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NFC Based Toll Collection System

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Abstract: This paper suggests a new system for raising tolls on infrastructures under Open Road Tolling (ORT). The current Electronic Toll Collection (ETC) applications do not meet basic usage criteria, such as interoperability and portability between systems and road users (in the same or separate countries), as well as automated toll monitoring and recording (capacities protecting user privacy, an important aspect of car rental or sharing use cases). The Charge Collector System (C2S) is a project in development that will provide certain services, such as versatile payment options, tracking of accrued tolls and making them available to end-users and management agencies, exploring technology synergy in the ETC situation, namely Dedicated Short Range Communication (DSRC), Global Navigation Satellite System (GNSS), Near Field Communication (NFC) This framework often reflects an alternative to interoperable ETC systems, in a manner that incorporates solutions based on DSRC and GNSS together.

Keywords: Toll Collection, Electronic Toll Collection (ETC), DSRC, GNSS, Multi-technology, On Board Unit (OBU).

INTRODUCTION

Electronic toll collection system is a kind of advanced digital traffic charging technology, vehicle drivers automatically pay the tolls without slowing as they cross toll lane. ETC development work has been in many countries for more than ten years, and that effectively boosts the efficiency of highway transportation.This technology is new in India and is based on the implementation pattern of dedicated short-range communications standards. The application situation of ETC, the Chinese national standard GB/T20851-2007 electronic toll collection dedicated short-range communications sequence specifications released and introduced in 2007 and Networked toll collection system criteria provided by the transport ministry in the same year that determined the short range contact frequency 5.8GHz of the ETC network in China and introduced the ETC and MTC compliant charging scheme. The production and implementation of ETC in recent years is driven by these principles and technological specification. But in most provinces several kinds of problems in different degrees arose in the application process of the ETC program. For example adjacent lane intrusion, following vehicle mistake release, vehicle passing low speed, after transaction no release, and so on. To ensure the efficient, stable, reliable operation of ETC system engineering, evaluation and control of quality inspection by ETC system engineering is very important, and the special quality control standard for ETC engineering is not currently exiting in the field of transportation.According to ETC Engineering's framework function and application condition, comparison to some existing national standards and industry standards, a check and assessment scheme for specific design specifications was analyzed, and main test items that influence engineering efficiency were defined, the quality control policy for ETC machine engineering was placed forward.

LITERATURE REVIEW

This paper describes a networked infrastructure for the provision of intelligent resources using e-toll transponders. The architecture works with existing unmodified transponders, enabling applications that, given wireless accidents, contact, find, and count transponders. To do so, author exploits the structure of the transponder signal in the frequency domain and its properties. And developed Caraoke reader into a tiny PCB that harvests solar energy and can be quickly installed on street lamps, Caraoke also tested and demonstrated its

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capabilities in four streets on our campus[1]. The paper discusses ETC's main economic, technological and administrative features in accordance with toll charges defined by the capital cost recovery laws. The subject of this paper is not electronic road pricing (ERP) as a method for introducing full road user charging (in accordance with economic principles of effective use of road space), despite the primarily financial rationale for establishing tolls for private roads. The fundamental reasoning for tool roads in most nations ' political climate does not imply any intention to reform the procurement system in accordance with ERP when the network is returned to the public sector when the capital costs are recovered[2]. The aim of this paper is to define the explanatory variables that affect the use of ETC technologies by the toll road users. To this end, a binomial logit model was established to investigate the perceptions of consumers towards the use of ETC systems based on a national survey targeted at road users of interurban toll roads in India[3].This thesis establishes a disaggregated model of choice for electronic toll collection (ETC), focused on a large-scale survey of car drivers in Taiwan. The latent class logit model is used to classify respondents into different groups without subjective segmentation to recognize the difference in preferences among car drivers[4]. This paper presents a decision supporting tool for the location of electronic toll gantries on freeways in terms of toll revenue maximization. The embraced case study comprises of one of Portugal's most significant freeways, with an expansion of 180 km and a recently introduced automated toll collection system and implemented a categorical binary model in the first stage of the modeling process to establish drivers ' route preference between the tolled freeway segments and the quickest non-tolled alternative routes, based on traffic data gathered before and after the toll fees were added[5].The paper presented a revised safety effect of the use of multiple toll collection systems. The results showed that the AETC program significantly improved traffic safety for all types of crashes; and modified toll plazas on Expressways from the highest risk to be similar to regular segments[6].

METHODOLOGY

The Charge Collector System (C2S)[7] proposed in this paper is developed specifically for ORT infrastructures and consists of a new OBU that integrates the most widely used toll collection technologies: DSRC and GNSS, with a mobile smartphone application, providing new features for users, such as:

a) A web application with a user-friendly interface that offers various types of information (e.g. path rates, preferred directions, payment tolls, payment system / bank account collection, etc.);
b) A modern NFC-based payment[8] method that many expect will be commonly used in the near future – user simply taps the OBU with a device and receives all the bills to be charged.

In fact, gathering the hallmark of this program implementation, there is an opportunity to establish a new interoperability process between the various technologies used in toll collection, as the C2S OBU proposal incorporates the two technologies found on most of the actual systems.

C2S Overview

The idea to create this system stems from the expected demand for mobile applications and paying bills using NFC technology. This proposal for a system breaks the current paradigms, introducing the possibility of flexible payment after toll incurred.This device should follow the process outlined in Figure 1 in most ORT infrastructures. So the C2S is made up of two components / devices, one on the vehicle's board, called OBU, and the other acts in a mobile application, in a smartphone with an NFC feature. The simple event sequence, shown in Figure 1, starts with the first part, the OBU, which is not recognized by the traditional DSRC tolling device, when it passes on tollbooths, the enforcement system is activated and the Automatic License Plate Recognition (ALPR)[9] takes a picture.The OBU has spared the fee, though, and it offers the option of charging within a reasonable timeframe. The user should use a mobile application to collect the toll logs, which will receive the logs via NFC, which is why the user "touches" the OBU with his smartphone. Finally, the mobile application provides a simple user interface in which the user should submit all the toll collections via Internet connection to the respective toll provider.

With respect to scalability, the interface architecture defines the web service load management that is related to

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the mobile application and is responsible for controlling and receiving all customer toll registrations. Increasing the answer thus positions itself in improving the Web service. The solution's strategy plan is to develop a web service that can be installed via the back office platform, with front endpoints (to link to mobile applications) and a business gateway to deliver all logs to a variety of third party agencies, such as toll carriers or rental companies. Although this subject is outside the reach of the paper, it is ideal to deploy and mount the application in a cloud after the creation of the web service, where it is feasible to contract Infrastructure as a Site (IaaS)[10] and it is simple to add more resources in overloading situations, installing more "hardware" with network security / connectivity and multi-tenancy problems being protected, to promote stability and elasticity in the approach.

OBU Architecture

The architecture's initial design has been focused on the user experience, also talking about the specific application of post payment in the Digital Toll Collection. In terms of architecture, the overall solution consists of two parts, one of which can be split into two: the first is the OBU, fixed aboard as described above, and the second is the Smartphone, where there is a front-end application operating on the native mobile network and a back-end framework linking the C2S to the toll provider's back-office.The C2S solution's OBU consists of several blocks as shown in Figure 2 and is implemented on an embedded device that offers interfaces to connect to a GPS receiver, a DSRC Beacon Service Table (BST) detector, and an NFC module. The built-in computer runs three processes for managing certain peripherals. In Figure 2, a device is also included as an aspect of the framework on the block diagram, because it is where the user interface is applied in the mobile application.

The two components communicate via NFC as it is a promising technology based on user-friendly experience and is safe because it forces the user to "touch" the OBU with their smartphone, making the system not easily accessible to the vehicle's external people. The NFC module is a dedicated module that responds to smartphone interactions, which are hard to predict since they are essentially dependent on user behavior. Nevertheless, this module is an Embedded Computer's peripheral device that manages all activities but as a basic feature it has log processing and toll monitoring.

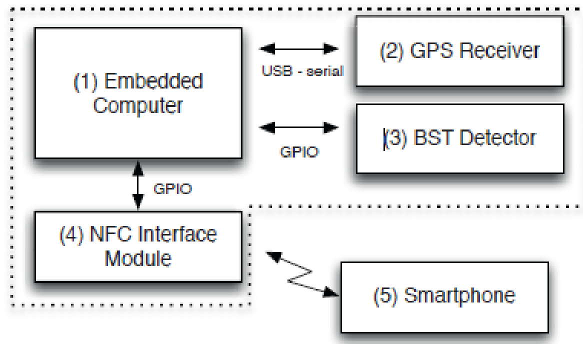

Figure 1: OBU Block Diagram

OBU Operation

The OBU process is divided into several general phases as illustrated:

- When the system starts, it sets the time and date through GPS and decides whether the vehicle is on a DSRC or GNSS/GSM network;
- When a vehicle (with this OBU) goes through a gate, it identifies a BST and records its position via a GPS receiver; if the vehicle is in a GNSS / GSM infrastructure, the OBU activity is divided into several general stages.
- The customer only has to contact his device with the OBU during the road trip and the data comprising the tolls to pay is transferred on to the mobile phone. So, the customer will test how much he has to pay for the tolls through the mobile application.

Eventually, in a lawful era, the customer has to pay the tolls, via a web service. In case of fraud, or infringement of contract, there are two ways to implement enforcement mechanisms, suggested by this approach to the two key technology used. The first, proposed for DSRC toll systems is based on existing, already installed mechanisms, e.g. ALPR, where it is possible to identify which user / vehicle already charged their tolls via C2S via back-office crossing data and deactivate the equipment of restriction fees.

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Those tolls that are not sent to the bill, though, are continued on the OBU locally at the back office. The second solution, to GNSS/GSM, suggests a link between the authority and the OBU-installed DSRC system board, which should relay a signal when there are tolls to be charged out of legal time. All these processes must be linked and managed under the oversight of the back office where a web service will manage all the payment process and all the compliance activities provisioning.

The web service component is outside the scope of this paper but it is worth mentioning that it is possible to provide the ability to specify the payment method, bank account and other options. However, in terms of communication with the OBU and user navigation, some steps have been taken in the development of mobile applications.

Mobile Application

The smartphone device, centered on the Android system, has been developed with two simple components, so two operations, the key one of which would be responsible for providing the NFC connection, assisting the consumer with the "press" protocol (interaction with the OBU) and the second one, which should be activated after reading, provide a user interface where it would be possible to check and apply to payment all in. The framework was also built to accept additional blocks to provide potential functions (e.g. bank account alternatives or traffic info), and gain mostly the required APIs to connect with a back office to provide payment capabilities.

GNSS – GPS Receiver

The GPS service is commonly used in contrast with NMEA 0183 (National Marine Electronic Application Specification) produced by most GPS, as it is simpler to decipher details. On the other side, it understands various sensors and, with zero settings, it can smell all incoming data, it is almost plug and play. Although the GPS is an open source project, it does have functionality and is an audited product that has already received the Partnership for Product Excellence's Good Software Grant.

When the sensor receives a signal, it fed the packet sniffer, which has the job of telling the core library to be interpreted which contains payloads. The driver determines the type of information regarding the packet. When the packet reaches the end, the data will be sent to an exporter for a client to access. The main exporter uses sockets where JSON generates an object and is provided to all clients watching the device. There is also the possibility of exporting data via Shared Memory or D-Bus. The GPS service includes a linkable library of C services that encourages developers to use it on their applications.

The goal, then, is to implement a program that starts a process that configures and creates a client session. The client session on GNSS/GSM networks can monitor the GPS and equate its position with virtual tollbooth fixed locations. There is a problem here in terms of execution. It is important to define a strategy of how to determine if the vehicle incurred on tolls to increase the system's efficiency.

CONCLUSION

The number of ORT infrastructures is increasing, based on their user benefits and reduced operational costs for toll firms. Such schemes, though, have some drawbacks and do not meet the needs of some consumers, such as rent-a-car costumers, ride share users and foreign drivers. The C2S will enable any road user to easily pay the tolls incurred in a user friendly interface. The proof-of-concept project is now completed, with the core device components, frameworks, and communication technologies now running, entering the OBU and the mobile application in a package.

For future work, an application must be created that passes all the toll data to the toll provider via mobile application, so having an API (Application Programming Interface) in toll provider systems is important. Eventually, to conclude the principle evidence it is necessary to test this approach in actual situations, in different systems across several countries.

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