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Automatic Toll Collection, Vehicle Identification During Collision & Theft Detection using RFID

Akshay Bhavke and Sadhana Pai
akshay.bhavke@gmail.com

***Abstract*—"Automatic Toll Collection, Vehicle Identification During Collision & Theft Detection using RFID" addresses the problems faced at the toll plaza and culprit identification during collision. The system also identifies the vehicles against which stolen cases are registered using RFID. The mobile application is used to create an account and register his RFID number at central database. When a vehicle with RFID tag arrives at toll plaza the Toll Collection Unit (TCU) classifies the vehicle as a passenger carrying vehicle or goods carrying vehicle based on its RFID Number. The goods carrying vehicle is weighed and if it is overloaded then charged with extra toll. The amount to be charged is then decided based on whether the vehicle is passenger carrying vehicle or goods carrying vehicle. RFID Number and amount to be charged is then passed to Central Server Unit (CSU) where a balance is deducted from user account after which CSU indicate TCU to allow the vehicle to pass. If the vehicle is identified as stolen vehicle by CSU based on RFID Number of vehicle, CSU will indicate TCU not to allow the vehicle to pass. In order to identify the culprit in hit and run case collision detection mechanism is implemented using vibration sensor. Theft Detection Mechanism is implemented to protect the vehicle from thief.**

Keywords—Analog to Digital Converter, Computers, Database, Interrupts, Infrared Sensor, Load Cell, Mobile Application, Piezoelectric Sensor, Public Domain Software, RFID Reader, RFID Tag, Vibration Sensor, Web Services.

I. INTRODUCTION

Congestion, wastage of time and wastage of fuel are the problems faced at toll plaza. RFID based Toll Collection system is an economic solution to above problems. RFID based Toll Collection system helps to speed up the process at toll plaza. The RFID based Toll Collection system requires much less transaction time than the Manual Toll Collection system. The Manual Toll Collection System also causes human errors which may lead to the incorrect toll collection. Due to rash driving, the numbers of hit and run cases are increasing on large scale. It is very difficult to identify the culprit in hit and run cases. According to report "ROAD ACCIDENTS IN INDIA 2015" of MINISTRY OF ROAD TRANSPORT & HIGHWAYS during year 2015, the total number of Hit and Run cases were 57,083 which are 11.4 per cent of the total road accidents. [15]

The numbers of stolen vehicle cases are increasing, stealing of vehicles has now become a common crime and it is difficult to track stolen vehicle.

According to report "Crime in India 2013" of "National Crime Records Bureau, India" the total number of vehicles stolen in 2013 are 1,67,838 out of which only 39,241 are recovered.[16]

The vehicles which are stolen or vehicles against which hit and run cases registered are marked as blacklisted vehicles. Such blacklisted vehicles can be tracked by using RFID based toll collection system.

The goods carrying vehicles are usually overloaded; this may lead to an accident and also damage the roads. According to report "ROAD ACCIDENTS IN INDIA 2015" of MINISTRY OF ROAD TRANSPORT & HIGHWAYS, during year 2015 overloaded vehicles caused 77,116 road accidents constituting a share of 15.4 per cent in total road accidents. Accidental deaths due to overloaded vehicles caused 25,199 deaths in constituting a share of 17.2 per cent in total road fatalities in the country. In order to avoid overloading of goods carrying vehicles, the vehicles are weighed, and if it is found to be overloaded then charge them with extra toll. Payment modes are made flexible by using the mobile application for all transactions and making all transactions online. Mobile application is also use to keep track of user account. [1][2]

The rest of the paper is organized as follows: - Section II consists of literature survey. Section III describes the system model and detailed working of the system. Section IV gives the brief description of experimental result to evaluate our proposed system. Section V provides the conclusion. Section VI gives information about future work.

II. LITERATURE REVIEW

The demand of RFID based applications are increasing due to its less manufacturing and implementation cost which seeks the attention of researchers. Some of the RFID Based applications are Logistic and supply chain visibility, item level inventory tracking, manufacturing, access control, animal

tagging, library system, real time location system, etc. Now-a-days an RFID system is also incorporated in toll collection system.

In [6] RFID based toll collection unit is incorporated in the system, when vehicle comprising RFID tag arrives at toll plaza RFID Reader detects the RFID number of the tag and toll amount is deducted from the corresponding user account then vehicle is allowed to pass. In [6] RFID based toll collection unit is incorporated in the system, when vehicle comprising RFID tag arrives at toll plaza RFID Reader reads the RFID number of the tag and toll amount is deducted from the corresponding user account.

After deduction the information of the transaction is sent to user mobile using GSM module, so that the user has a valid proof of transaction. In [3] RFID based toll collection unit and stolen vehicle detection mechanism is incorporated in the system, when the vehicle arrives at toll plaza it is checked whether the vehicle is stolen or not. If a vehicle is detected as stolen vehicle then information regarding the vehicle is sent to the owner. Otherwise, the balance is deducted from user account and a vehicle is allowed to pass. In [5] ANPR (Automatic Number Plate Recognition), the ANPR system is incorporated with toll collection system. When the vehicle arrives at the toll plaza, the image of the number plate of a vehicle is captured using high definition camera.

Once the image is captured the vehicle number is extracted using ANPR system. Based on vehicle number, toll amount is deducted from the corresponding user account. The above system doesn't require RFID tag, but the installation cost is high. A number of automobile companies are working to develop the efficient Vehicle Identification during Collision mechanism to detect the culprit in hit and run case. But the implementation cost of such system is very high, hence only few people can afford it. In [9] GPS and Zigbee module is used for vehicle identification during collision. When a collision occurs vibration sensor placed in front of the vehicle, which senses the vibration and gives an alert to traffic police via Zigbee. In this case if culprit tries to escape without stopping, then the GPS module in the vehicle sends the corresponding location to the traffic cop server via Zigbee. The ETC system which is currently used in India [11] [12], does not provide an external module that acknowledges the toll transaction to the vehicle owner. The system simply scans the vehicle tag and proceeds provided the vehicle is not under any sort of defaulter category. The equipment's required for electronic toll collection (ETC) system in India is supplied by Mitsubishi Heavy Industries Ltd. (MHI), MHI began commercial operation on an expressway in Gujarat state [14]. The ETC system is managed and maintained by 3 road developing companies, namely Larsen and Toubro (LT), IRB Infrastructures and National Highway Authority of India (NHAI). The electronic toll collection project is equipped with RF Scanners which detects the passive tags operating at frequencies of 850MHz-950 MHz at a distance up to 90 feet with a response time of 10 milliseconds. Although the system is cost efficient, but there is no external module that can acknowledge the motorist about the successful transaction and pending balance. The ETC system used in Canada is known as the Canada 407 [11] [12] Express toll route (ETR). It is one of the most sophisticated toll collection systems in the world. The system is well equipped with optical cameras which record the license plate of the vehicle [13]. The camera specific to this type is called Optical Character Recognition (OCR). The OCRs are used to capture images and recognizing the license plates of the vehicle without transponders (tags). Laser beams are placed at the top of the solid infrastructure which detects the vehicle type. The project developed above is not cost effective and the expense of the built infrastructure is recovered from the motorists by increasing the toll bill.

III. System Working

The system mainly consists of four units Toll Collection Unit (TCU), Vehicle Control Unit (VCU), Central Server Unit (CSU) and Mobile Unit. The purpose the TCU is to collect toll and allows valid vehicles to pass at toll plaza. The VCU plays a crucial role in Theft Detection Mechanism and Vehicle Identification During Collision. The CSU contains the database tables which keeps the track of all transactions at toll plaza and the complete information about vehicle. The CSU also checks whether the RFID number of vehicles are valid or not based on information available in the database table and sends information about the vehicle to TCU. After every transaction of vehicle at toll plaza the information about user account is sent on the user's mobile application. The mobile application is also used for registration of new user along with his RFID Number. If balance in the user account is less the mobile application is used to deposit the amount in user's account through online transaction. Fig 1 shows the block diagram of entire system.

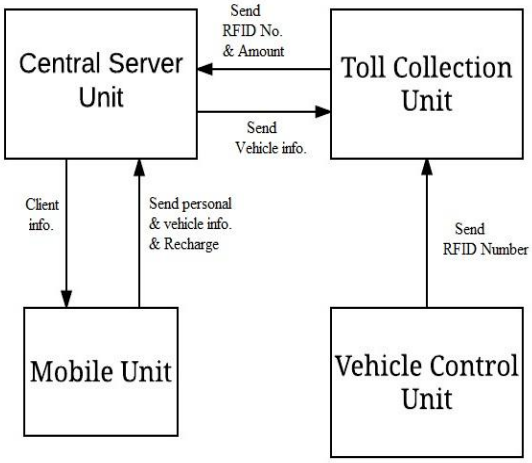

Fig 1 System Model

The detail explanation of each unit of system with its block diagram and working is as follows.

A. Toll Collection Unit (TCU): -

Fig 2 shows the block diagram of Toll Collection Unit. When the vehicle with RFID tag arrives at toll plaza, RFID reader reads the RFID Number of the RFID tag. The RFID reader at toll plaza sends the RFID number of RFID tag attached to the vehicle to the Arduino Mega. Based on received RFID number Arduino Mega classifies whether the vehicle is goods carrying vehicle or passenger carrying vehicle. If Arduino Mega identifies the vehicle as goods carrying vehicle then it is weighed and if it is found to be overloaded then charged with extra toll.

The amount to be charged for goods carrying vehicle depends on whether the vehicle is overloaded or not. Once the amount is decided, it is send to CSU along with the RFID number.

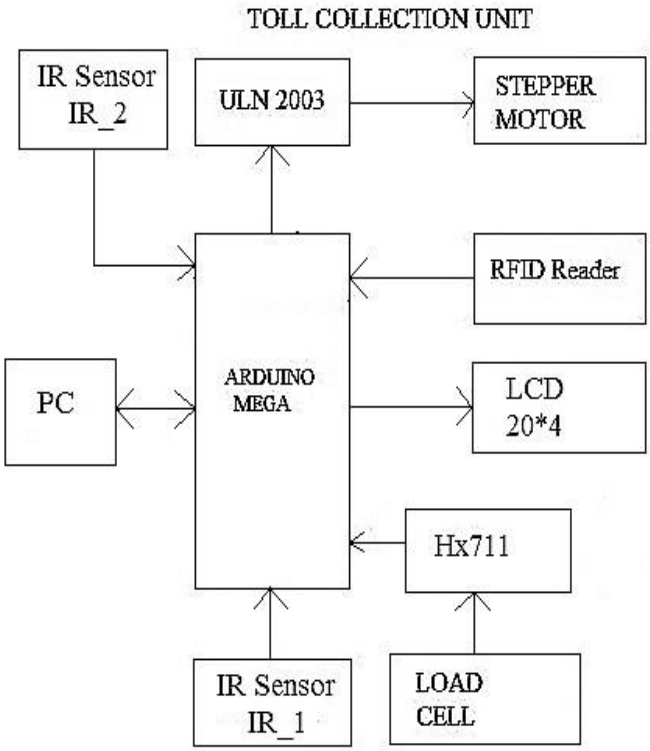

Fig 2: Toll Collection Unit

If Arduino Mega identifies the vehicle as passenger carrying vehicle, then the amount to be charged is decided directly without weighing the vehicle. The amount to be charged along with the RFID number of vehicle is sent to CSU.

Once the CSU receives an RFID number of vehicle and amount to be charged from TCU through web services using post method, CSU checks whether the vehicle is stolen or any accident case is registered against the vehicle. If any case is registered against the vehicle (i.e. if the vehicle is stolen or any accident case is registered) or if there is no sufficient balance in users account, the CSU declares the RFID of the vehicle as an invalid RFID. The CSU informs TCU that RFID is invalid using post method, thus the vehicle is not to allow to pass through toll plaza. If the user doesn't have sufficient balance in the account, then user can pay toll using cash mode. If the vehicle is not blacklisted and the user account has sufficient amount in his account then balance is deducted from the user account at CSU. After every transaction, information about the user's account is sent on user mobile application.

B. Central Server Unit (CSU): -

Fig 3 shows the block diagram of the Central Server Unit. Central Server Unit is used to store the information of vehicle

in database at web server on public domain using web services.

CSU also keeps record of stolen vehicles and vehicles against which hit and run case is registered. CSU keeps the record of all transaction of the user at toll plaza and delivers the information of every transaction on the android mobile application.

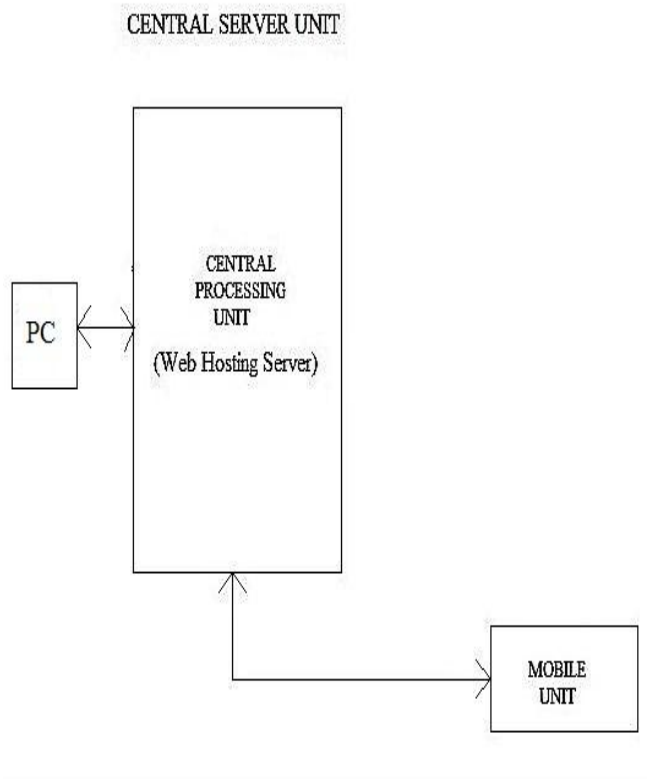

Fig 3 Central Server Unit

When vehicle arrives at toll plaza, TCU requires information of vehicle like balance of user, whether vehicle is stolen or any accident case is register against the vehicle. In order to get the above information the processing sketch use post request, where the parameter to be send is "RFID Number". Processing IDE is interface between Arduino at TCU and Web server at CSU.

On receiving post request, CSU collects information like user balance, any case is registered against vehicle and whether is stolen vehicle for corresponding RFID Number using PHP script stored at server database.

Once CSU collects information for corresponding RFID Number, it sends this information to TCU using post method. When amount to be charged is deducted from balance of user, the TCU post the remaining balance to server.

The remaining balance amount received from TCU is then update in user account at CSU using PHP script. The Central Server Unit also consists of a separate table for each toll plaza in server database which maintains record of all transaction on Toll Plaza.

C. Vehicle Control Unit (VCU): -

Vehicle Control Unit is implemented in vehicle. The main purpose of VCU is vehicle identification during collision and Theft Detection Mechanism. The Vehicle Control Unit implemented with robot vehicle satisfies both the purpose. Fig 4 shows the block diagram of Vehicle Control Unit implemented with dummy vehicle. While the Vehicle Control Unit implemented with dummy vehicle satisfy the purpose of vehicle detection during collision.

Fig 5 shows the block diagram of Robot Vehicle with Vehicle Control Unit . The Vehicle Control Unit comprises of RFID tag and RFID reader in order to provide unique ID to each vehicle. Piezoelectric sensor is attached on the front part and vibration sensor inside the door or on the side part of the vehicle to sense the vibration during collision.

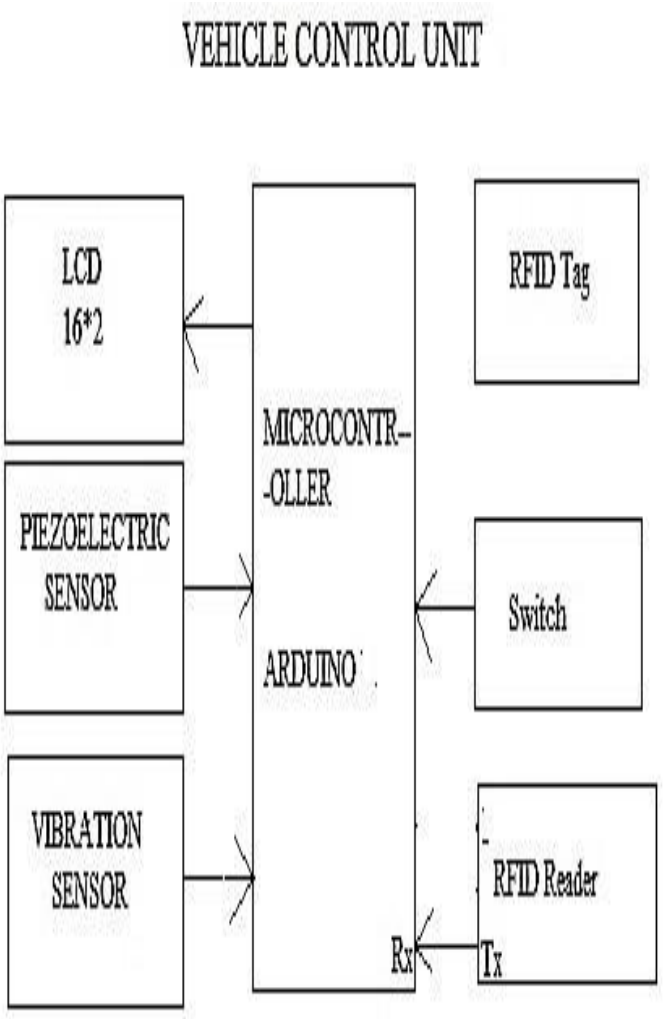

Fig 4 Vehicle Control Unit implemented with dummy vehicle

When Dummy vehicle and Robot vehicle collide each other, the Piezo-electric sensor along with comparator or vibration sensor attached to both vehicles produce electric signal.

If one vehicle among both collides on front part the piezoelectric sensor produces the output voltage. The output voltage of piezoelectric sensor is very small and it has high impedance. The piezoelectric sensor gives electric signal to comparator circuit. The circuit diagram of comparator circuit is shown in Fig 6.

The first transistor is held in "bottoming" and the second in "cut-off." This offers very low current consumption and produces the maximum output. The second transistor is "turned-off" because the first transistor is "ON" and the voltage across its collector-emitter terminals is about 0.35v and which is below the turn-on voltage of 0.65v to the base of the second transistor.

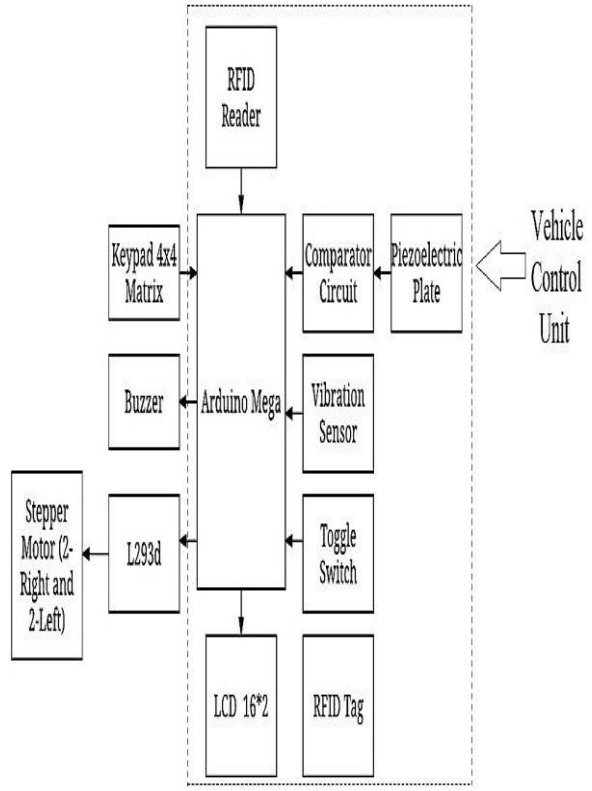

Fig 5 Robot Vehicle with Vehicle Control Unit

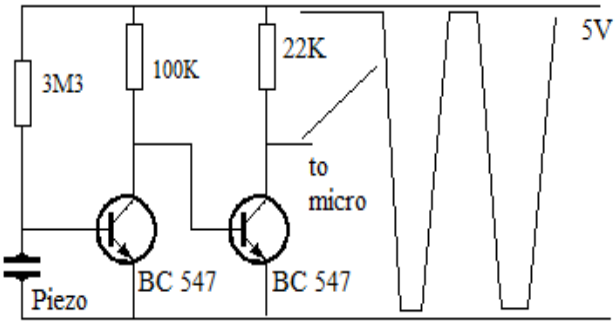

Fig 6 Comparator Circuit for Piezoelectric Sensor

The first transistor is fully turned on but the turn-on current is very low and this allows the maximum waveform to be produced by the piezo for a given strike intensity. In other words the circuit puts the lightest load on the piezo. When no-signal is present, the output of the circuit is HIGH i.e. 5v. A signal from the piezo produces a full-rail waveform to exactly match the waveform from the piezo. By monitoring the output of the circuit it is possible to detect the instant the waveform produces a LOW.

In case if dummy vehicles collide from front, the piezoelectric sensor generates small signal due to collision, the comparator circuit gives active low signal on digital pin 8 of Arduino Uno. In response Arduino enables RFID reader. The RFID reader then reads the RFID number of robot vehicle, and sends to Arduino. The Arduino then store the RFID number in EEPROM memory and also show on LCD screen in vehicle.

In case if robot vehicle collides from front, when the piezoelectric sensor generates small signal due to collision, the comparator circuit gives active low interrupt on digital pin 3 of Arduino Mega. In response Arduino enables RFID reader. The RFID reader then reads the RFID number of dummy vehicle, and sends to Arduino. The Arduino then store the RFID number in EEPROM memory and also show on LCD screen in vehicle.

In case if robot vehicle collides from side, the vibration sensor generates signal due to collision, the vibration sensor gives active high interrupt on digital pin 2 of Arduino Mega. In response Arduino enables RFID reader. The RFID reader then reads the RFID number of dummy vehicle, and sends to Arduino. The Arduino then store the RFID number in EEPROM memory and also show on LCD screen in vehicle.

In case if dummy vehicle collides from side, the vibration sensor generates signal due to collision, the vibration sensor gives active high interrupt on digital pin 2 of Arduino Uno. In response Arduino enables RFID reader. The RFID reader then reads the RFID number of robot vehicle, and sends to Arduino. The Arduino then store the RFID number in EEPROM memory and also show on LCD screen in vehicle.

The RFID Number stored in EEPROM memory of Arduino after collision can be used as a valid proof while registering case or claiming insurance. If the case is registered against vehicle then the vehicle is marked as black listed in database at CSU.

D. Theft Detection System: -

When user wants to start the vehicle he must have valid RFID tag, vehicle will not start until the RFID reader detects valid RFID tag. If a vehicle is stolen, then the case is registered against it and marked as black listed vehicle. If such vehicles arrive at toll plaza, CSU detects it as a stolen vehicle. CSU gives response to TCU that a vehicle is stolen vehicle and don't allow vehicle to pass. The theft detection mechanism is implemented in vehicle by using some components of vehicle control unit in order to protect vehicle from thief as shown in Fig 5. The RFID reader and RFID card are the two essential elements for theft detection mechanism. Here we have implemented theft detection mechanism in robot vehicle. When user wants to start the robot vehicle he/she must have valid RFID card with RFID Number. The vehicle doesn't start until the RFID reader detects valid RFID tag. If RFID Number is invalid "Get Out" message is displayed on LCD screen and buzzer is activated which indicate that vehicle is being stolen. If RFID Number is valid the vehicle is allowed to start by pressing the specific buttons on keypad.

It is also possible to track the stolen vehicle using theft detection mechanism along with Toll Collection Unit and Central Server Unit. If a vehicle is stolen the case is registered against it, and the vehicle is added to the stolen vehicle list in server database.

When vehicle which has RFID tag with RFID number marked as stolen vehicle arrives at toll plaza, TCU send RFID Number to CSU. CSU detects it as a stolen vehicle based on information of vehicle stored in server database.

IV. RESULTS

A. Results of vehicle identification during collision

When a robot vehicle with tag T1 (RFID Number 3E00677FAC8A) collides with dummy vehicle with tag T2 (RFID Number-3E0067807DA4), piezoelectric sensor or vibration sensor attached on both vehicles gives interrupt to the microcontroller.

Fig 7 Robot Vehicle display RFID Number of Tag T2

In response to interrupt the Arduino of both the vehicles enables RFID reader to read the RFID number of opposite vehicle, so both the vehicles exchange the RFID numbers. The Arduino stores the RFID Number received from RFID Reader in EEPROM both the vehicles. In order to display RFID numbers stored in EEPROM, interrupt is provided by the toggle switch. In response to interrupt Arduino display data on LCD screen.The RFID Number stored in Robot Vehicle is shown in Fig 7. The RFID Number stored in Dummy Vehicle is shown in Fig 8.

Fig. 8 Dummy Vehicle display RFID Number of Tag T1

B. Results of theft detection

A Robot vehicle is used for demonstration of the theft detecting mechanism. In order, to start a Robot vehicle valid RFID tag is required. When RFID Reader attached on the vehicle, detects the RFID tag it reads the RFID Number of the tag and send to Arduino on serial pin using serial communication. Arduino compare the received RFID number with RFID number stored in Arduino memory.

If the received the RFID Number matches with stored RFID number, then Arduino declares the RFID tag as valid RFID tag. When Arduino detects valid RFID tag, then it display message "Happy Journey" and vehicle is allowed to start as shown in Fig 9.

Fig 9 Arduino display for Valid RFID tag

If the received RFID Number doesn't match with stored RFID number, then the Arduino declares the RFID tag as invalid RFID tag. When Arduino detects invalid RFID tag, then it display message "Get Out" and buzzer is activated and vehicle is not allowed to start as shown in Fig 10.

Fig 10 Arduino display for Invalid RFID tag

V. CONCLUSION

The vehicle detection during collision helps to exchange the RFID of vehicles during collision. Hence it is easy to detect the culprit in hit and run cases. Implementation of theft detection will help to prevent vehicle from getting stolen. Implementation of toll collection unit helps to reduce congestion at toll plaza. Management of toll collection becomes easy since all toll plazas are connected using Web server. Development of mobile application helps user to keep track of his account and Recharge his account when required.

VI. FUTURE SCOPE

Development and installation of 'Deposit Machine' at toll plaza in order to deposit desired amount in user account if his cell phone network is weak. Implement GPS tracking along with theft detection mechanism for tracking stolen. Increase security features in Android Application.

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