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Automated Toll Collection System with Vehicle Categorization and Enhanced Security

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Abstract - *Now-a-days manual toll collection system has created a problem for managing the traffic at the toll plaza. The number of vehicles is observed to be increasing day by day as the population increases in cities. It has become very frustrating waiting in the queues for a long time and that results in unnecessary fuel consumption of the vehicles. The present scenario is responsible for slow toll collection process and huge wastage of time. So, in order to solve the current issue of manual toll collection system, we have decided to implement Automated Toll Collection System which will reduce the manual collection of tolls and finally help the vehicle pass smoothly without any wastage of time, avoid congestion on roads and also reduce needless noise pollution due to vehicle honking. We strongly believe that after the implementation of our project, it will bring a vast change in the current scenario and help towards future. Our method was able to greatly reduce the time taken by 54 seconds at the existing toll plazas by implementing lane categorization and lane segmentation.*

Key Words: Toll Plaza, RFID, 8051, ESP8266 Wi-Fi module, Traffic Congestion.

1. INTRODUCTION

The Internet of Things (IoT) is a hardware, software, and sensor platform. It enables data collection, management, and transmission. From the standpoint of the toll collecting system, vehicle geolocation, and real-time data acquired from deployed IoT infrastructures give a wealth of information for improving user-friendly social services.

Automatic toll collection is a technology that enables for the collecting of toll fees in an automated and computerized manner. Researchers have explored and deployed such a procedure of Automatic Toll Plaza in numerous expressways, bridges, and tunnels.

ATP can determine whether or not a vehicle is registered, and then notify the management center of any violations, debits, or participating accounts. The best feature of this ATP system is that it can eliminate toll plaza congestion, especially during peak seasons when traffic appears to be higher than usual.

The RFID technology detects and reads the information stored in the RFID passive tag connected to the car using EM waves generated by the RFID reader.

RFID (Radio frequency identification) is a rapidly growing field of automated identification that is currently being examined for improving data handling procedures, complementing existing data capture technologies such as bar coding in many ways.

The suggested Automated toll collecting system is moving forward after combining IoT and RFID technologies with other important software-hardware modules.

When a vehicle passes through the toll gate, the scanner detects the RFID tag's incoming frequency of roughly 125 kHz and reads a unique RFID number provided by the government authority, debiting the toll amount from the connected bank account.

2. Methods of Toll collection System

2.1 Manual Toll Collection:

The toll is collected manually where a toll collector stands and accepts the cash from the driver and the information is fed on the spot in the computer and then the toll receipt is generated.

2.2 Electronic Toll Collection:

This system also is human-less however it involves electronic machines that accept tokens provided by the toll agency booth.

2.3 Automated Toll Collection:

The whole system is automated and human-less. It uses a tag to identify the vehicle and the toll is debited automatically from the bank account as the vehicle passes through the toll gate.

3. LITERATURE SURVEY

P. Arokianathan et al. [1] developed a model of an automatic toll booth with theft detection system where the user is supposed to enter the source and destination and then he is routed to the payment method which still remains a time-consuming process. But the major advantage in this paper is that the theft detection system which was incorporated helps to catch a stolen car when it comes at the toll plaza.

Sabbir Ahmed et al. [2] developed a model of a toll collection system which uses RFID which helps to reduce the amount

of manual labor required in collecting the toll tax. But there was no system to verify whether the RFID which is being scanned belongs to that particular vehicle only which has entered the toll plaza. So, this remains as a major disadvantage of the model proposed by them.

Chintaman Bari et al. [3] examined the existing toll plaza present at the Ghoti Toll Plaza in Nashik, India. They concluded by saying that the electronic toll collection (ETC) system reduced the delay caused by manual toll collection (MTC) system by 95%.

Rajiv Israni et al. [4] implemented an automatic toll collection system for the current problem of manual toll collection. The main technology followed by him is Image processing technique. This technique follows OCR (Optical character recognition) to extract the license plate number from a vehicle through camera. After extracting the data by image processing, it is searched in data base whether it's valid or unregistered. If it is a valid register number, the toll amount is directly detected and the vehicle is allowed to pass.

Raed Abdulla et al. [5] designed an Electronic Toll Collection system using RFID Technology and IoT. When a vehicle enters into the toll the RFID tag is scanned and IoT is used to transmit data and send to main office by cloud. Here a different model is proposed by author that barrier gates are opened and do not close for the valid registers. So that in average 6s of time the vehicle passes through the toll which consumes lot of time.

Mavik Patel et al. [6] has used RFID and FASTag in order to reduce the waiting time for vehicles since otherwise there are very long queue. This paves a way out for a greener solution, also decreasing the carbon emissions but there is a risk and so we need to double verify, if a vehicle has actually paid the toll amount.

Kavyashree M et al. [7] have developed and automatic toll collection system using RFID tags. They have also implemented GPS and GSM modules. These modules were used to detect vehicle accidents, which can further be used for vehicle theft detection, an SMS app has been used to notify these vehicle accidents and theft.

Deepashree K et al. [8] have implemented an automatic Toll Collection system including RFID tags. Here, the author has given the flexibility of payment for the user at toll, including option like credit card and google pay. This can be implemented by the govt since this will also reduce the pollution of the country on overall and reduce the queues in Toll Plaza's.

4. METHODOLOGY

The proposed research is predominantly dependent upon Internet of Things (IoT) technology. This project was completed using the C programming language and the matrix technique. Sensors, 8051 microcontroller, RFIDs, breadboards, wires, resistors, and other components are also employed. When the first vehicle approaches the toll plaza, the sensor detects it, according to the project's flow diagram. Now, the user may insert their card into the RFID module, and if the card is legitimate, RFID will verify the balance and guarantee that the card has adequate balance before withdrawing the balance. The bar will open and the car will be able to go after the payment is confirmed. If the card is not valid, it displays a notice stating that it cannot be accessible unless the driver inputs a legitimate card. Once the driver enters a valid card, it is immediately accessed and functional. If the card's balance is insufficient, a message appears on the screen instructing the user to recharge the balance; after the balance has been recharged and the payment has been cleared, the bar will open, allowing the vehicle to drive through the Toll Gate.

4.1 Research Instrumentation:

RFID is mostly used for data reading and identification. RFID is made up of two components: an RFID tag and an RFID reader. RFID is a popular instrument that can be found in any robotics lab and electrical store, and it is inexpensive. There are two types of RFID tags: Active RFID tags and Passive RFID tags. The RFID reader uses two components: a transponder and transceiver that help read data. The transponder is used to identify the item, while the transceiver is used to read the value. The major difference between a transponder and a transceiver is that a transceiver is a passive tag, whereas a transponder is an active tag. A passive reader called a transceiver can detect an active tag transponder from hundreds of meters away since it has its own mini battery and an antenna with an electronic Microchip. One of the processes for automatically identifying objects and receiving data is RFID. The transceiver uses its appropriate antenna to connect with the tag. In recent years, extensive usage of radio frequency detection has been discovered, and it has been the focus of development.

ESP8266: The ESP8266 Wi-Fi Module is a self-contained SOC with an inbuilt TCP/IP protocol stack that can provide access to your Wi-Fi network to any microcontroller. The ESP8266 may either host an application or offload all Wi-Fi networking functionality to a separate application processor.

2*16 LCD Display: There are sixteen characters per line and two lines in an LCD (liquid crystal display). It has a parallel interface and utilizes 14 or 16 pins. The operating voltage must be between 4.7 to 5.3 volts.

IR Sensor: An infrared (IR) sensor is a type of electrical gadget that detects and measures infrared radiation in its surroundings. It can detect motion as well as measure the heat of an item. It has a detection range of 2 to 40 cm.

Other Components used: LED's, Resistors and Capacitor's.

4.2 Proposed Model:

If we look at our project's workflow diagram, we can see that when a vehicle enters the toll plaza, the sensor detects the vehicle, and the RFID module reads the id number to see if it's registered or not. If the card is registered, the RFID module checks the balance to see if it's sufficient, and then deduces the balance. When the balance display deposit on the LCD is deduced, the traffic gate opens, the IR sensor detects the vehicle departing, and then the gate closes. If the card has adequate balance, it can update the balance on the LCD, and if the card is not registered, it cannot be used; however, if the card is registered, RFID can read the id again and the system may continue.

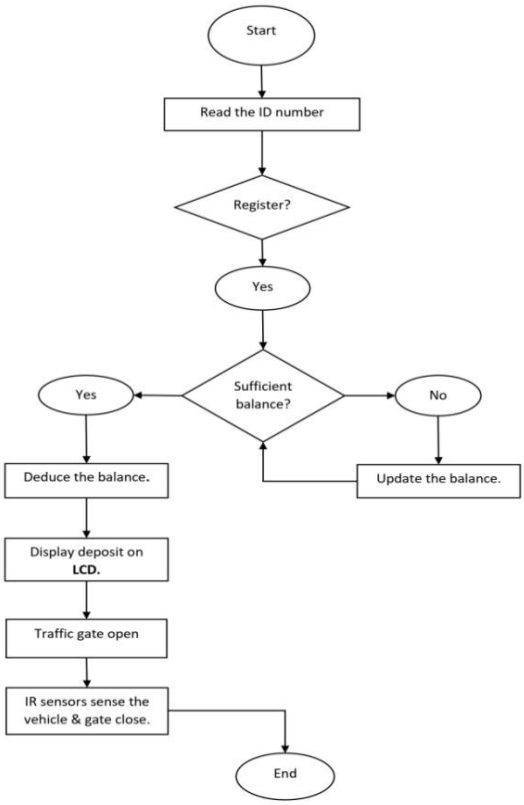


Figure 1: Flowchart of the proposed Model

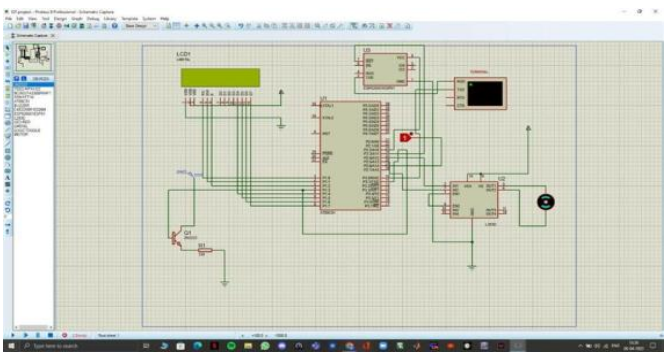


Figure 2: Circuit diagram of proposed setup

4.3 Lane Segmentation

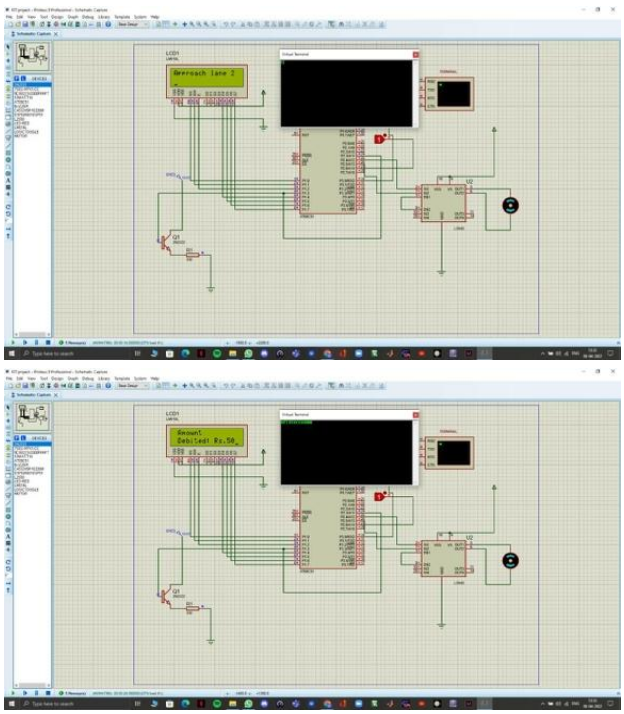
We know some vehicles need to have more priority than some other vehicles. For example, an Ambulance carrying a patient with emergency needs have to go through the Toll Plaza, since there is a life at stake. For these kinds of situations, we have implemented a Lane Segmentation system, which allows vehicles like Ambulance, Fire Brigade and Police Jeep to have a separate lane, through which there is instant pass for these vehicles, we have assumed Lane 4 for this case. Lane 2 for cars and private vehicles alone. Lane 3 for Heavy Vehicles like Trucks. And Lane 1 for Bike's and Three wheelers which are exempted from Toll Tax.

4.4 Performance of the Model

We put our project model to the test and achieved a remarkable outcome The model will be much more beneficial for our country, India. Our model can observe that the automobile has been able to identify the purchase as soon as it is made. The project's concept requires no more than five seconds to process payments and collect information about all automobiles. This model has the capability to store driver information such as name, date, vehicle number, time, and id number, making it easier for the government to locate vehicle information. If we compare the manual Toll Collection system to our project, we can conclude that our project has a more optimum performance since it operates at a rapid pace.

5. SIMULATION RESULTS

5.1 Car



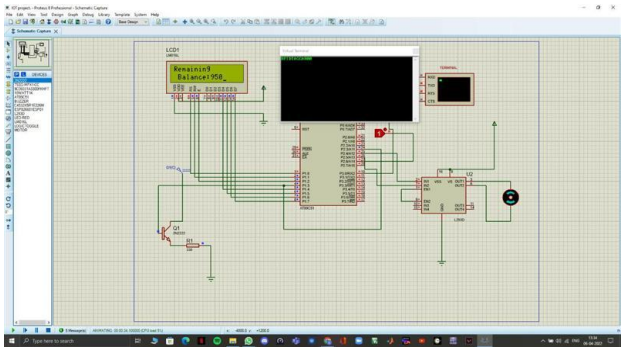


Figure 3: When car enters the proposed toll plaza

5.2 Ambulance

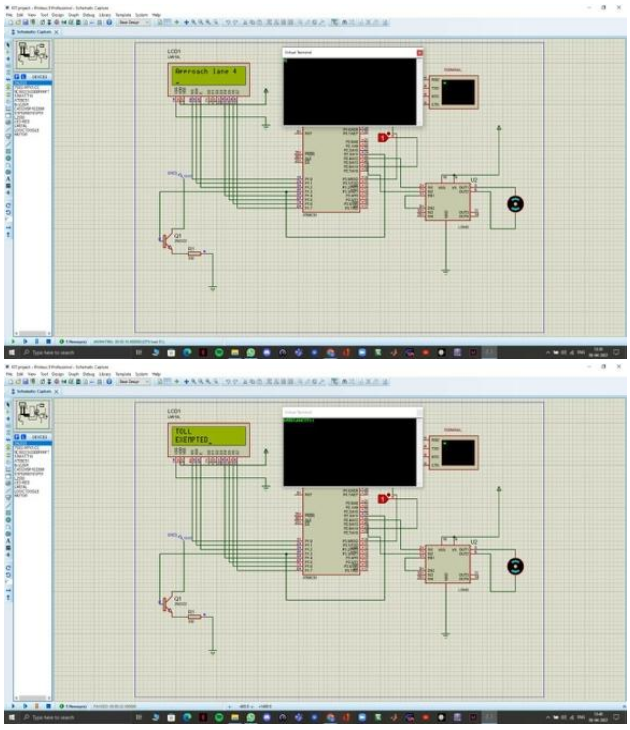


Figure 3: When ambulance enters the proposed toll plaza

5.3 Excel Database

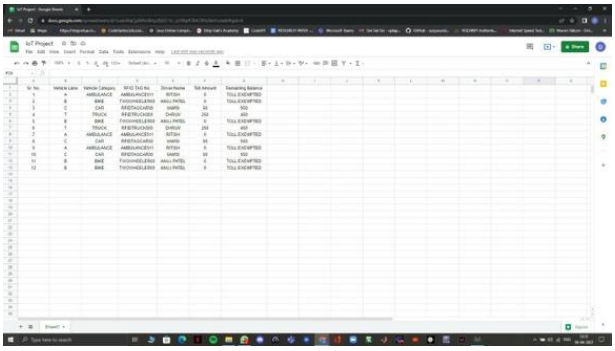


Figure 4: Excel database for records

6. RESULTS AND DISCUSSIONS

The results of the model used in our project6 are on the positive side. To explain, when a vehicle enters the toll plaza and the driver punches the card in RFID, it reads the data and transfers it to an Excel sheet using the WIFI module. It can collect information such as the date the driver punches the card, the exact time the payment clears, the driver's original name that they use in bank registration, the vehicle registration plate number, and the User Id. In case someone's information needs to be recovered, the toll organizer can easily find it by going through the online database which has a history of transactions and the list of users. This way the safety of every person's data can be kept safe and easy to access in case of any kind of disaster or disruption. When we compare different models to our model, we can observe that our prototype takes less than 120 seconds to transact the amount and display the message, while most of the other models have taken much longer. Each second counts, by this way we are saving a lot of fuel and hence, a better thing environmentally. Also, when there's lesser fuel consumption, there's going to be lesser pollution caused, and since nearly 30% of the pollution caused in India (source: Wikipedia) is due to vehicles, we presume this is a great step towards reducing it. Using Lane Segmentation in our project has addressed the need to give attention in case of emergency or disaster. With this, the ambulances or Fire Trucks or NDMA (national disaster management authority) have the access to faster way to the destination, which at times can have lives at stake. We have made it easier, faster, safer, more flexible, and time-saving for Indians to use E-Toll.

Table -1: Time Comparison for vehicles at toll plaza

	Methodology	Methodology
Average Time	2 min 34 sec.	

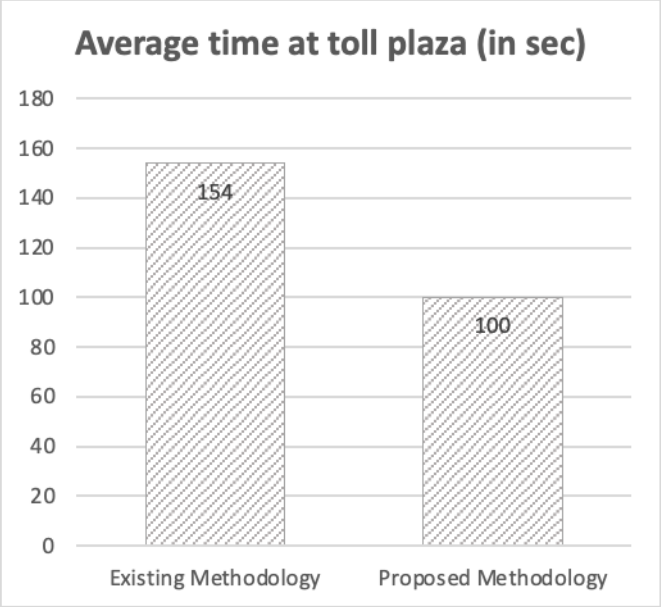


Figure 5: Time Comparison for vehicles at toll plaza

7. CONCLUSION

There is a great deal of traffic congestions in Toll Plaza's. In India, we have been adopting to FASTag, but it isn't been incorporated by most of the rural areas yet, where they still use MTC (Manual Toll Collection) which consumes a lot of time of the passengers. To overcome this issue, here in this model we have used RFID technology to be able to compress the timing that one shall wait at a Toll Plaza. We have obtained an average time of 5.005 seconds for the process. This if and when implemented by the government shall make huge amounts of differences in the carbon emissions of the country. This also decreases the workload on the Toll Plaza workers who can now help out in case of emergency or transaction failed or Online Database crash. It is important to maintain the online database and do regular checkups against virus and stuff. Since the world is moving towards faster Toll Collection systems, in which the RFID technology plays a very important role. NHAI (National Highway Authority of India) has started a latest technology involving highspeed highways with the least Toll Plaza wait time on route Delhi to Jaipur. Sometime in the future, Pilotless automobiles will be employed as vehicle infrastructure technology advances. The technology for collecting tolls on Indian Highways will change dramatically at that time. It's possible that free-flow toll collecting on Highways (no need to stop at the plaza) will become a reality.

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