Electronic Toll Collection (ETC) System Using Wi-Fi Technology

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Abstract— A toll system is one in which a fee (or *toll*) is assessed for passage of a vehicle from the tollway. In the existing toll tax system, we observe limitations like mismanagement of time, long queue for the payment of toll tax, the payment in cash. Our aim in this paper is user need to pay toll electronically. Wi-Fi toll collection stations allow the traffic to flow continuously, and vehicle being stopping and starting again. This, in combination with reduced fuel consumption has positive effect on environment.
By introducing the Wi-Fi technology, we can make this system automatic and easier. The Android phone need to be included in each vehicle and the details of the vehicle owner must be stored in the database of toll tax system. Wi-Fi technology will leverage the existing payment systems used in ETC and will influence the future of toll collection modes in India.

Keywords— *ETC, Wi-Fi, Android Mobile, AVI*

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1. OBJECTIVE

This paper focuses on the Wi-Fi technology required to support the collection of tolls with electronic based toll system and also including the use of android technology, for the range of potential toll facilities under consideration in India. Wi-Fi toll collection stations allow the traffic to flow continuously, and vehicle having avoided stopping and starting again. This in combination with reduced fuel consumption has positive effect on environment. Society and the business community will also gain from the system as it results in faster transport. The system does not require special road lanes to be built at the toll stations. The objective is to build the system which is cost effective (these systems provide the payment through prepaid card). So user need not carry hard cash, and the traffic will flow continuously.

2. INTRODUCTION AND OVERVIEW

The toll collection system all over India is the manual toll collection system. We have proposed an idea of making the toll collection totally electronic with the use of Wi-Fi and Android technology [1].

Electronic toll collection (ETC) is a technology enabling the electronic collection of toll payments. It has been studied by researchers and applied in various highways, bridges, and tunnels requiring such a process. This system is capable of determining if the vehicle is registered or not, and then informing the authorities of toll payment violations, debits, and participating accounts. The most obvious advantage of this technology is the opportunity to eliminate congestion at tollbooths, especially during festive seasons when traffic tends to be heavier than normal. It is also a method by which we can curb complaints from motorists regarding the inconveniences involved in manually making payments at the tollbooths. Other than this obvious advantage, applying ETC could also benefit the toll operators.

2.1 Manual Toll Collection

Until somewhat recently, the most common approach for collecting tolls was to have the driver stop and pay a toll collector sitting in a tollbooth. The toll collector determines the amount to be paid by each vehicle based upon its characteristics or classification [9].

2.2 Electronic Toll Collection (ETC)

Automatic Vehicle Identification (AVI) technology can accurately identify a specific vehicle at highway speeds, thereby, enabling a wide variety of ETC applications. In its basic form, a vehicle passing through a toll collection point has its identification device read, after which the toll is deducted from the customer's pre-existing account or the customer is sent an invoice. The driver pays the toll without stopping and tollbooths are not required. ETC also determines whether the vehicles passing are enrolled in the program, and gathers information on the vehicle for further collection or enforcement action [1] [2]. Figure 1 outlines the basic block diagram of the proposed system.

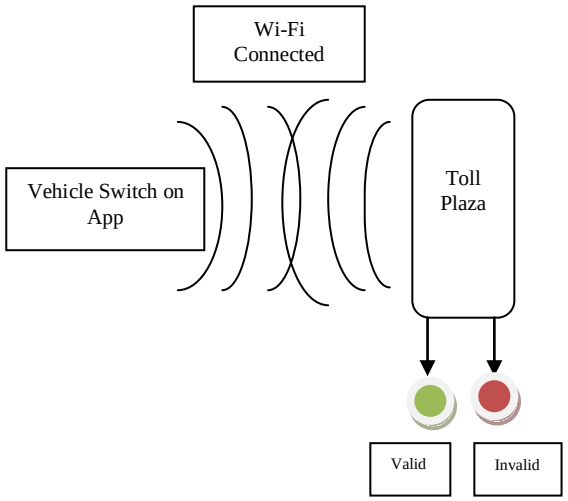

Figure 1: Block Diagram of proposed system

2.3 Wi-Fi Technology

Wi-Fi is a local area wireless technology that allows an electronic device to participate in computer networking using 2.4 GHz UHF and 5 GHz SHF ISM radio bands. Many devices

can use Wi-Fi, e.g. personal computers, video-game consoles, Smartphone's, digital cameras, tablet computers and digital audio players. Wi-Fi is a radio frequency (RF) specification for long-range point to point and point to multipoint voice and data transfer [5] [6].
These can connect to a network resource such as the Internet via a wireless network access point. Such an access point (or hotspot) has a range of about 20 meters (66 feet) indoors and a greater range outdoors. Hotspot coverage can comprise an area as small as a single room with walls that block radio waves, or as large as many square kilometres achieved by using multiple overlapping access points.

2.4 Android SDK

Android is a mobile operating system (OS) based on the Linux kernel and currently developed by Google. With a user interface based on direct manipulation, Android is designed primarily for touch screen mobile devices such as smart phones and tablet computers, with specialized user interfaces for televisions (Android TV), cars (Android Auto), and wrist watches (Android Wear). The OS uses touch inputs that loosely correspond to real-world actions, like swiping, tapping, pinching, and reverse pinching to manipulate on-screen objects, and a virtual keyboard [7].

Package *android.net.wifi* provides classes to manage Wi-Fi functionality on the device. The Wi-Fi APIs provide a means by which applications can communicate with the lower-level wireless stack that provides Wi-Fi network access. Almost all information from the device supplicant is available, including the connected network's link speed, IP address, negotiation state, and more, plus information about other networks that are available. Some other API features include the ability to scan, add, save, terminate and initiate Wi-Fi connections.

Some APIs may require the following user permissions:

- ACCESS_WIFI_STATE
- CHANGE_WIFI_STATE
- CHANGE_WIFI_MULTICAST_STATE

```
<Manifest...>
  <uses-feature android:name="android.hardware.wifi" />
    ...
  </manifest>
```

2.5 SQL Server 2008

SQL Server 2008 (formerly codenamed "Katmai") was released on August 6, 2008 and aims to make data management self-tuning, self-organizing, and self-maintaining with the development of *SQL Server Always* On technologies, to provide near-zero downtime. SQL Server 2008 also includes support for structured and semi-structured data, including digital media formats for pictures, audio, video and other multimedia data. In current versions, such multimedia data can be stored as BLOBs (binary large objects), but they are generic bit streams. Intrinsic awareness of multimedia data will allow specialized functions to be performed on them. According to Paul Flessner, senior Vice President, Server Applications, Microsoft Corp., SQL Server 2008 can be a data storage backend for different varieties of data: XML, email, time/calendar, file, document, spatial, etc as well as perform search, query, analysis, sharing, and synchronization across all data types [8].

3. IMPLEMENTATION DETAILS

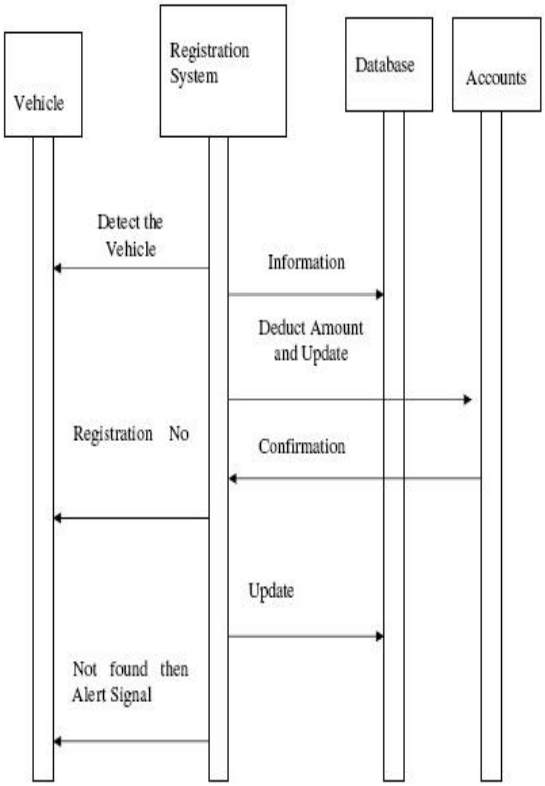

Figure 2: Sequence diagram

To connect to a Wi-Fi LAN, a computer has to be equipped with a wireless network interface controller. In the existing toll tax system, we have observed the following limitations. The very first is the mismanagement of time. In this system when one vehicle reaches at the station, the employees there first take the payment for the toll tax from the owner and then the operator at the computer feeds the amount, vehicle number and other information etc. in the computer and gives the receipt to the owner. During this period, there may be a long queue for the payment of toll tax. Due to this problem, the traffic system may be disturbed.
The next problem which we have observed is that there may be the case when one vehicle may pass through the station without giving the toll tax due to the negligence of the employees or may be due to more manual load. The last problem which may be considered is that the payment in cash which is collected, the proper attention is given to deposit the amount to the government and risk of cash at the toll tax stations and security forces are there for this purpose.
In the existing system due to above limitations and problems, we have proposed the Wi-Fi technology for the same. In the Wi-Fi system, the system will become automated and time management will be done efficiently and also the cash

problems will be removed. Due to its inquiry procedures, nobody will escape from paying the toll tax and the problem of long queues and traffic blockages will be removed.

In the new design, we require Android enabled Smartphone in each vehicle and at every toll tax station, the Wi-Fi transmitter and receiver will be there, and also prepaid card system with the networking. By introducing the Wi-Fi technology, we can make this system automatic and easier. The Android phone should be included in each vehicle and the details of the vehicle owner will be stored in the database of toll tax system. When a vehicle come within the range coverage area the computer will give a signal and the net balance of amount of the prepaid system will be shown on the screen.

According to the vehicle (car, trailer, bus, truck etc.), toll tax amount in the accounts will be updated. The amount payment system must be prepaid. If the balance of a vehicle is lesser than the amount required, a red signal will be given for the alert and cash on the spot will be received as shown in Figure 2. In this application we can solve the problem of mismanagement of time, problem of long queues and problem of maintenance of accounts. When the vehicle come within the range of Wi-Fi receiver installed at the toll tax stoppages, the database at the receiver will be checked.

After deducting the amount from the prepaid account of that vehicle, green signal will be sent otherwise a red alert signal will be sent.

In the traffic management, the database contains the information about the vehicles, their type, owner, vehicle no, Address, Balance etc [3]. Road patrol will give the indication if some rules and regulations of the traffic system are not followed, peripheral services will contain the extra queries from the customer about the system [4]. In this system before billing the vehicles, the rating of the amount of tax is done and payment will be deducted from the prepaid account. Figure 3 depicts how the proposed system will be installed at the toll plazas.

Figure 3: Proposed System Layout at Toll Plaza

ETC has already been installed at 55 toll plazas and their integration with the Central Clearing House (CCH) operators has almost been completed on the Delhi-Mumbai route via Haryana, Rajasthan, Madhya Pradesh, Gujarat and Maharashtra. A pilot project for an inter-operable ETC system of 10 toll bad has already been tested and seamless ETC plazas between Mumbai (Charoti) and Ahmeda on this section is in operation.

Wi-Fi technology will leverage the existing payment systems used in ETC and will influence the future of toll collection modes in India. ETC application includes options that will allow customers to carry out their respective toll transactions in an efficient manner.

4. MODULES DEVELOPED

4.1 Client

After client has login and then authenticated, it will try to accessing services that are hosted on server. Client will fetch all the details from server database and if the balance is sufficient it will pay the toll. Once client will login, next time it will never login again. It will track's the session and it will automatically login.

Figure 4: Home Screen

Figure 5: Connect Button

 ISSN: 2321-8169
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Figure 6: Login

Figure 7: User Details

4.2 Server

After server is authenticated the client takes service from server. The server is providing services to the client. The Administrator is the one handling the server website.

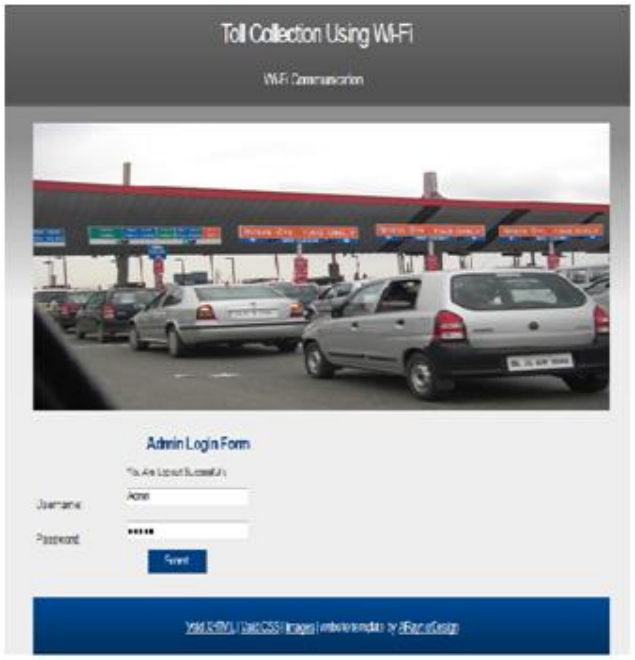

Figure 8: Admin Login

Figure 9: Home Page

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Figure 10: Manage Users

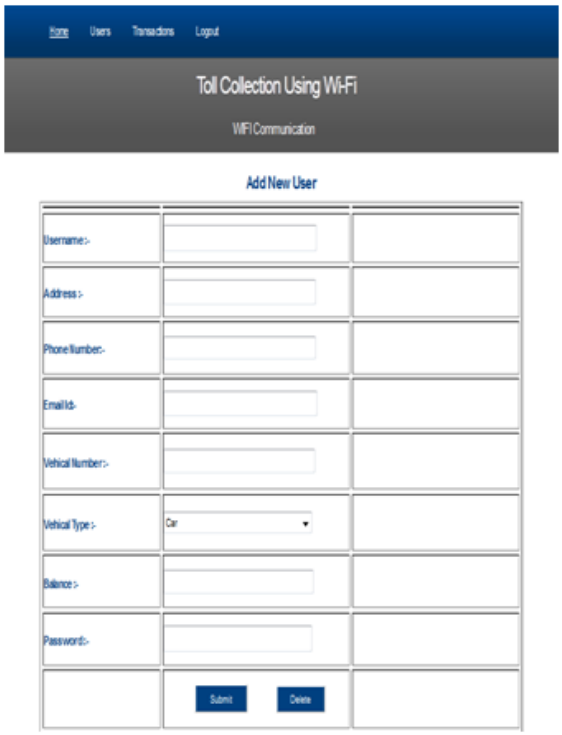

Figure 11: Add User

Figure 12: Transaction

Figure 13: Charges successfully deducted

4.3 Features of ETC application

1. **Registration**: The customer must register by filling in the application form and submitting the required information.

2. Database Update: After registration is done, the database is updated with existing mobile number and other vehicle related details.

3. Recharge: To begin using ETC application the user must have prepaid account of minimum of Rs.500/-. The customer can now cross verify the transaction and keep a track of the balance amount left in his/her prepaid account.

5. ADVANTAGES

1. Reduces the man power.
2. No hard cash required.
3. Saves time and money.
4. Minimizes work stress.

6. REQUIREMENTS

If we use technology like Wi-Fi which is accessible to common people, toll collection system can be made transparent, faster, convenient, user friendly. The following are the minimum requirements that need to be satisfied.

- Android version should be above 4.2
- Amount withdrawal is only possible through registered ETC-application users.
- There is a lower limit on the prepaid account.
- The users should be acquainted with technology.

7. CONCLUSION

In this paper, we have presented the implementation of Wi-Fi technology in the application of toll tax system. Wi-Fi toll collection stations allow the traffic to flow continuously and vehicle having been avoided stopping and starting again. This in combination with reduced fuel consumption has positive effect on environment i.e. pollution created will be minimum. Implementing the Wi-Fi technology is also not so costly. Man power and cash risks are also reduced to minimum. Furthermore, only a minimum of traffic disruption is caused during installation. The system also increases safety, as bottlenecks and long queues are avoided. Society and business community also gain from the system as it results in faster transportation. The system is cost-effective, time saving and easy to install which benefits the operator as well as user.

8. ACKNOWLEDGEMENT

With profound sincerity and gratitude, we acknowledge our constant discussion with our professor **Mr. Nilesh Patil** for his valuable guidance and support extended during the work. We would also like to thank our HOD **Mr. Dilip Dalgade** for carrying out this work as a part of our B.E. project.

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