

Automated Toll Collection System using NFC

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Abstract

Automatic Toll Collection System(ATCS) is an essential part of improved and upgraded form transportation systems, which represents the innovative technologies, used in our day-to-day life. In this paper, we aim at suggesting an open and secure e-ticketing system, which acts as an alternative to the conventional paper-based ticketing. Our solution is based on NFC, which will facilitate its interoperability with value-added services and from the third party services as well. NFC smartphones or tags used in this system is a new impeccable approach. The proposed system will use NFC enabled mobile phones either in card emulation or peer-to-peer mode for exchanging data and for validating tickets for instance. We also propose a solution for both NFC enabled and non-enabled mobile phones. This paper provides an overview about the major problems, discusses advantages and disadvantages of the new approach, and finally concluding with implementation of this idea.

Keywords

Automatic toll Collection; NFC; RFID; Arduino

I. INTRODUCTION

In the era of technology development one of the most conventional system is the automated systems. This leads to a minimum level of human interference which leads in increasing the efficiency and saves a lot of time. In many cities around the world, the concept of the so-called electronic ticketing is being extensively used for issuing travel permissions which may eventually result in conventional paper-based tickets being completely phased out already in the nearest future. In the earliest stage, paper-based ticketing system was being used. It was a complete manual system and it had a lot of disadvantages in terms of security and proper maintenance of the rules. Some used to runaway without paying the toll tax. Till the late 90's, the most common approach for toll collection was the manual system. On arrival at the tollbooth, the vehicle had to stop and pay the fare and was then allowed to pass the toll booth. The toll

collector determines the amount to be paid by each vehicle based upon its characteristics or classification. Stopping at the toll booth causes a lot of chaos and queues at the toll gates. Interviewers used to verify the details of the car and the driver too. It leads to a lot of consumption of fuel along with wastage of time as well. To overcome all the hues of this system electronic toll collection system was first introduced. Now with the world pioneering in the development of technologies, automated toll collection system is one of the most recognised invention.

In 1959, William Vickrey was the first person to propose an electronic system in Washington Metropolitan area. Every car would be equipped with a Transponder. When it comes across the intersection at the toll gate, it would automatically show on the computer feed. A bill will be generated which will be added on to the customer's bill account. [1]. In the 1960s and 1970's, free flow tolling was tested by fixing transponders at the undersides of the vehicle and readers were located under the surface of the highway. Norway has been the world's pioneer in ETC technology. First it was introduced in Bergen, in 1986, operating together with conventional tollbooths. In 1991, Trondheim introduced the world's first use of completely unaided full-speed electronic tolling. In 1995, Portugal became the first country to apply a single, universal system to all tolls in the country. In the year 2004-05 Santiago, Chile has implemented the world's first 100% full speed electronic tolling with transponders crossing through the entire city's urban freeways. India has also taken a step ahead in developing the country by implementing the Digital India movement. India has introduced Intelligent Transportation System in and around of the capital New Delhi. In 2014, Fast Tag with an RFID tag used for the automatic toll collection was introduced in India. Many other countries have also adapted similar services like Opal Card in Sydney, Oyster Card in London, Touch & Travel in Germany are all the examples of how well the e-ticketing has been accepted both by customers and public transportation companies.

In this paper, we are aiming at suggesting a simple yet performant ATCS model which is based on open source components. The proposed system architecture adheres to the system for public transportation widely deployed. That is, the customer does not have to prove the possession of a travel permission every time using the transportation service (e.g., to pass through a toll booth) but rather be prepared to present a valid travel credential if being checked by a conductor. NFC (Near Field Communication) is a radio frequency technology which fits in as a special application in the field of mobile consumer electronics. It is designed for bidirectional data transmissions over a distance of up to 10 cm and a maximum data rate of 424 kB/s. Based on Radio Frequency Identification (RFID) standards according to ISO/IEC 14443, NFC technology works at an operating frequency of 13.56 MHz. Consequently, NFC is compatible to existing contactless smartcard technologies such as NXP's Mifare or Sony's Felica.

II. RELATED WORK

Electronic toll collection system deals with DSRC (Dedicated Short Range Communication) Technology. In some countries like China they have introduced a GPS based Automatic Toll collection system [2]. It preinstalls an OBU (On Board Unit) mounted on the vehicles and the RSU (Road Side unit) communicates within very short range. Saijie Lu also proposed to use a GSM module to notify the customers and to the Control Center [1].

RFID tags are also used for the same system. There are two kinds of RFID tags- Active and Passive. Active RFID tags can communicate within the range of 30 m. This range of communication can be extended with the help of an RF modem [4]. NFC is one of the high frequency RFID's.

Mobile phones in today's generation have NFC technology enabled in them. It has been proved very efficient and reliable for data transfer. Mobile ticketing using NFC has been considered to be the most promising applications in real time [6]. Finkenzerler [5] states that the public transport domain is of great potential for RFID and contactless chipcards. He suggests that transport associations in Europe and the USA operate at a huge loss, which can be improved using contactless chipcards for EFM.

Windmann has proposed the usage of the VDV core application which has been implemented in Germany [8]. It implies cashless payment, electronic ticket and automatic fare management.

In [3] Grechenig a pilot project was conducted by the OBB and the Austrian Mobile Network Operator and A1 Telekom in the first quarter of the year 2009. The implementation was on the basis of VDV Core

Application. For two rail routes 100 test users could buy electronic tickets via a special application on their Nokia 6212 mobile phone over the air. The validation of the tickets by the train staff was accomplished using a second Nokia 6212 mobile phone. The OBB Handy-Ticket [6] is currently available as a service offered by the OBB. It enables customers to purchase tickets with their mobile phone via SMS or WAP. The ticket is a simple SMS service provided with a security code which is used for the mobile verification.

C. Saminger [9] introduced the Inverse Reader Mode which uses light weight protocols which makes the application compatible for existing mobile phones. The mobile phone shall remain in the reader/writer mode and the electronic ticketing system in the card emulation form.

ZigBee is a high level wireless communication protocol which uses small low power digital radios based on personal area network. It is simpler and less expensive than other WPAN's. The only demerit is that it cannot be used in mobile phones.

III. PROPOSED SYSTEM

In this paper we provide to implement the simplest way for the automatic toll collection. A web application will be created where the customers have to register themselves with the help of their mobile phone of the unique ID present in the tag. It will ask for uploading details of their licences and car details. It will also be linked to the customer's bank account from where the toll fare will be deducted. For the mobile phone users who have NFC enabled in them can use the app for the payment. NFC tags shall be provided to the customers who do not have NFC enabled phones. The Website will be used as a portal to keep a check on the payments done and further more we can implement this for gas stations as well. It will save a lot of time congestion which is caused at the toll booths.

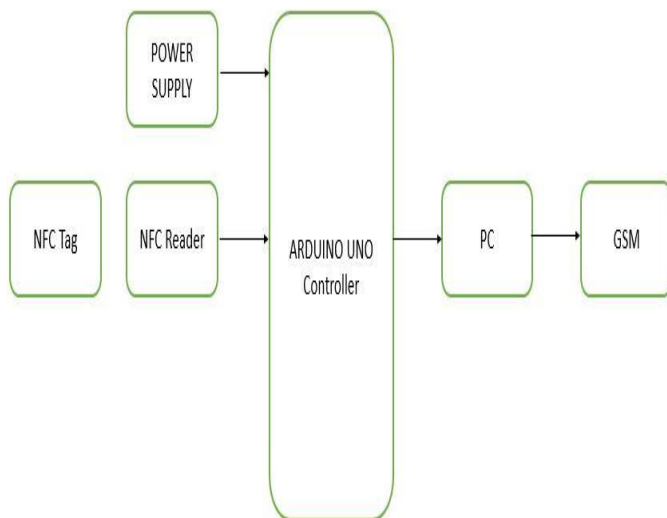
An NFC reader shall be set up at the toll gates. On intersection with the NFC tags it shall communicate and make the payment for the toll. If the customer is not a valid user or hasn't yet registered it has to manually pay to the person assigned at the toll booth. If the customer doesn't intend to stop for payment or violates the rules, Traffic police will soon receive a complaint for the toll booth and fine should be penalised.

Customers will receive messages with the help of the GSM module providing information about the deduction and their balance too. Warning messages or alert messages shall be sent to the customers if

balance in the linked account is low. This leads to more efficiency in the system and makes it more reliable in terms of payments and transaction. Free flow of traffic can be maintained reducing the time congestion and fuel wastage.

FASTag which is used in the regions of Delhi, uses RFID tags. The backlog of the system is that it increases the number of cards a customer should carry on their way to any toll booth. We can use our phones instead. Govt can launch the app which requires to fill in all the available data from the customers.

BLOCK DIAGRAM



IV. ARDUINO UNO

Arduino is an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs.

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button.

The Arduino acts as a controller which connects both the PC and GSM module. It acts as an interactive phase. It can be given power through the help of the PC. It connects to the NFC reader which detects the NFC tag and sends a message to the controller board Arduino. After the verification of the vehicle number and details, it connects to the payment option and sends a message to the customer with the help of the GSM module.

The block diagram denotes the path of connection of the proposed system. NFC reader communicates with NFC smartphones or tags and transmits the message to the Arduino. The Arduino controller is the medium for the entire system. It is linked to the database where the customers' register. It seeks to match the unique id i.e. NFC tag id with the database. Once the verification of vehicle and customer is completed, it proceeds towards the payment section. It automatically deducts the amount for the account else for any other uncertainty, manual payment is also allowed.

V. GSM MODEM

A GSM modem is a wireless modem that works with a GSM wireless network. A wireless modem behaves like a dial-up modem. It can be considered as an external device or a PC Card / PCMCIA Card. Typically, an external GSM modem is connected to a computer through a serial cable or a USB cable. It should be inserted into one of the PC Card / PCMCIA Card slots of a laptop computer. Like a GSM mobile phone, a GSM modem requires a SIM card from a wireless carrier in order to operate.

Functions of GSM-

- Reading, writing and deleting SMS messages.
- Sending SMS messages.
- Monitoring the signal strength.
- Monitoring the charging status and charge level of the battery.
- Reading, writing and searching phone book entries.

After the completion of the wireless transaction from the customer's account, the GSM module sends a notification message to the registered mobile number of the customer. It shows the important details like the car number, amount and time of transaction, location of the toll booth and the balance remaining in linked account of the customer.

NFC shall be used in this system as it uses a short range of communication and can be proved much more efficient if customers start using their mobile phones instead of another card.

VI. CONCLUSION

An Automated Toll Collection System with NFC is much more efficient and reliable system and overcomes the drawbacks of DSRC-based system. NFC is better when compared to RFID is better in terms of range. It acts as a both reader and a writer tag as well. It has a short range read limitation which makes the proposed system more efficient and reliable. NFC tags are also available for non enabled mobile phone users. According to the news , nine out of top ten handset makers have nfc enabled in their handsets which supports ios, android and windows users.The suggested architecture satisfies the major requirements for the automated toll collection system.

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