

A Review on Automated Toll Collection System

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Abstract

Many automated and smart toll fees collection systems has been proposed and implemented till date. The sole purpose of this review paper was to study such systems whether they are faster, efficient, low cost and secured. Main objective was to study the automated toll collection system. Automated toll collection system allows the vehicles to pass through toll barrier without stopping. The respective amount will be deducted from the vehicle owner's linked bank account. It includes various types of protocols, techniques and implementations, which uses Radio Frequency Identification (RFID), Near Field Communication (NFC) and LEACH-C.

Keywords: Automated Toll Collection System, RFID, NFC, LEACH-C

I. INTRODUCTION

Every day the rate of vehicles on Indian roads is increasing so does the organizations. This hiking rate leads to aggregation of vehicles on road in busy hours. This can cause congestion at toll plaza, which is a major problem for emergency vehicles. [1] To avoid this congestion at toll plaza automated toll collection system is the option over manual toll collection system.

William Vickrey, the Nobel Economics Prize Winner was the first one who proposed a system for electronic toll fee collection in the Washington Metropolitan Area. From that time to present time there has been tremendous development in the field of VANET. [1] In automated toll collection system information of vehicles is read at toll plaza and used for fee collection. The architecture of VANET technology is complex, which is more time consuming in reading and processing vehicle information.

To overcome this, some new systems using wireless sensor network are implemented in which tiny devices that can collect and capture physical information. Unlike VANET they are easy to install and cheap. Some of these systems are not only capable of collecting toll fees but can detect stolen vehicles. [1] In this review paper study of two such systems are discussed and there flaws are tried to overcome. First system was proposed by Anish Dhurat, Parag Magal, Manish Chheda and Darshan Ingle which was based on RFID tags and RFID reader. [6] And the second system was proposed by Jayapriya. CT, Y. Bevish Jinila which was based on WSN protocol called LEACH-C. [1]

II. OBJECTIVES

The main goals behind designing an automated toll fees collection system are given below.

A. Fast Vehicle Movement on Toll Plaza

Since this system is automated, there is no need to stop for paying the toll fees. The required amount is automatically deducted from the customer's bank account and the movement of the vehicles will increase eventually. [1]

B. Time Saving

Since there is no need to stop at the booth as the system is automated, there will be no traffic and the vehicles need not to wait in long queues for toll fees payment. [1]

C. Faster Data Transmission

For data signaling the methods used here is clustering and RFID. In this, nodes are grouped into a cluster and among the nodes, a cluster head is selected. All the node in a cluster gathers the data and transmit it to the cluster head this makes the data transmission faster. [1]

III. RELATED STUDY

As mentioned earlier the two different system studied are based on RFID and LEACH-C implementations. To understand both the system there is a need to have some prerequisite knowledge about each of them. Some basic information is given below.

A. Knowledge about RFID

RFID stands for Radio Frequency Identification. It uses electrical fields to identify and read the RFID tags attached to objects. These tags store data in electrical manner. To identify tags a two-way radio transmitter- receiver called as reader is used. The reader reads the response from tags and sends it to the base station. Most of the RFID sensors work on various bands such as

- Low Frequency (LF) 120-150 kHz
- High Frequency (HF) 13.56 MHz
- Ultra High Frequency (UHF) 433 MHz, 868 MHz (Europe), 928 MHz (North America)
- Microwave 5800 MHz
- Ultra Wide Band 3.1 – 10 GHz

As compared to all other bandwidth Ultra wide bands (UWB) has better range coverage, it can be said that if the antenna is high enough it will increase the range more effectively. Our requirement is only a small sized low profile antenna, for that we can use a Microstrip antenna. Microstrip Antennas has found its enormous growth in the field of RFIDs. Main reasons behind such enormous growth is low profile, its advantage is its low cost production. [3] But disadvantage of Microstrip antenna that it uses a low bandwidth. The major drawback of the antenna will perform duties as an advantage for RFIDs that it will dismiss the signals that are outside the radius of the antenna. The vital disadvantage of RFIDs will not affect as it uses narrow bandwidth. [3]

B. LEACH-C based study

Low-Energy Adaptive Clustering Hierarchy-Centralized (LEACH-C) is a WSN protocol, which is based on cluster formation. This protocol mainly focuses on energy conservation of wireless sensor nodes. Once the nodes are deployed it become difficult to replace the battery, hence energy should be conserved as the nodes are fully depended on the battery.

In LEACH-C clusters are formed and every cluster has a cluster head. Cluster head is randomly selected from the nodes with energy above the average. Once the cluster head is selected, the remaining nodes in that cluster transfer the information to the cluster head, then cluster head aggregate and compress the received information which is then transferred to the base station. After every successful transmission to base station, a new cluster head is selected which has energy above the average.

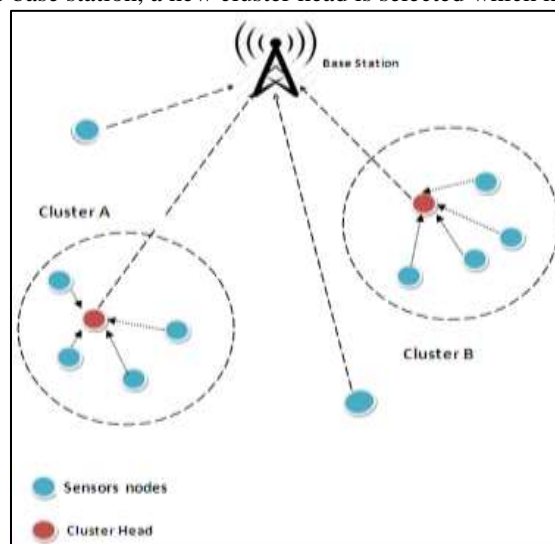


Fig. 1: Architecture of cluster and cluster head.

Since sensors communicate with each other in LEACH-C and it uses multi-hop, therefore there will be routing issues. Routing issues becomes more challenging for the wireless sensor nodes which are battery powered. Amol Dhumane [5], proposed some optimization techniques in routing. Using such optimization techniques in routing, energy of the sensor nodes, redundancy of data and delay in data transmission can be avoided.[5]

IV. PROPOSED SYSTEM IMPLEMENTATIONS

A. RFID Based Implementation

Anish Dhurat, Parag Magal, Manish Chheda and Darshan Ingle proposed a system based on RFID. [6] In this every vehicle is implanted with a RFID tag which is unique for every individual vehicle. As the vehicle crosses the RFID reader which is attached to the toll booth, the tag emitting the RF signals are received by the reader and processed. Whenever the user passes the toll the count is maintained and at the end of the month a system generated bill regarding the total pending amount to be paid by the user is sent to the user via mail or an android application.[6]

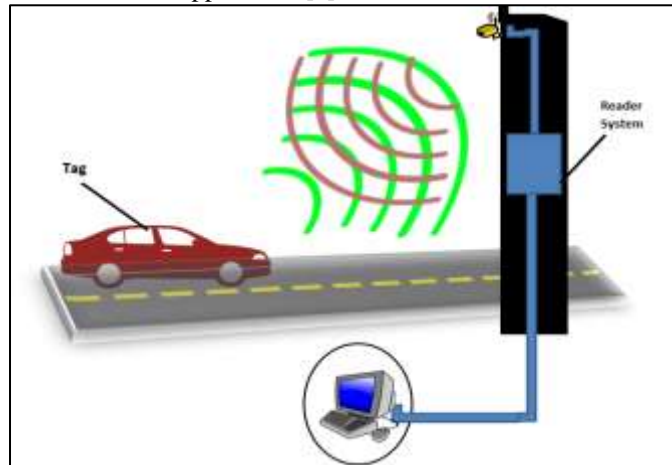


Fig. 2: RFID based System framework.

B. LEACH-C Based Implementation

Jayapriyaa. CT, Y. Bevish Jinila [1] implemented a system in which cameras are fixed at the toll plaza to monitor the vehicles passing by the booth. These cameras detect the registered ID of vehicles and the details of the vehicles are gathered from the database.[1]

These details either belong to a particular organization or a private vehicle. These details are stored in a database in prior. According to the ID verified, system checks whether that vehicle belongs to a particular organization or a private vehicle.[1] If the vehicle is a private vehicle then there is no need to process the data and the amount will be directly deducted from the users account. And if the vehicle belongs to any organization then in the sensor field these sensor nodes are organized into clusters and assigned a cluster head to that cluster. The cluster head represents all the vehicles in that cluster and generates a unique ID based multi signature for authentication.[1] Thus all the nodes communicate with cluster head and transmits the information to it. After successful authentication, the cluster head transmits the data to base station.

Using the vehicles information the toll fee is deducted from the user's linked bank account. For security ID based multi signature scheme is used since direct transaction is processed.

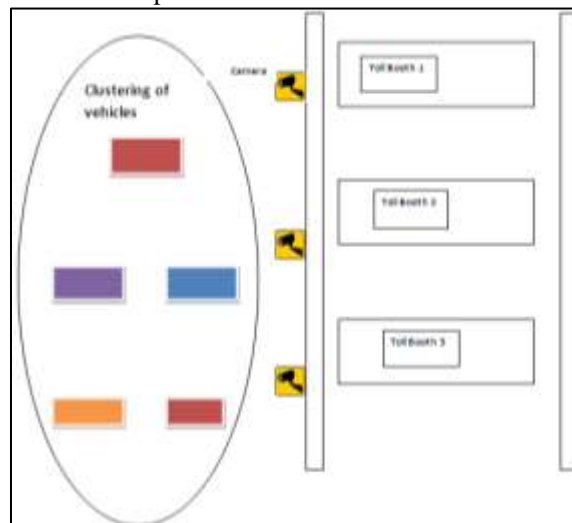


Fig. 3: LEACH-C framework.

The system works in following stages:

1) Cluster Formation

Here clustering is done on nodes in wireless sensor network. Cluster formation is on the basis of organization. The nodes which belong to same organization are grouped in a same cluster. Thus by cluster formation, it becomes easy to transmit the signal to base station and identification of every node becomes easy.[1]

2) LEACH-C cluster head selection:

To improve the performance of Low Energy Adaptive Clustering Hierarchy Centralized (LEACH-C) by improving the method of selecting the cluster heads a new algorithm is used.[1]

Firstly, number of cluster heads is formed on the basis of the density. Then that node is selected as cluster head who has highest remaining energy and lowest energy consumption.[1]

3) Multi signature scheme based on ID

As the bank account is directly linked, to provide more security a multi signature ID based scheme is used. This scheme uses generation and verification of signature. The algorithm has following steps.

- ID is broadcasted by all the nodes.
- The cluster head generates a signing key by receiving the ID of all the members in its cluster and delivers that signing key to all cluster members.
- The members in cluster generate a sub signature and send it to the head.
- Then a multi signature is generated by the cluster head by representing the cluster members and delivers it to the toll booth server.
- The multi signature is verified by the toll booth server for authentication. When the authentication is successful, then based on the number of vehicles in that cluster the respective amount will be deducted from the user's linked bank account.[1]

V. STANDARD PARAMETERS

After studying the RFID based system the desired dimension for the RFID reader antenna are tabulated below:[3]

Table - 1
Dimension for optimized antenna [3]

Parameters	Values
L_s	105 mm
W_s	165.5 mm
h_A	1.5 mm
L_A	96 mm
W_A	156.5 mm
W_l	10 mm
L_l	4.5 mm

Where,

L_s - Length of substrate of antenna.

W_s - Length of substrate of antenna.

H_A - Height of the antenna.

L_A - length of antenna.

W_A - width of antenna.

W_l - feed line.

L_l - feed line.

Some standard values are calculated in LEACH-C system for road structure having maximum 50 nodes by ayapriyaa. CT, Y. Bevish Jinila.[1] Every single node is interconnected with each other in WSN. The results are shown below:

Table - 2

Simulated parameters [1]

Parameter	Value
Simulation Time	1000 sec
Channel Type	Wireless Channel
Radio Propagation	Two way ground
Antenna	Omni Antenna
Network Interface Type	Wireless PHY
Link Layer Type	LL
MAC Type	802.11
Communication Range	100 m
Packet Rate	2Packets/ sec
Length Of Road	00 m

VI. PROPOSED SYSTEM BASED ON COMPARISONS

From the study we found that under some situations both the systems are not up to the mark. In RFID based system, since the amount is paid at the end of the month, there is a chance that the user might not pay the amount or forgot to pay. This can lead to problem for the user on his/her next pass through the toll plaza. And the major drawback was that the system was not able to handle multiple RF tags at same time.

And in the system, based on LEACH-C protocol, the sensing is done by the cameras present at the toll booth which is not precise every time, if the cameras does not capture the image properly this can lead to access problems for the customer to pass through the barriers

According to a study, time taken by 1 vehicle with 60 second average stop in a month is: $50 \times 30 = 1500$ Seconds, yearly it takes around 5 hours. This is too much of time. Thus it is assumed that 5 min of yearly time is enough. Therefore on comparing both the systems, the outcomes were not satisfactory therefore a new Hybrid system is suggested by combining both the systems into one. Instead of using cameras for vehicle identification at the toll booth, RFID tags and RFID reader can be used which gives precise results. And further routing is done by using LEACH-C protocol. Instead of monthly bill generation, the toll fees will be deducted daily.

Further improvements can be made by improving the antenna design of RFID. The parameters that will improve the strength of antenna are given by Bhushan Bhimrao Dhengale.[3]

Table - 3
Parameter Comparison

Parameters	RFID	Leach -C	Hybrid
IR Sensor for counting	Not used	Not used	Used
Time Required to pass	Medium	High (due to Image sensing)	Low
Traffic Congestion in Toll	High	Medium	Low
Deduction Method	Monthly	Monthly	Daily
Daily Report	Not Generated	Not Generated	Generated

VII. ARCHITECTURAL FLOW

Following Figure shows the architectural flow of hybrid System

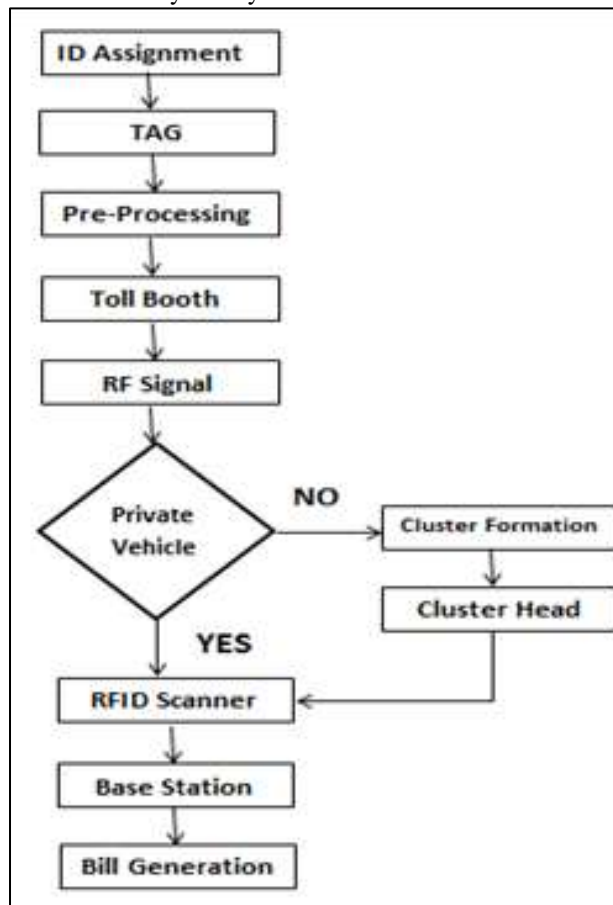


Fig. 4: Architectural Flow

VIII. CONCLUSION

From the study of the automated toll collection system using RFID and LEACH-C we conclude that both the systems gave desired outcomes to some level of extent. Also by implementing the suggested hybrid system the objectives of automated toll fees can be achieved.

IX. FUTURE SCOPE

From the development point of view, improvements to the existing system can be made by adding parameter such as submitting the report to the Government authority by keeping count of the vehicles passing through the toll plaza on daily basis.

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