process share memory and other resources, they can communicate with each other without invoking the kernel. It is fast compared to other algorithms and thus makes it much useful. It provides better security and involves no complex calculations.

b) Advanced Encryption Standard: Advanced Encryption Standard (AES) is a symmetric key algorithm. The data is available as 128-bit and the keys are of 128/192/256-bit. It is an iterative rather than a Feistel cipher. It is stronger than triple DES and can be implemented using Java or C language. It is based on the substitutive-permutation network. AES performs all its computational operations in bytes and not in bits, which makes it efficient and fast. The security mechanism of data storage and retrieval makes is appropriate for usage. As the user data integrity and security is a major concern.

6. Methodology

The main objective of automated toll management system must be that it should be serviceable hence they need to be user-friendly, affordable and less complex. The system is made cost effective by using a small, low powered microcontroller Arduino Board as shown in fig.1. Our system consists of R305 fingerprint scanner that is used to scan the fingerprint of the user in order to authenticate the payment. The QR CODE reader module is used to scan the QR code present on the windscreen of the vehicle in order to obtain the details about it. The fingerprint scanner has 4 pins out of which one corner pin is connected to +5V, then next pin is connected to Ground (GND). The TXD goes to MCU's RX-IN, and last pin is RXD which goes to MCU's TX-OUT pin. The QR code reader has 5 pins where TX is connected to Pin 1, RX is connected to Pin 2, NC is connected to Pin 3, GND is connected to pin 4 and pin 5 is used for +5V. This Arduino board is connected to the Wi-Fi and the sensors are coded accordingly by using Arduino IDE. The sensors will collect the data timely and will store it in the cloud. The data can be easily transferred and retrieved from the cloud using Byte-Rotation Algorithm and Advanced Encryption Algorithm. All details about the vehicle passed the toll at what time will be stored in the database and can be easily accessed by the authorized user.

7. Experimental Setup

The experimental setup is a prototype of the system as shown in the fig.4 the desired sensors are connected to the Arduino Board at the assigned pins in order to get the output.

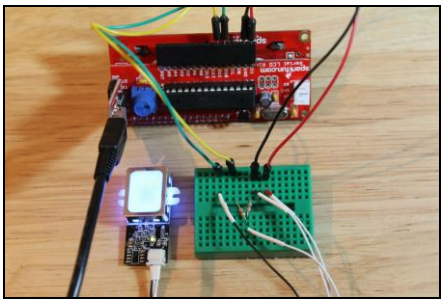

Fig 4: Experimental Setup

8. Results

The fig (5) shows the flow diagram of the system representing the sequence in which the operations are performed. The ease transaction through the toll gate can assure a less traffic congestion and a faster payment collection. As an e-receipt is generated, it also assures that paper is saved and can thus, help in a healthier and greener environment.

If the car owner is not driving the vehicle, then the driver can directly scan his/her Aadhar card at the toll gate to pay via account. Thus, the mobile linked with the Aadhar used at the time of payment receives the receipt and that receipt can be further used for routing.

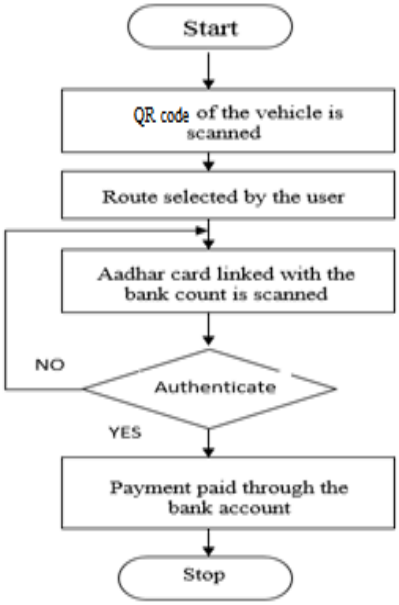

Fig 5: Flow Diagram of the system

The prototype of the system results are shown below. The fig. 6 represents the welcome page of the system whenever a new vehicle arrives at the toll booth.

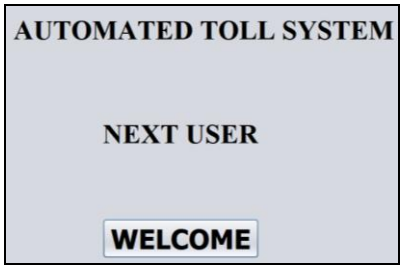

Fig 6: Welcome page

The QR code is scanned from the vehicle and the Aadhar card is scanned. Based on the details linked with the Aadhar card the data is retrieved from the database as shown in Fig.7.

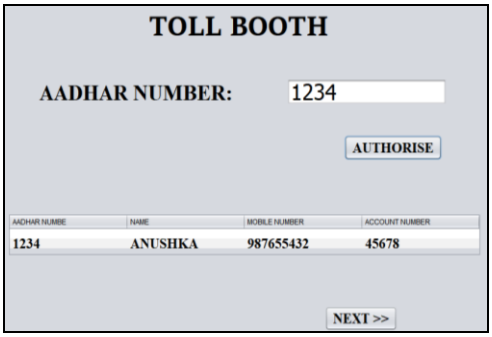

Fig 7: Aadhar Verification

Fig 8: Retrieval of Aadhar linked information

The fig.9 shows how the user selects the route he will travel from the toll based on which he selects one way or two way. The toll is calculated for that particular route and the payment is authenticated by scanning the fingerprint of the user.

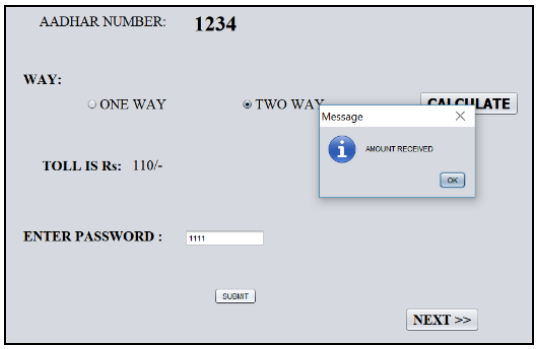

Fig 9: Route Selection

The fig.10 shows the generated receipt send to the registered mobile number with the bank account.

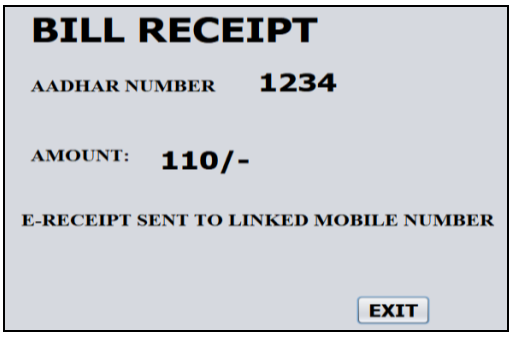

Fig 10: Receipt send to the registered mobile number

9. Conclusion and Future Works

The proposed system provides an efficient, affordable, user-friendly toll booth management system. The data about the car is collected by scanning the QR CODE. Thereby, the payment of the toll can be done easily by scanning the Aadhar card to which the desired bank account is linked. These data are stored securely in the cloud storage and thus, it can be easily accessed anytime by anyone who has access rights. The system uses a microcontroller Arduino, two sensors and a cloud storage with all the components connected to the internet which makes it easy to operate and less complex. This system enables user to make cashless payment at the toll without waiting for a long time.

Through this process of toll collection the time required, manual power and efforts required can be reduced. This system can keep a track of number of vehicles passing through the particular toll booth in a day. It can also calculate the total toll collected from all the vehicles. The main advantage will be the detection of cars that are stolen if it passes from the toll plaza. The future works may include to develop a multi vehicle amount deducted and send a SMS at a time to multiple numbers.

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