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AETC: AN AUTOMATED ELECTRONIC TOLL COLLECTION USING ZIGBEE

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ABSTRACT: The highway transportation has become more and more important in modern road network and the traditional manual toll collection system has become outdated due to its drawbacks. By employing automated toll collection system, driver of vehicles need not to stop at a window or toll machine and waste time waiting in a long queue to pay their toll. This reduces the consumption of fuel, reduce road congestion, increase road safety and traveler become pleased. Electronic Toll collection (ETC) system is basically designed for an uninterrupted toll collection, which has become an important part of intelligent transportation system. This paper presents the concept of Automated ETC using ZigBee transceiver instead of RFID technology. The communication range is increased comparatively. ZigBee automated ETC can eliminate manual toll collection, require minimum employee, and thus lower the cost of operation.

Keywords: Electronic toll collection, ZigBee, Wireless, Remote control, Automated

1. INTRODUCTION

In the era of technology development most of the conventional systems are modified as automated system. Due to automation minimum human interference is required and this provides the facility so that the time and energy saves and efficiency increases. With the revolution in computer technology, communication and embedded system, etc the new era of intelligent transportation systems (ITS) has been started. These results in the establishment of ETC system to facilitate the traffic jam, delay, etc and could drastically improve the efficiency of road operation. Due to these benefits provided by ETC systems, it has been deployed worldwide to improve toll collection efficiency.

In 1959, Nobel Economics Prize winner William Vickrey was the first person which proposes an electronic tolling system for the Washington metropolitan area. Each car would be equipped with a transponder. The transponder's signal would be picked up when the car passed through an intersection, and then relayed to a central computer which would calculate the charge according to the intersection and the time of day and add it to the customer bill account [1]. In the 1960s and 1970's, free flow tolling was tested with fixed transponders at the undersides of the vehicles and readers, which were located under the surface of the highway. Norway has been the world's pioneer in the widespread implementation of ETC technology; it was first 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.

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Most of the researchers presented the use of 5.8 GHz DSRC transceiver for the Korea/Japan ETCS [2]. The distributed DSRC transceivers are implemented in SiGe-BiCMOS process, which is expensive and not compatible with CMOS demodulators. Furthermore, they used many external components, which is not cost effective. In [3] presented the concept of ETC using RFID technology but communication range is limited, not cost effective and problem of unauthorized reading arises. Juels et al, [4] described the blocker tag and Enhancer Proxy concept. To overcome this, the users require to carry an auxiliary device such as PDA [5]. Users may not be willing to carry these devices always and will not be available at the time of accessing RFID tags. Global Positioning System based concept of ETC system is presented in [6]. This may not be feasible when roads are covered by greenery and clear sky view is required. In [7] presented the design of ETC system using Infrared LED. In Infrared ETC system the problem of irregular LED radiation pattern and emitter design is arises [8].

ZigBee is a wireless high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area networks [9]. It is simpler and less expensive than other WPANs, such as Bluetooth. ZigBee RF frequency range is 2394-2507 MHz, suitable for applications where a low data rate, long battery life, and secure networking is required. ZigBee-compliant wireless devices are expected to transmit from 10 to 100 meters.

This paper presents an algorithm for Automated Electronic Toll Collection (AETC) system using ZegBee transceiver. Each vehicle is equipped with ZigBee

transceiver. Transceiver is also deployed at Automated ETC center. Ultrasonic sensor is mounted at exit gate of each lane so that gate can be closed or opened accordingly.

The rest of the paper is organized as follows: Preliminaries and basic concept is presented in section 2. An algorithm is proposed in section 3. Section 4 concludes the paper.

2. PRELIMINARIES AND BASIC CONCEPT

Each vehicle is equipped with a ZigBee transceiver, a microcontroller and power supply is taken from the vehicle battery. An automated ETC centre is equipped with ZigBee transceiver, computer terminal with network connected. At AETC center a gate, signal (Red/Green), and a sensor is deployed at each lane of the road. Figure1. show the arrangement of sensor, gate and direction of vehicle movement by arrow at AETC center. If any defaulter is there its vehicle is detained and necessary action is taken by the authority. An ultrasonic sensor is mounted at the exit gate of both lanes. It is used to sense whether the vehicle is passed through the gate or not.

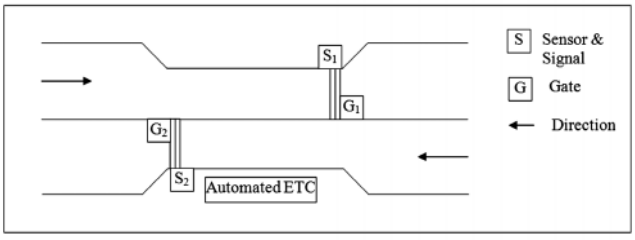

Figure 1: Showing the Arrangement of Automated ETC

3. THE PROPOSED ALGORITHM

Initially both exit gates are closed and signal becomes red. When vehicle comes within the communication range of toll collection center transceiver it starts communication with ZigBee transceiver's vehicle. As soon as, vehicle is detected process of AETC started. AETC will check whether the vehicle is registered or unregistered in AETC if not the vehicle is detained and alerts to authority and toll collected manually with penalty. Penalty is forced so that it will register vehicle in AETC and prepay amount regularly. If the vehicle is registered in AETC note down the details of a vehicle i.e., time and date of arrival of vehicle. If sufficient amount is available deduct the amount applicable for that particular vehicle from his account. The account is of prepaid type. If insufficient amount available then detain a vehicle and receive toll in cash with applicable penalty so that customer will take care of insufficient fund in future and then allow vehicle to pass through gate. Send SMS on his mobile and also alert about the payment/ deduction/ balance amount/prepayment alert if needed. Turn signal green, open the corresponding gate and allow vehicle to pass. Check whether the vehicle is passed or not if not wait till vehicle pass through gate. Close the gate and turn signal red. Accordingly the corresponding lane exit gate will remain open till vehicle passes and exit gate will remain closed till next vehicle is allowed to pass. Again searching of a vehicle and detection process started.

The process of operation of AETC is presented in the following algorithm.

Algorithm

Step 1: Is vehicle detected? No, Go to step 1.

Step 2: Yes, Is vehicle registered in ETC ? No, Go to step 9.

Step 3: Yes, Read details of a vehicle and note down the time and & date of arrival of a vehicle.

Step 4: Is sufficient amount is available in his account? No, Go to step 9.

Step 5: Yes, deduct applicable amount from the account.

Step 6: Is amount paid? No, Go to step 9.

Step 7: Send SMS of the payment/deduction/balance amount/prepayment alert if needed.

Step 8: Go to step 11.

Step 9: Detain vehicle and take necessary action.

Step10: Receive toll in cash with penalty.

Step11: Signal = Green.

Step12: Open corresponding lane exit gate.

Step13: Allow vehicle to pass.

Step14: Is vehicle passed through gate? No, go to step 14.

Step15: Yes, close exit gate.

Step16: Signal = Red.

Step17: Go to step 1.

4. CONCLUSION

An automated ETC using ZigBee technology provides compatibility with other system in ITS and overcomes the drawbacks of DSRC-based ETC system. This paper described the algorithm for automated ETC system. The communication range of ZigBee transceiver is high compared to RFID based ETC and hence more efficient and cost effective. It is advantages over GPS, RFID and Infrared LED based ETC system. The application of ZiBbee based AETC in national expressway network toll collection will be the major issues of future work. The effectiveness of this approach can be judged after designing and implementing the system in our research laboratory which is future plan of action.

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