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A Review on Various RFID Based Automated Highway Toll Collection Systems

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***Abstract*—Lot's of cars travel on the highway and toll tax needs to be collected from them as they pass by but it is a very tedious process and improper management can lead to high levels of waiting time, and pollution levels too. Many systems have been developed to reduce the complexity of the process by introduction of Automation in Toll Collection. There are a bunch of systems available, we compare some of them and also find the scope of further improvement in such systems.**

***Index Terms*—Toll Collection, RFID, GSM, Automation, Automatic, Automation, E- Payment, 8051, Micro-controller Systems.**

I. INTRODUCTION

There are many highways on the road and they on an average pass through a toll collection system on an average of 50 kms and there are many cars that pass through a single toll plaza. And since people have the urge to reach their destination on time, and the fact that they need to wait in a line (in conventional systems) to pass through a toll gate, involves the process of stopping at the toll gate, giving change to the toll gate manager, and take the ticket and return change(if any) only then the manager will raise the gate for your vehicle to pass through it. The entire conventional process is very time consuming and make take a vehicle anywhere between 15 mins - 1.5 hrs depending upon the traffic conditions. Hence, there arisen a need to develop automated systems that would help reduce the complexity of the process. Many people have developed such automated systems so that cars could just pass through the toll gate without stopping and also automatic payment facilities were provided. We discuss some of the most widely systems that are viable for use in such a situation. We also shall give an insight of the possible flaws of the system, and also what we could improve in such systems to make it more apt for the problem faced above.

II. LITERATURE SURVEY

We now continue to analyze some of the systems developed. The first paper[1] discussed a system that was developed to provide with the following features:

i. Reduce time for collecting toll at the toll plaza.
ii. RFID tags can be read at much greater distances; an RFID reader can pull information from a tag at distances up to 300 feet.
iii. As the vehicle approaches the identification site, the computerized control unit placed near toll lane receives the identifier signal and calculates the toll to be debited and electronically debits the toll on the account of the particular vehicle.
iv. This system allows a vehicle to persist past the scan point without stopping, thus offering maximum convenience to motorists, speeding up the flow of traffic, and reducing the number of human resources required at highway toll plazas.
v. Smooth traffic flow at toll gates.
vi. Convenient toll collection without handling cash.
vii. Reduction of management costs.
vii. Convenient and quick service to the vehicle owners.
viii. Stolen vehicles can be detected.

The first paper[1] then discussed about RFID technology. RFID is the acronym for Radio Frequency Identification The components of the RFID System basically include RFID transmitter, a RFID receiver and some processing machine(a computer). The paper then goes on to discuss about the types of RFID tags(RFID transmitters). Types of RFID tags include Active Tags and Passive Tags. Active tags are used to transmit information that includes the RFID tag's ID, as well as some other information that can be soft-coded into it. Soft coded information means that it can re-writable and can also be dynamic in nature. In this problem statement, the soft-coded information could include the Global Position Coordinates of the vehicle on which the RFID tag is attached.

The paper[1] then goes on to discuss a micro-simulation model of the actual toll collection system by providing an architecture for the system.

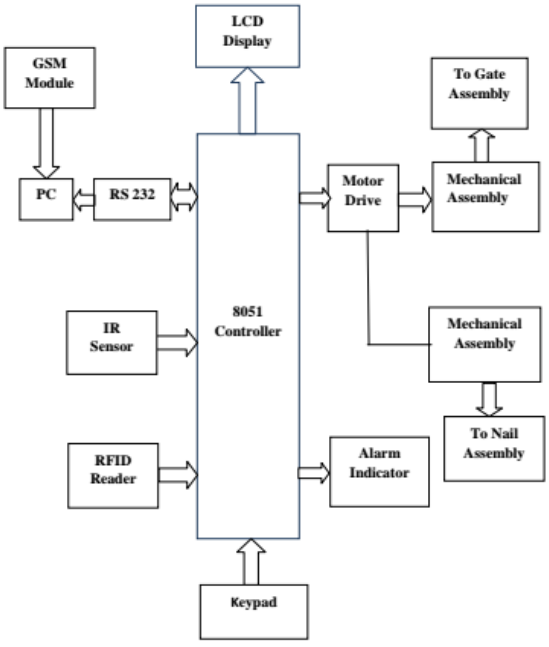

Fig. 1. Hardware Implementation of System in Paper[1]

The RFID reader is used for receiver for the information of the vehicle of the system which is mapped to the database. The GSM module is used for connecting the entire system through the Internet. The LCD system is used to display the information of the vehicle passed such as the RFID ID, The Number Plate of the Vehicle, the Existing Balance of the Vehicle and so on. The sub-system to the right of the micro-controller is the mechanism for controlling the passing of the vehicle through the toll gate. The Motor Drive is for raising the gate of the system, while the Alarm Indicator is for raising an alarm if any illegal vehicle passes through the Toll Gate.

Then the paper[1] proceeds with the logical view of the various modules of the implemented system as shown below:

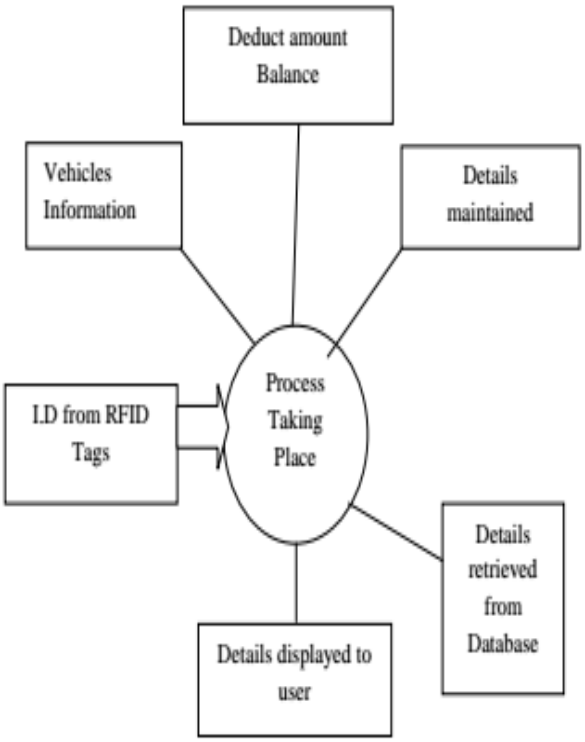

Fig. 2. Logical View of System in Paper[1]

The paper then concludes by stating the advantages/disadvantages of the system as well as the future scope. The advantage is that of the RFID technology that scores high on reliability. The disadvantages include difficulty in duplicating tags, installing tags on an uneasy location and requirement of power(Active Tags) to transmit information.

The second paper[2] is a variation of the first paper[1]. The basis of both the paper remains the same but the method of implementation is different. The hardware implementation of the system is as shown below.

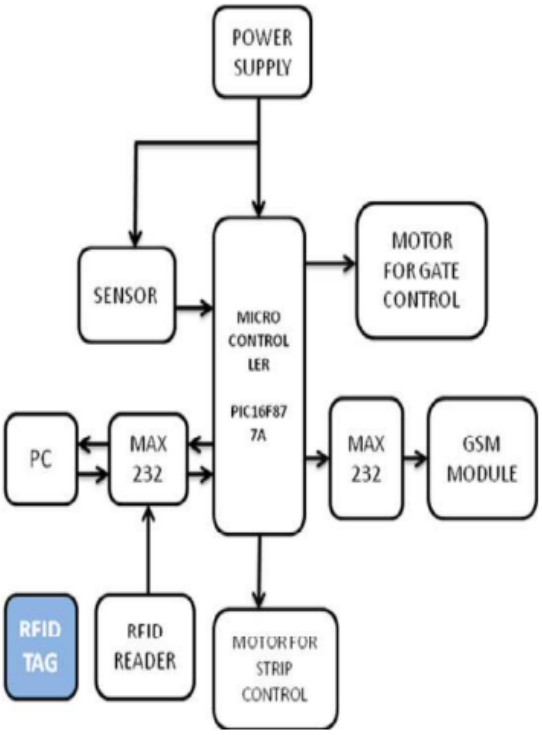

Fig. 3. Hardware implementation of System in Paper[2]

The hardware architecture of the system discussed in the second paper[2] is similar to the architecture discussed in the first paper[1]. The only difference between the two systems is the software implementation of the system. The hardware component functionality is being explained in the previous section.

The software architecture of the system involves a user interface(UI), a Database Program(which is responsible for the connectivity between the front end and the beck end of the software, and MPLAB which is another IDE(Integrated Development Environment) for interfacing the Personal Computer and the Micro-controller. The combination of the three is the overall software used for the application. To give more clarity on the working of the proposed system, the paper provides with the flow chart of the events that occur in the system.

The flow chart shows the simplicity of the implementation of the system. We can conclude this by the fact that it contains only one decision node and the sequence of execution of events is linear. But there is one possible flaw. Supposing a vehicle tries to pass the road and there is insufficient balance to let the car pass through the gate, the driver would just keep wondering for the reason why the gate is not lifted up. Only when the user comes to know by the notification on his mobile phone that the driver will know the reason, this could cause up unexpected traffic jams which is highly undesirable.The flow chart is as shown below.

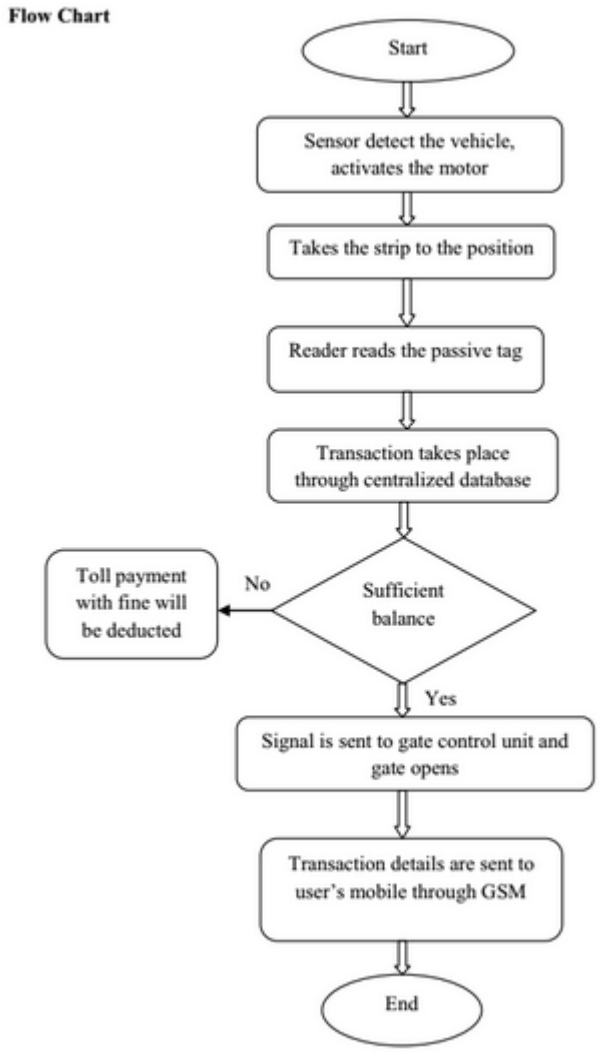

Fig. 4.Flow Chart of Working of System in Paper[2]

The second paper then concludes with the usability of the system in real life conditions by the fact that RFID is a very stable and reliable technology and that the system will help reduce congestion at toll gates and significantly reduce the overall complexity of the system.

The third paper[3] discusses another system which aims to solve the problem of waiting period and payment issues faced in the conventional manual toll collection system.The paper[3] starts giving an introduction to the problems in the conventional system, and how will the new system be able to solve majority of the problems.

The paper[3] proposes a system which has the following major components:

ix. Tag: transponder
x. RF Reader: Antenna
xi. Traffic Controller System
xii. Central Server

The Tag:Transponder is the RFID tag which is there on every vehicle which wants to avail the facility of this automatic system. The RFID tag can be of two types: Active or Passive in nature. Also that the tag can contain information including the Tag ID, along with some other information as discussed in the first paper[1]. The RF Reader: A hardware component for reading the information stored in the RFID tag.

The paper then gives a detailed review of the various types of the RFID technologies available so that we could make an apt selection of the correct type of RFID technologies that is the most suitable for tackling the given problem. The table is necessary in determining a RFID technology that can be read from a decent distance, doesn't require battery power and a long operating life. The table is shown below.

Type of Tag	EPC Class	Memory Type	Radio Frequencies Used	Word Length, Bits	Power Source	Reading Distance, Meters
RFID passive	0	ROM	138 KHz 13.85 MHz	64	Reader EMF	0.04 – 3
RFID active	4	ROM	13.85 MHz	64	Battery	3 – 10
RFID passive programmable	1	EEPROM	138 KHz 13.85MHz	96, 128	Reader EMF	0.04 – 3
RFID active programmable	2, 3, 4	EEPROM	138 KHz 13.85 MHz	>128	Battery	3 – 10
Data tag	2, 3, 4	CMOS RAM Flash RAM	13.85 MHz 985 MHz (UHF)	>128	Battery	3 – 10
RF location	-	EEPROM or CMOS RAM	303 MHz, 2.4/5.8 GHz, UWB	64	Battery	1 – 100

Fig. 5. Types of RFID tags discussed in Paper[3]

The Traffic Controller System is what makes the system different from the systems discussed in the first two papers. This sub-system allows the distribution of the cars incoming across a set of parallel toll gates. This sub-system using an appropriate Lane Allocation Algorithm. The purpose of the algorithm is to allocate the cars approaching the toll gate to be distributed among the set of the toll gates for optimum traffic management. This algorithm is crucial for the entire system, because if the algorithm fails to optimally allocate cars, then however fast the cars pass through the system, the overall objective of reducing the traffic conditions won't be achieved then.

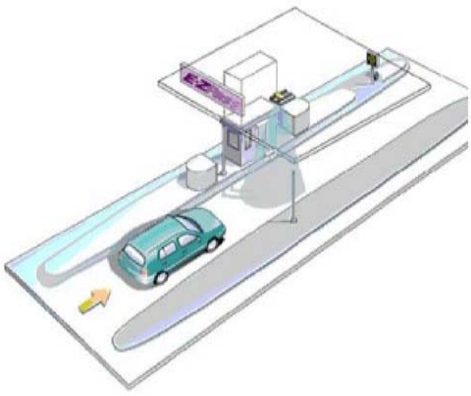

Fig. 6. Visual View of Traffic Control System in Paper[3]

The physical implementation of the toll gate is as shown below.

Fig. 7. Construction of Toll Plaza of System in Paper[3]

Also, the second important component that differentiates this system with the previous two systems is that of the traffic speed controller. In this technology, Active RFID tags is given access to the ECU(Electronic Computer Unit) of the vehicle. So that once the RFID tag comes into the range of the Toll Plaza, the ECU is directed to reduce the speed of the vehicle in case the vehicle is over-speeding. This is done, so that if the vehicle is over-speeding, then there are chances that the RFID tag could not be scanned and this would make the system impractical and would result in a major flaw in the system also resulting in financial losses.

The paper[3] ends up proposing a much better system than the systems proposed in the first two papers due to the two new technologies being used in the system to make it much more reliable and practical in real-life conditions.

III. Inferences

Now that we have done a deep literature survey of the 3 papers, we have an overview of the possible systems that can be implemented to tackle the solution, we basically know where we are heading. Also we are clear that what objectives have been completely achieved, what has been partially achieved, and what is yet to be achieved. Also, we need to take in the fact that technology is growing at a faster rate, hardware costs are coming down, softwares are now easier to maintain, we need to use the most modern technology available. Probably, we should get out of 8051 MC and use some advanced micro-controller to increase the overall processing ability of the system. If we utilize the available technology today, we shall always end up having better systems tomorrow.

IV. Conclusion And Future Scope

Thus we have tried to analyze some of the current RFID highway toll collection systems and to predict their practicality

in real conditions. We also support researchers who take this review as a baseline to continue to better the systems discussed for better performance, efficiency or reduced complexity.

Acknowledgment

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