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AUTOMATED TOLL COLLECTION SYSTEM WITH ZIGBEE COMMUNICATION

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Abstract

Toll collection systems have evolved over time, with the introduction of cloud computing. A proposed system combines contactless payment methods, cloud-based services, and real-time data processing to improve toll collection. The system's central control unit is a Raspberry Pi board, which connects parts and the cloud. The toll booth uses an RFID scanner to recognize RFID-tagged vehicles, and the sensor module captures real-time data from cars passing through stations. The system also features an LCD screen for user and toll booth manager information. Vehicle information and collected data are securely transmitted and stored in a centralized database for processing via cloud integration. This allows for real-time monitoring of toll transactions, automatic toll charge calculation, and seamless payment gateway integration. Contactless payment technology, such as electronic wallets and smartphone apps, enhances user comfort and facilitates a secure toll collection process. The system reports and analyzes data via cloud services, enhancing transportation planning, optimizing toll pricing strategies, and understanding traffic patterns.

Key Words – Collection Automation, Zigbee Communication, Dynamic Traffic Routing

1. Introduction

Traditional toll collection systems have long been associated with inefficiencies, delays, and potential safety hazards on roadways. Manual toll collection processes often result in long queues, increased traffic congestion, and frequent delays, particularly during peak hours. Moreover, the reliance on cash transactions and physical interactions between toll collectors and drivers poses health risks, especially during public health crises such as the COVID-19 pandemic. In response to these challenges, this paper proposes an innovative solution. Automated Toll Collection Using Zigbee Communication. Zigbee communication technology offers a promising avenue for revolutionizing toll collection systems by enabling seamless interaction between toll booths and vehicles equipped with Zigbee- enabled devices. Zigbee, known for its low-power, low- cost, and short-range wireless communication capabilities, presents an ideal solution for facilitating efficient and reliable communication in toll collection environments. By leveraging Zigbee technology, toll transactions can be automated, eliminating the need for manual intervention by toll booth operators and significantly reducing transaction times. The proposed automated toll collection system operates as follows: Zigbee-enabled devices are installed both in vehicles and at toll booths. When a Zigbee-equipped vehicle approaches a toll booth, the toll booth's Zigbee device communicates with the vehicle's device to initiate the toll transaction process. Vehicle identification, toll calculation, payment authorization, and transaction confirmation are all performed automatically, without requiring drivers to stop or interact with toll booth operators physically. This paper discusses in detail the design, implementation, and evaluation of the automated toll collection system. The design phase involves the development of hardware and software components tailored to the specific requirements of toll collection operations. Implementation considerations, including device installation, network configuration, and system integration, are also addressed comprehensively. Challenges encountered during the design and implementation phases are identified and solutions are proposed to mitigate them effectively. Evaluation of the automated toll collection system encompasses various metrics, including transaction speed, accuracy, reliability, and user satisfaction. Field tests and simulations are conducted to assess the system's performance under real- world conditions. The results demonstrate significant improvements in toll collection efficiency, with reduced transaction times, decreased traffic congestion, and enhanced user experience reported. Automated toll

collection using Zigbee communication represents a transformative innovation in transportation infrastructure management. By streamlining toll collection processes, this system not only improves efficiency but also enhances road safety and reduces environmental impact by minimizing vehicle emissions associated with idling in toll queues Future research directions may focus on scalability, interoperability with other transportation systems, and integration of emerging technologies to further enhance the effectiveness and versatility of automated toll collection systems.

2. Related Work

Ramakrishnan Raman and Karthiayani A, **"**Cloud- based Electronic Toll Collection: Enabling Contactless and Automated Payments System", 7th International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC),IEEE,2023.Toll collecting systems have traditionally used human payment or specific electronic toll tags. With cloud computing, toll-collecting systems have improved. The suggested system integrates cloud-based services, contactless payment mechanisms, and real-time data processing to improve toll collection. Traffic data, toll-collecting statistics, and historical data may be studied to understand traffic trends, optimize toll pricing techniques, and improve transportation planning.

Sanket Gupta and K. Vadivukkarasi, "Electronic Toll Collection System Using Zigbee And Rfid", International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 4, April 2017 The paper demonstrates the use of Electronic toll collection using RFID and zigbee transceiver technology to provide benefits over fuel wastage, traffic congestion and theft vehicle. The RFID tag is used for creating rechargeable account. The toll Gates are equipped with RFID reader, RFID antenna, database handling software and zigbee receiver. The driver vehicle is equipped with RFID tag which handles the name, total amount and the mobile number , the zigbee transmitter that transmit the vehicle number for theft vehicle detection. As the vehicle approaches the toll gate the RFID reader reads the RFID tag and zigbee receiver receives the vehicle number. The toll gate opens only when the vehicle theft detection report is negative and the RFID tag amount is above the desired set amount to be deducted. The GSM technology is used to send messages about the money deduction. This model provides the benefits of stopping illegal toll collection, reliability and security.

Chintaman S. Bari, Yogeshwar V. Navandar, "Delay modelling at manually operated toll plazas under mixed traffic conditions", Toll plaza operations in India are entirely different from that of the United States (US) and European countries. The majority of tollbooths in India are manually operated, where all the vehicles arriving at the toll plaza have to stop at tollbooth to pay the toll. During this process, a vehicle first decelerates, joins the queue and pays the toll at tollbooths.Afterwards, the vehicle accelerates and regains the stream speed. The overall process causes delay to each approaching vehicle due to deceleration, waiting time in the queue, service time at the tollbooth and finally due to acceleration. Hence, the present study aims to quantify the overall delay that includes system delay (service time and waiting time), acceleration and deceleration delays at manually operated toll plazas under mixed traffic conditions. The overall delay model has been proposed by using (i) dynamic acceleration and deceleration values, (ii) waiting time in the queue and (iii) service time depends upon traffic composition and approach volume. The delay thus obtained from models has been validated from field observed delay values and it is found that no significant difference between observed and predicted delay values. Therefore, the proposed delay model can be used in future to quantify the vehicle delay at toll plazas and can also propose Level of Service (LoS) thresholds and the number of tollbooths required for prescribed LoS.

Sakina ELHADI and Nawal SAEL "Comparative study of IoT protocols", The second International Conference on Smart applications and data analysis for Smart cities, February 2018. Internet of thing, or Connected Objects (IOT) is considering a modern concept. A few years ago, the IoT has invaded our professional and personal life revolutionizing the near future. Indeed, the goal is to create an environment composed of intelligent devices and systems which can communicate with each other through computer networks. These data exchanges allow better decision- making in an increasingly complex context. The success of the Internet depends on the widespread adoption of clearly defined protocols. It represents a common language to all connected systems, regardless of brand, operating system or software tools used. In the absence of such a common language, the Internet would be reduced to a patchwork of proprietary and incompatible networks. This research analyses some of the major evolving and enabling protocols in the IoT. Particularly, it focuses on Layer Network and applications Protocols. Our study evaluates their capabilities and compares their main characteristics and behaviors in terms of various criteria of these protocols. The comparison presented in this paper would benefit researchers and developers in selecting an appropriate protocol for the IoT

applications. In This paper we aim to provide first a complete overview of the IoT architecture, then the different protocols. In addition, we present a comparative of application and network layer protocols.

G.Rajesh Babu and G.Ananth Kumar , "RFID based Automated Toll Plaza System", International Journal on Recent and Innovation Trends in Computing and Communication ,Volume: 4 ,Issue: 4 , April 2016. The RFID tag and RFID peruser are contained in RFID innovation. RFID implies Radio Frequency Identification that comprises of the labels which can be either dynamic or aloof tag. Inactive tag don't have own energy supply, much less expensive to fabricate and little loop reception apparatus is utilized. Then again, dynamic tag must have own energy supply. It has longer range and bigger recollections. It can store extra data sent the RFID peruser. RFID peruser is an investigative specialist. RFID frequencies range between 30kHz and 2.5GHz to recognize question remotely. A fundamental RFID framework comprise of three parts a reception apparatus or curl a handset (with decoder) a transponder (RF tag) electronically customized with extraordinary data the innovation can likewise be utilized as a part of toll Collection at toll doors and this empowers the following of vehicles and additionally the merchandise they convey continuously.

3. System Model

The proposed solution introduces an automated toll collection system that consists of two setups: one at toll

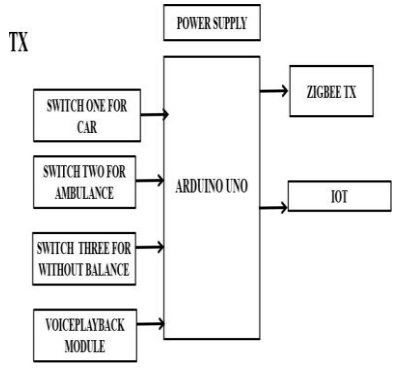

Fig 1 Zigbee transmitter module

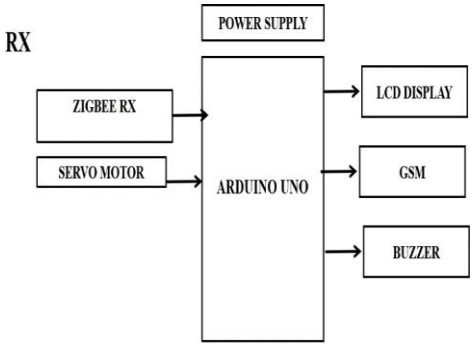

Fig 2 Zigbee receiver module

booth and other in vehicles. The system uses zigbee protocol for communication and connects to external network via zigbee mesh gateway. The system operates in three modes:

1. Non-tollable vehicles(ambulances etc..)
2. Tollable recharged vehicles
3. Tollable non-recharged or non-connected vehicles

3.1 Non-tollable vehicles

When activated, this mode prioritizes ambulance passage. The toll gate system, upon receiving the Zigbee signal, not only opens the gate but also communicates to surrounding lanes for a coordinated response, optimizing traffic flow and ensuring timely emergency access

3.2 Tollable recharged vehicles

The toll acquirer's details are relayed as broadcast message to all vehicles in range(500 meters) of zigbee transmitter. Upon successful payment of toll the vehicles send back a confirmation to the booth. Then they are redirected to paid lane. If the vehicles come closer than 250 meters to the booth without payment the buzzer arises to alert.

3.3 Tollable non-recharged or non-connected vehicles

The vehicles that come in range with the zigbee transmitter with invalid recharge are redirected to cash payment lane. Also the vehicles that do not reflect any zigbee signal(not zigbee enabled) are also redirected to cash payment

lane.

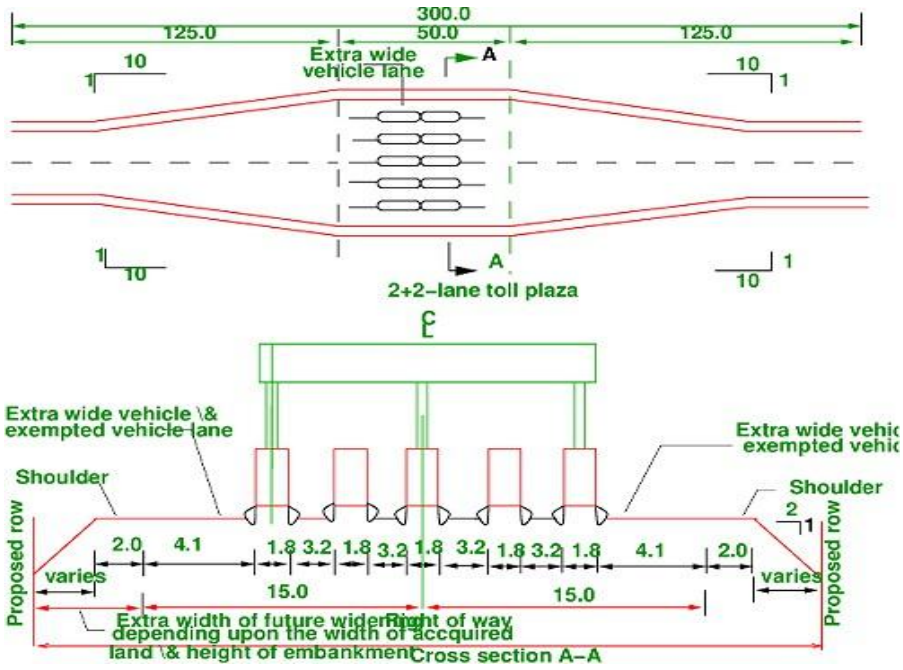

Fig. 3 Structure of toll booth construction issued by NHAI

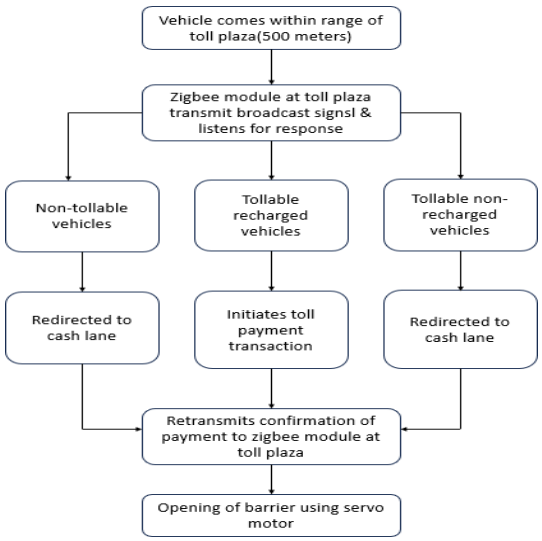

Fig. 4 Workflow of toll automation system

Vehicles come closer to the toll plaza. When they are within a distance of 500 m from the tall booth they will start receiving signal from the zigbee transmitter at the booth. Upon detecting this signal the zigbee module in the vehicle will establish connection with toll booth module and send the distance it had travelled since the previous toll up to the current toll.Now transmitter transmits another signal which consists of the following information: 1. toll plaza details (name area pin code). 2. total amount required bank details.3. acquire bank details. The vehicle's zigbee module will then connect with external network and initiates payment transaction. Upon successful payment, confirmation sent to module at toll booth. The toll gate system sends audio feedback conveying gate details which is audible within the vehicle. Then the server motors help in opening the boom barrier.

4. Results

The Cloud-Based Electronic Toll Collection System improves efficiency, accuracy, and security by modernizing toll payments through contactless, automated processing. It optimizes traffic flow, supports scalability, and lessens its impact on the environment by utilizing real-time data and cloud technologies. Both users and authorities gain from the system's enhanced communication and user-friendly features, which also establish a new benchmark for toll collecting and facilitate easier, more convenient travel.

5. Conclusion

The Cloud-Based Electronic Toll Collection System offers an effective solution for toll payment procedures. The contactless and automated payment features benefit both customers and toll authorities. The system ensures efficient toll collection through speed, accuracy, scalability, and security features. The solution analyses real-time data to optimise traffic management and make informed decisions. Automating payment procedures improves communication, reduces environmental impact, and increases tax collection. Integrating innovative technology and cloud-based infrastructure ensures seamless interoperability and an intuitive user interface. The Cloud Based Electronic Toll Collecting System revolutionises the toll-collecting industry with innovative features, improved traffic flow, and secure payment processing. This sets a new standard for toll collection systems, leading to more convenient and comfortable travel for all.

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