A Review on Location Based Efficient Road Toll Collection System using RFID and NPRS Techniques

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Abstract. The road traffic controlling and road toll collections are became one of the challenging tasks in most of the developing and developed countries. The tollgate systems doesn’t account and verify from which particular place (source) the vehicle is started or joined that concern toll road and up to which particular point (destination) it reached/left/disjoined/used the road. If a toll road is of 60 KM length and a vehicle X started 05 KM away from its tollgate and another same category vehicle Y starts from 60 KM away will have to pay same charges. These existing systems are unable to tell which vehicles are using how much road services and accordingly how much should they pay for it. Therefore, specifically in Indian state highways are concern, road toll collection systems are not efficient and not justifying with the road pricing practices with vehicle owners. Due to these, most of the vehicle owners and passengers are facing numerous types of problems while travelling from one place to another place by road. To solve these issues, I tried to propose an efficient location based road toll collection system using RFID (Radio Frequency Identification) and NPRS (Number Plate Recognition System) techniques in this paper. The proposed model will help to collect toll charges efficiently from all vehicle owners as per their road usage.

Abbreviations: RFID (Radio Frequency Identification), NPRS (Number Plate Recognition System), GPS (Global Positioning System), ETC (Electronic Toll Collection).

1 Introduction

Road network is one of the very important infrastructures and become one of the primary platform to travel and transport goods from one place to another. Road transport is become the one of the life line of every human life. As day by day the population is increasing, the numbers of vehicles can also be seen increasing on road in which its become more challenging to provide proper infrastructure and services by the authorities.

India is having 2nd largest number of road network across the world. Transportation has come in front of us as a regnant part of India [1]. The development of road infrastructure in any country needs to undergo through very high investment and most of the concern government ministries/departments take this responsibility. In India, the Ministry of Road Transport and Highways look over the development and maintenance of National Highways. According to the 2022-23 Annual Report of Ministry of Road Transport and Highways of India, the total length of National Highways is 1,44,955 KM, and State Highways is 1,67,079 KM which in totality serve as the arterial network of the country as shown in Figure 1. [2][3]. The road map displayed in Figure 1 is compiled in QGIS 3.30 which uses Survey of India’s road map data. Apart from these national and state highways, there are few other types of roads can be found such as service roads, village roads etc. which are used for the local road transportation.

Now days most of the state and national highways in India are collecting toll taxes for the development and maintenance of their concern roads to provide a safe and hassle free road transportation [1]. Electronic toll collection (ETC) systems make it easier for drivers to pay the fee for driving on toll roads [5]. Among all these tollgates, most of the tollgates are equipped with Fastag (Digitally captures the radio frequency by means of RFID technology) automatic payment collection system, but few are still using manual payment collection system [4][11][12].
Due to manual toll collection system and their slow processing, the heavy traffic jams and long queue at the toll plazas has become a great challenge in India \cite{6}. In these road price collection practices I observed few limitations and the same are discussed with some suitable possible solutions in the next section 2.

India has a very vast road network (Figure 1) in which all roads are providing their own kinds of services to crores of vehicles daily. For better road services like safe and hassle free road transportation, the ‘Toll plazas’ or ‘Tollgates’ are the need of the hour which required for the development and regular maintenance of road infrastructures. But, most of the toll plazas are using traditional toll collection systems which do not justice with all vehicle owners.

As per my opinion, if a vehicle is using minimum road services should pay the minimum payments, and the vehicles which are using more or complete services should pay the appropriate or full payments. But here in India the story is different. Either you use the road or not it doesn’t matter, once you cross the tollgate means you must pay for it. And at another side, most of the vehicles are using maximum amount of toll roads and when the tollgates come they use to take some alternate or bypass roads to avoid the toll charges. One side few people paying complete road charges for using very minimum amount of road services and another side few are paying nothing even though they are using maximum road services by bypassing the tollgates. The possible solutions for the above discussed problems are presented in section 2 Methodology.

Depending on why they are charged, tolls are categorized as either road tolls (private pricing) or congestion tolls (congestion pricing). By redistributing traffic from peak to off-peak hours, from congested to less congested routes, or from private vehicles to public transportation, congestion pricing helps to reduce network congestion. When road links are established entirely or partially with private funding, the expenses associated with their construction or upkeep is recovered through the use of private toll pricing. Some recent changes in road pricing are covered in this special issue. One paper addresses toll adjustment for road franchising, while three papers look into congestion pricing. Theoretical results and optimization models may prove valuable in further road pricing research \cite{8}\cite{9}\cite{10}\cite{13}\cite{14}. 
The existing toll collection systems in India are unable to tell which vehicles are using how much road services and accordingly how much should be charge. Therefore, specifically in Indian state highways are concern, road toll collection systems are not efficient and not justifying with the road pricing practices with vehicle owners. Due to these, most of the vehicle owners and passengers are facing numerous types of problems while travelling from one place to another place by road. To solve these issues, I tried to propose an efficient location based road toll collection system using RFID (Radio Frequency Identification) and NPRS (Number Plate Recognition System) techniques in this paper.

2 Methodology

Today in India, the site locations of toll plazas or tollgates are not uniform or same on all their toll roads. As shown in Figure 2, 3 and 4, the tollgates can be located at the beginning of their toll roads, while few are at end locations, few are located in the middle, and few are placed at both ends in which they use to collect the toll charges.

According to the current review on the new developments and innovations of road toll collection systems, Researchers and Technicians are working on how to replace road tollgate systems with GPS automated system. But in India, It can be done later or after few years. Because today majority of the Indian vehicles are not fitted with GPS devices, therefore those cannot be monitored by satellites to collect their toll taxes. Therefore the possible solutions for the current problems are discussed in this section.

As discussed above, the tollgates may be located at any end, or in between of start and end points or of both sides. The tollgate pricing can be calculated by placing multi-model vehicle recognition system i.e. RFID (Radio Frequency Identification) Readers and NPRS (Number Plate Recognition System). These RFID readers and NPRS can be placed at the both sides of the toll roads (In and Out) at specific distance should be interconnected with each other to pass vehicle information to central system which can be placed in tollgates [3][2].

3 Results and Discussion

![Diagram of RFID Readers and NPRS network on Roads with tollgate at both ends](image)
As shown in Figures 2, 3, and 4 the RFID and NPRS system will find that from which location a vehicle is started or joined the toll road and how much distance of road it used. Once the start and end locations of the vehicle will get confirmed, the road tax for that particular vehicle will be calculated and the same can be get collected using Fastag system. The local authority/management will decide how much charge should be paid for a particular distance.

The possibilities of collection of toll charges with reference to vehicles start point, end point, Low balance in Fastag, not recharging of Fastag are discussed here:
Consider if a vehicle starts from a point and travels some distance and becomes unavailable to the next RFID & NPRS point, then the distance between starting RFID&NPRS point to its last detected RFID & NPRS point can be calculated and the same can be collected using Fastag. If a vehicle fails to pay the toll amount due to low balance in Fastag, the balance can be made negative and the same can be collected back with some specified fine when it will get recharged. Further, if a vehicle Fastag having negative balance and started to use the toll road can be punished or penalized by the authority. Otherwise, the system will not run properly.

Once the government/authorities will make it mandatory to have GPS devices in each and every vehicle, the work of toll collection will become easier. But, depending on only GPS systems does not work in future also, because some GPS devices in some vehicles may not work properly, may get damaged or some may be removed from their vehicles. Therefore I suggest a multi-model vehicle recognition and tracking system which will consist of RFID Readers, NPRS and GPS for future toll collection. If GPS fails, the RFID will recognize the vehicle; if both fail the NPRS will recognize the vehicle. Therefore the error rate in this multi-model system will be null or very less. Even if a vehicle passes without giving its identification to the said system, the system can generate a message and same can be passed to concerned road authority people to manage this issue.

Providing a summary of price defining methods, simulation methodologies, and a discussion of the most recent technological uses in the industry. The most popular technique for defining prices turned out to be optimization, however, control-based algorithms are widely used in controlled lanes toll pricing schemes [9].

4 Conclusion

Majority of people in the world prefer road network for their regular travelling and transportation purposes. The development of faster, safer and hassle-free road infrastructure needs very high investments. The governments/authorities are investing more and more money for the development of road infrastructure, and the same is recollecting from vehicle owners. But, while recollecting money in the form of toll taxes, these tollgates/toll plazas are not doing justice with vehicle owners. In this regard, some possible solutions to design an efficient toll collection system which can justify all vehicle owners is proposed in this article. The models which are proposed in this article will definitely help for road pricing as far as current problems are concern.
As far as future study is concerned, the multi-model (RFID + NPRS + GPS) system may be used for future problems. Because, today, the majority of vehicles are not fitted with GPS devices and are not made mandatory in India. Therefore, the multi-model system may work better in future once all vehicles will get fitted with GPS devices and will become mandatory by government.

5 References

[5] https://mORTH%20Annual%20Report%20for%20the%20Year%202022.pdf