Near Field Communication (NFC) based Electronic Toll Collection System

Nikhil Mohan .O.K, Savita Patil
PG student, ECE Dept, Associate Professor, ECE Dept, AMC Engineering College, Bangalore
Email: ok.nikhilmohan@gmail.com, sampatil949@gmail.com

Abstract—Electronic Toll Collection system is considered as an effective method in order to alleviate traffic congestion and jams, enhance the convenience and safety of travelers, and minimize air pollution and fuel consumption for environmental protection need. ETC system determines whether the vehicles passing are enrolled in the program, alerts enforcers for those that are not, and debits electronically the accounts or the amount in the IC card of registered cars without their stopping An architecture for collecting vehicles toll using Near Field Communication (NFC) is presented in this paper. The basic idea is to develop the automatic challan system that can check for signal break by any vehicle. The NFC Reader reads the information like vehicles no and automatically sends a report to the owner of vehicles and simultaneously information is given on the site itself through. This project will check all the documentation of the car which will about to cross. It uses a passive NFC tag as carrier to identify actual vehicle path in loop road. The ETC system will toll collection without parking, also census traffic flow and audit road maintenance fees. It is necessary to improve expressway management. The performance of the system is evaluated in ASP.NET

Index terms—ETC, IR sensor, NFC, NFC tags, OCR

I. INTRODUCTION

Road tolls were levied traditionally for a specific access (e.g. city) or for a specific infrastructure (e.g. roads, bridges). These concepts were widely used until the last century. However, the evolution in technology made it possible to implement road tolling policies based on different concepts. The different charging concepts are designed to suit different requirements regarding purpose of the charge, charging policy, the network to the charge, tariff class differentiation etc. In a time-based charging regime, a road user has to pay for a given period of time in which he may use the associated infrastructure. The term tolling is used for charging a well-defined special and comparatively costly infrastructure, like a bridge, a tunnel, a mountain pass, a motorway concession or the whole motorway network of a country. Classically a toll is due when a vehicle passes a tolling station, be it a manual barrier-controlled toll plaza or a free-flow multi-lane station. In a kilometer or area charging system concept, vehicles are charged per total distance driven in a defined area.

II. RELATED WORKS

Since the first electronic-toll-collection (ETC) systems appeared around the early 1990s, the number of ETC systems in the world has rapidly grown. There are more than 80 important systems currently in operation in more than 25 countries. Current ETC systems can be distinguished between single lane and multi-lane free flow. For communication between onboard units (OBUs) and roadside units (RSUs), several different media are utilized, such as 900-MHz, 2.4-GHz, and 5.8-GHz microwaves based on dedicated short range communication (DSRC) and infrared light. In [9], the authors designed in-pavement antennas with carrier frequency 915MHZ. The tag is on the lower edge of the front license plate, and the in-pavement antennas are buried under the road. The transmission range is one meter wide and 2 meter high. It support variable bits packet for several operations. However, it is not sufficient for congested traffic.

In [7] they proposed Electronic Toll Collection Based on Vehicle-Positioning System Techniques. VPS is a category of location based service which can be applied to electronic toll collection. It combines vehicle positioning, wireless communication, image capture and processing, onboard computer (OBC) and the backend system. In VPS, it combines GPS and mobile communication such that vehicles could report its real-time position to the server and the drivers could receive the bills by cell phone. The communication mechanism used in VPS is mobile telecom such as GSM/GPRS. The OBC adopts the Windows@ CE operating system, has build-in GPS positioning and GPRS communication modules. The main advantages of this system are the total cost of VPS is much cheaper than DSRC based ETC system, it’s easy to setup a new toll area or remove the old ones, transaction time won’t be the problem. Disadvantages includes High precision requirement for vehicle positioning in ETC applications, problems associated with GPS signal outages, it is more difficult.
in the matching process between the debit and enforcement information, so the VPS system needs more post-processing jobs in order to reduce the mismatch failure, the personal privacy problem is still there, just the same as DSRC-based ETC, the bandwidth of current microwave systems whose carrier frequencies are only up to 5.8 GHz is not sufficient.

Global Positioning System technique is applied to ETC to replace DSRC technique. It implements ETC system based on positioning and Global System for Mobile communication (GSM) technologies[4]. The OBU receives vehicle positioning information from GPS, automatic calculates and deducts the road using charge, and sends fee data to the Control Center through the GSM. Advantages of this model includes the total capital input of road side unit will be largely reduced its easy to setup a new toll area or remove the old ones by calculating the traveling distance the vehicle traveling multi-path identification problem will be completely resolved. Main drawbacks of this system are GPS is a new coming technology it's currently on the development and field trial stage worldwide. The business operation instance is only in Germany. And also it is more difficult in the matching process between the debit and enforcement information, so the system needs more post-processing jobs in order to reduce the mismatch failure, the cost of OBU is still high for the users.

[3] is an automatic identification technology. It uses a passive RFID tag as carrier to identify Actual vehicle path in loop road. The ETC system will perform toll collection without parking, also census traffic flow and audit road maintenance fees. This ETC system uses Windows XP operating system, software development tools using VC + +, database using MYSQL. The system uses 920MHz passive RFID tag. It is installed at the front windshield and at the top of rear-view mirror. RFID based ETC system has the advantages of very small size of the tag, it doesn’t need a direct line of sight for the information to be read, vehicle need not to stop to complete the path identification. Collect vehicle tolls, Tolls accurate split and high rate of recognition accuracy. At the same time disadvantages of it includes range is not desirable in applications like cash cards or passports, RFID tags are active components. So its costly, Malicious people can receive your information and clone it into another tag and use it for themselves. This is where NFC comes in,[2] implements the design of Infrared Electronic-Toll-Collection Systems With Extended Communication Areas and Performance of Data Transmission. Infrared short-range communication in the wavelength band of 780–950 nm is very important due to its low cost and simple technology. The infrared ETC system currently used in Taiwan is one of the examples. In this wavelength range, low-cost light-emitting diodes (LEDs) and p-n photodiodes are commonly used as the transmitter source and the receiver detector, respectively. Main disadvantages of this system is signal attenuation. Also here they used more than 25 types of LEDs from different Companies. Unfortunately, almost none of their radiation patterns were smooth, and some even have serious irregularities, which make them unsuitable for ETC applications.

In this paper, we suggest an architecture that collects the toll using Near Field Communication. NFC Toll Road Payment systems have really helped a lot in reducing the heavy congestion caused in the metropolitan cities of today. It is one of the easiest methods used to organize the heavy flow of traffic.

**III. ELECTRONIC TOLL COLLECTION (ETC) SYSTEM**

ETC systems currently used in the world can be classified into two types: single-lane free flow (SLFF) and multilane free flow (MLFF). It is well known that multilane free-flow systems represent much greater complexity than single-lane systems, but the former is more convenient for faster traffic throughput, especially in high-traffic-loading areas due to less restriction on vehicle passing speed.

Fig 1: (a) Multilane Free Flow (b) Single Lane Free Flow

In Fig. 2, it shows the four components of a typical ETC system [IS]. It includes 1) Automatic Vehicle Identification (AVI); 2) Automatic Vehicle Classification (AVC); 3) Transaction processing; and 4) Violation enforcement. The AVI component involves the use of OBU-to-RSU communications to identify the vehicle when entering the toll gate area. The type of OBU can be either a transponder or a radio-frequency identification (RFID) tag so that the vehicle can automatically be identified.

Fig 2: Electronic toll collection Architecture

For AVC component, vehicle class can be determined by the vehicle's physical characteristics, such as the number of axles. A higher toll is usually imposed on a
vehicle with more axles. Larger commercial trucks or vehicles pulling trailers, therefore, would likely pay a higher toll. Transaction processing entails debiting the toll from the customer's account and addressing customer inquiries. Violation enforcement usually includes cameras to capture images of license plates, and a license plate reader system to recode photographs and license plate numbers of all vehicles. Thus, automatic license plate recognition (ALPR) technology is often used in violation enforcement.

IV. SYSTEM OVERVIEW

In our project we are eliminating the current problem of tollgate in India. Across all over India at the polls, we need to wait at the tollgate for the taking the ticket that makes us delay for our important work. As we know, the heaviest traffic congestion on highways occurs near toll gates where vehicles make a short stop to pay the toll. So an electronic toll collection (ETC) system is usually built to eliminate the traffic jams. In order to find out the non-payment vehicles, the violation enforcement usually includes cameras to capture images of license plates.

The people traveling through this transport medium do not need anything else to get on a highway, instead the NFC tag carried by their vehicle will do everything. A commuter traveling through this medium gets to know how much amount has been paid and how much money is left in the tag. It does not require the person to carry cash with him to pay the toll gate all the time. The long queue waiting for their turn is reduced, which in-turn reduces the consumption of fuel. The NFC toll payment systems are really used in preventing trespassing on borders. The software solution developed can ensure a smooth running of vehicles without any need for further development. The software controlling these NFC tags and reader is easy to implement.

This project consist of NFC reader which will be placed at certain predefined distance before the tollgate, this reader will collect the identification number of the car and send the data to the tollgate system. The system will send a query to the main office for the data and will retrieve back the data and valuable documents belonging to the car. If any error found in the car, barrier will remain close otherwise it will open and let the car go (Fig 3).

The system will be connected to a microcontroller and stepper motor. The stepper motor is one which will make the barrier open and close. Once the car will pass from the toll gate it will send a SMS regarding the amount deducted from his/her prepaid account to the registered mobile number through the SMS gateway.

Here Basic idea is to develop the automatic challan system that can check for signal break by any vehicle. The NFC Reader reads the information like vehicles no. and automatically sends a report to the owner of vehicles and simultaneously information is given on the site itself through. This project will check all the document of the car which will about to cross, once any problem found in the car documents the barrier will not be open and further action can take on the car. The data related to car will be saved in the head quarter database and each and every tollgate will retrieve the same from the head quarter. Just after the crossing the tollgate the application running on the tollgate system will send a SMS to the owner of the car. The performance of the system is evaluated in ASP.NET.

Flow Chart:

Fig 3:Block Diagram

a) AT89S52-Microcontroller

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel’s high-density nonvolatile memory technology and is compatible with the Industry-standard 80C51 instruction set and pin out. The on-
chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

The ULN2803A device is a high-voltage, highcurrent Darlington transistor array. The device consists of eight npn Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collectorcurrent rating of each Darlington pair is 500mA.

The Darlington pairs may be connected in parallel for higher current capability. Applications includes relay drivers, hammer drivers, lamp drivers, display drivers(LED and gas discharge), line drivers, and logic buffers. The ULN2803A device has a 2.7-kΩ series base resistor for each Darlington pair for operation directly with TTL or 5-V CMOS devices.

c) IR Obstacle Sensor

This sensor works on 12V. It gives Digital high(5V) output whenever vibration is detected. The Vibration Sensor Detector is designed for the security practice When Vibration Sensor Alarm recognizes movement or vibration, it sends a signal to either control panel. Developed a new type of Omni directional high sensitivity Security Vibration Detector with Omni-directional detection. It works on electromechanical principle. Vibration velocity sensors operate in accordance with the electrodynamics principle and are used for measuring the bearing absolute vibration based on the piezoelectric effect. Change in resistance due to the force acting on it and convert it into 4 – 20mA. We have piezoelectric sensor which detects the vibration created on the surface. We can also use shock sensor to detect vibrations. Advantages includes it operates with only 5V of DC, highly accurate values as it operates on digital, helps in programming and implementation, highly sensible in sensing the slight movements.

b) Stepper Motor

A stepper motor (or step motor) is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor’s position can then be commanded to move and hold at one of these steps without any feedback sensor (an openloop controller), as long as the motor is carefully sized to the application.

DC brush motors rotate continuously when voltage is applied to their terminals. Stepper motor is known by its important property to convert a train of input pulses i.e. a square wave pulse into a precisely defined increment in the shaft position. Each pulse move the shaft through a fixed angle. The electromagnets are energized by an external control circuit, such as a microcontroller. To make the motor shaft turn, first, one electromagnet is given power, which magnetically attracts the gear's teeth. Motor driver act like the current amplifier. It is use for controlling the current in the motor. ULN2083 IC can control the two dc motor simultaneously.
Fig 9: Device image
d) MAX 232

![MAX232 Pin Diagram]

Fig 10: MAX232 pin diagram

The MAX232 is an integrated circuit that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals. The drivers provide RS-232 voltage level outputs (approx. ± 7.5 V) from a single + 5 V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices that otherwise do not need any voltages outside the 0 V to + 5 V range.

V. NEAR FIELD COMMUNICATION (NFC)

Near field communication (NFC) technology lets smart phones and other enabled devices communicate with other devices containing a NFC tag. Whether swiping your smart phone at the checkout lane in the grocery store, waving it over a display at a local museum, or bumping phones with a friend to share the latest games, near field technology lets you pay, play, and learn easily. NFC isn't a fundamentally groundbreaking technology. Like Bluetooth and Wi-Fi, its a wireless radio communications standard. Near Field Communication, or more commonly known as NFC, is a subset of RFID that limits the range of communication to within 10 centimeters or 4 inches. RFID is the process by which items are uniquely identified using radio waves, and NFC is a specialized subset within the family of RFID technology. Specifically, NFC is a branch of High-Frequency (HF) RFID, and both operate at the 13.56 MHz frequency. NFC is designed to be a secure form of data exchange, and an NFC device is capable of being both an NFC reader and an NFC tag. This unique feature allows NFC devices to communicate peer-to-peer. As a finely honed version of HF RFID, near-field communication devices have taken advantage of the short read range limitations of its radio frequency. Because NFC devices must be in close proximity to each other, usually no more than a few centimeters, it has become a popular choice for secure communication between consumer devices such as smart phones.

NFC Tags

NFC tags contain data and are typically read-only, but may be rewritable. The tags can securely store personal data such as debit and credit card information, loyalty program data, PINs and networking contacts, among other information. The NFC Forum defines four types of tags that provide different communication speeds and capabilities in terms of configurability, memory, security, data retention and write endurance. Tags currently offer between 96 and 4,096 bytes of memory.

- As with proximity card technology, nearfield communication uses magnetic induction between two loop antennas located within each other’s near field, effectively forming an air-core transformer.
- Theoretical working distance with compact standard antennas: up to 20 cm (practical working distance of about 4 cm)
- Supported data rates: 106, 212 or 424kbit/s (the bit rate 848kbit/s is not compliant with the standard ISO/IEC 18092)
- NFC devices are able to receive and transmit data at the same time. Thus, they can check for potential collisions, if the received signal frequency does not match with the transmitted signal’s frequency.

![NFC Tags Image]

Fig 11: NFC tags

VI. OPTICAL CHARACTER RECOGNITION (OCR)

OCR is the mechanical or electronic conversion of scanned or photoed images of typewritten or printed text into machine-encoded/Computer readable text. It is widely used as a form of data entry from some sort of original paper data source, whether passport documents, invoices, bank statements, receipt, business card, mail or any number of printed records. OCR is the field of research in pattern recognition, artificial intelligence and computer vision. OCR is a common method of digitizing printed texts so that they can be electronically edited, searched, displayed. OCR can be used as data entry for business documents, Automatic Number Plate Recognition, Automatic insurance documents key information extraction etc.
ASP.NET

ASP.NET is a server-side Web application framework designed for Web development to produce dynamic Web pages. It was developed by Microsoft to allow programmers to build dynamic web sites, web applications and web services. Microsoft Visual Studio 2005 IDE is used to develop the web portal. Microsoft Visual Studio .NET 2005 provide an integrated development environment (IDE) for maximizing developer productivity with the .NET framework. In this application source code is written in C#. The .NET version of C# is an improved version with more features and additions. The developed site can be checked by running locally on any PC using ASP.net development server local host.

ADVANTAGES

• No need to wait in the queue.
• No need to carry cash.
• No need to stop the car.
• Car documents can be checked in once.
• Blocked car can be track and catch.
• Government can block any car all over India by a centralized server.
• Owner can get the instance SMS regarding his/her prepaid account.
• Number Plate Recognition using OCR
• Need for manual toll based system is completely reduced

DISADVANTAGES

• Internet required

• Mobile payment method via NFC faces significant challenges for wide and fast adoption, due to lack of supporting infrastructure, complex ecosystem of stakeholders, and standards.

• Problems in Transactional payments

1. Poor reliability - transactional payments can easily fail as messages get lost.
2. Slow speed - sending messages can be slow and it can take hours for a merchant to get receipt of payment. Consumers do not want to be kept waiting more than a few seconds.

3. High cost - There are many high costs associated with this method of payment. The cost of setting up short codes and paying for the delivery of media via a Multimedia Messaging Service and the resulting customer support costs to account for the number of messages that get lost or are delayed.

VII. EXPERIMENT RESULTS

When the system detects any vehicles in the toll gate then NFC reader which will be placed at certain predefined distance before the tollgate will collect the identification number of the car and send the data to the tollgate system. The system will send a query to the main office for the data and will retrieve back the data and valuable documents belonging to the car. If any error found in the car, barrier will remain close otherwise it will open and let the car go. Microcontroller can be used for controlling the barrier. A snapshot of the Microcontroller with NFC Reader and sensor interface is showing in the figure 13.

VIII. CONCLUSION

The concept of the Electronic Toll Collection using NFC is practically implemented in this paper based on Atmel AT89S52 Micro controller, NFC reader, IR sensor and Optical Character Recognition(OCR). NFC Toll Road Payment systems have really helped a lot in reducing the heavy congestion caused in the metropolitan cities of today. When the car moves through the toll gate on any road, it is indicated on the NFC reader that it has crossed the clearing. The need for manual toll based systems is completely reduced in this method and the tolling system works through NFC. The system thus installed is quite expedient reducing the time and cost of travelers since the tag can be deciphered from a distance. Although our searching method can reduce human loading, there is an important limitation - camera modules must take pictures for every vehicle passing through the enforcement line. How to overcome this limitation is a worth investigation in the future.
REFERENCES


