



Towards Building smart toll tax collection system using Bluetooth LE Advertising

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Abstract: There has been a growing interest, over the past few years, in the Internet of Things (IoT), cutting across various industries, ranging from public transport to academia etc. Since mobility has become one of the basic necessities, the number of motor vehicles is increasing day by day. Hence, traffic load has swelled on every road, especially in and around urban areas. Often, the roads reach their maximum capacity during peak hours resulting in traffic jams and longer travel time. In metropolises with a high number of vehicles, it becomes essential to manage traffic by using smart and fast traffic data collection systems in the control center. The latest release of Bluetooth 4.2, also called Bluetooth Smart, carries features like Bluetooth advertising making Bluetooth LE (BLE) a competitive candidate among different low-power communication technologies for the battery oriented devices in the IoT space. This paper suggests a smart toll tax collection system using BLE Advertising. The system supports security properties including secure authentication, unforgeability, automatic correct billing, privacy, remote monitoring and detection of stolen vehicles, and can prevent various road mishaps and crimes. Furthermore, it provides real-time traffic information e.g. travel-duration, traffic jams, dwell time at intersections, origin/destination analysis as well as traffic flows.

Keywords: advertising, BLE, IoT, mobility, RFID, toll tax

I. INTRODUCTION

In India, the conventional toll tax collection system is based on paper that leads to complete disorder and confusion among public, [system loss], corruption and most disturbingly, to traffic jams causing wastage of time. A lot of effort is required at toll offices/booths to ensure proper security, hassle-free provision of manual license and checking of vehicle documents. What is alarming is the delays at the toll plazas and needs an explicable immediacy. Percentage of toll expenses and delays at total stoppages have increased over the years[1]. Transportation corporations have been using computing systems over the years to outdo efficiency, safety and customer travel/transit experience. However, an aggregate amount of obsolete devices are working against these objectives. Over the past few decades, toll has become the second largest expenditure in the transport sector coming only after fuel expenses, as over 374 toll plazas have sprung up across India to collect transit fees on most of the national highway networks. There are around one crore registered trucks and buses in India. Of these, a truck with a national permit, on an average pays around Rs 4 to 5 lakhs per year in tolls alone. The assumption, that the toll fees strengthens/aides/contributes to the national infrastructure, however, is not reflected in state and central budgets. Instead, toll plazas end up deterring traffic flow, despite better roads due to vicious computing systems.

As transporters opine, the average usage of a truck has remained the same while the cost of transportation have increased and profit margins are at an all-time low. A study on high-traffic highways revealed that delays at toll plazas cost the Indian economy RS 87,000 crores every year [2]. Addressing the issue of high toll charges, delays, and other mismanagement, IOT technologies make it easier to connect new and old systems together, thus enabling faster data sharing that can lead to a multitude of new opportunities. This paper is an attempt to draw the attention of the transportation

companies and the Government to the challenges put forth by the present public transportation system.

Using Bluetooth Smart, surveillance and toll tax collection systems can be merged to solve the prevailing problems. [Even though the RFID-based system can be designed], we propose the smart toll tax collection system based on Bluetooth advertising for its usage of low power, swift detection, low cost, easy operation, portability, durability, reliability and for being much more user-friendly. When a vehicle is within the range of the Bluetooth device placed at a toll station/booth, The Vehicle advertises the data by broadcasting it. The system (toll Plaza) extracts the data and advertisement address typically known as MAC address of the mobile vehicle. This MAC address is searched in the database, which identifies the vehicle type, its owner, and its number plate. According to the vehicle type (car, bus, truck etc.), toll tax amount will be deducted from linked the prepaid account. The account will be updated with remaining credits.

II. SYSTEM DESCRIPTION

Bluetooth [13].is a globally unlicensed IEEE standard operating in the 2.4 GHZ short-range radio frequency spectrum. Bluetooth is a short range, low power standard with a 48-bit unique MAC address which makes it uniquely identifiable. New applications based on Bluetooth arose over the past few years due to its uniquely identifiable property and suitability for battery oriented devices. The Bluetooth detection model is shown in figure 1. In this era of technology, Bluetooth is used in almost all devices ranging from handheld devices to smartphones to vehicles and thus can be used for toll tax collection and monitoring of vehicles.

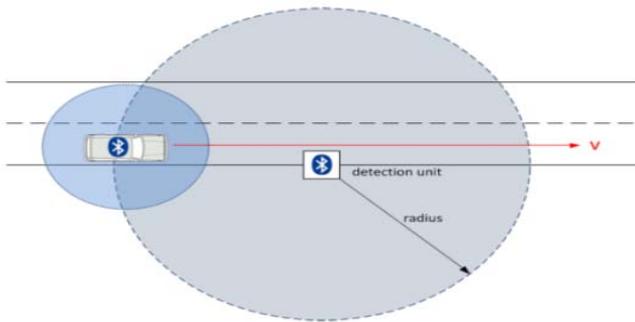


Fig. 1. The Bluetooth detection principle

A. Bluetooth LE Advertising

Bluetooth LE Advertising [14-19], one of the most vital and interesting features of the Bluetooth 4.0 and above standards, allows the devices to discover and communicate with other devices without an explicit pairing operation and authentication like earlier standards of Bluetooth which typically require manual pairing between devices to communicate. In Bluetooth Advertising, the content to be advertised, which can vary from a simple text messages to multimedia content, is broadcasted via Bluetooth protocol which nearby devices can receive and react to without traditional pairing which thereby turns into a Bluetooth iBeacon. Bluetooth Broadcasting allows only 31 bytes of advertising packets, so you can't broadcast huge amount of data but is certainly a perfect carrier to send important data during advertising. Fig. 2 displays packet format of an advertisement packet. The maximum octets we can use is 28 including Universal unique identifier(UUID). Except UUID and other overheads, we can use only 8 octets (red oval in Fig. 2).

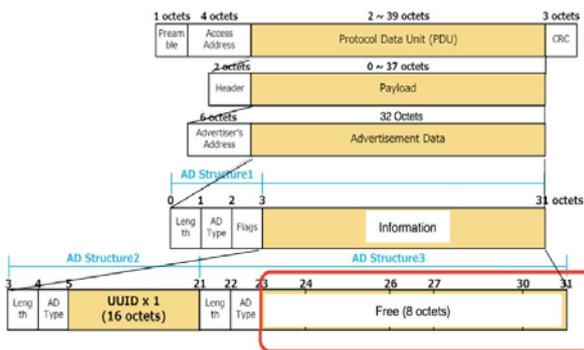


Fig.2 Packet format of BLE advertisement

III. PREVIOUS WORK

In this paper, building a toll tax collection system based on Bluetooth advertising is proposed. Previous work suggests building RFID based toll tax system [3][4][5] but numerous limitations and unresolved issues still hinder the widespread application of RFID [6]. Automatic toll collection using QR code scanning for toll collection in minimum time to overcome the traffic problem. It use QR code as a live picture so web cam will first capture each vehicle's unique QR code and then will scan it as soon as it passes through toll plaza. After recognizing the string from QR code it will then perform the task of transaction. The amount of toll tax is then reduced from account number registered with vehicle at the

time of vehicle registration [7]. Others suggested DSRC (Dedicated Short Range Communication) for electronic toll collection [8]. It can provide services to both vehicle to vehicle and vehicle to infrastructure up to 1km and supports data rate of up to 27Mbps. It has been observed that the current specification of DSRC performs poorly in high density and mobility conditions [9]. Bluetooth based toll tax collection system was suggested by [10]. But due to high enquiry time and initial pairing and authentication issues made it less competitive. However, the latest release of Bluetooth 4.2 [11] so called Bluetooth smart and recently announced Bluetooth 5 [12] with Broadcasting feature makes it a perfect technology for collecting toll tax automatically.

IV. OPERATIONAL PRINCIPLE OF PROPOSED SYSTEM

The goal of the proposed toll tax collection system is to establish a connection between the Bluetooth device equipped at toll plazas (BP_x) and the devices equipped in vehicles (BV_x) within the detection range to exchange information efficiently. The BV_x will contain a group of data to be broadcasted given in Table 1.

TABLE I. POSSIBLE DATA COMPOSITION for BV_x

| MAC Address | Vehicle No. | Vehicle Type | Vehicle Owner | Account No. |
|-------------|-------------|--------------|---------------|-------------|
|-------------|-------------|--------------|---------------|-------------|

A. Outline of the BLE Protocol

Packet format of advertising packet for our system is described in Figure 3. According to the definition of BLE, we can use 28 octets in the packet. We introduced the following information in the advertising packet.

- 1) Data Type: indicate message type(1 Byte)
- 2) Vehicle Hash TYP: Vehicle Type (1 Byte)
- 3) Vehicle Hash ID: Vehicle Number (2 bytes)
- 4) Vehicle Hash ACCOUNT: Vehicle Prepaid Account Number (2 bytes)
- 5) Data ID: Sequence number of message(1 byte)
- 6) TTL: lifetime of packet (TTL)

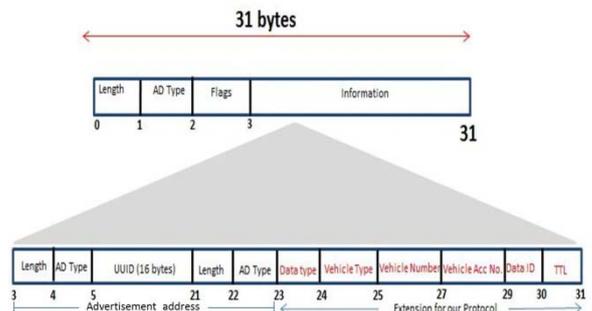


Fig. 3 Adding New Features to BLE Advertisement Packet

Toll Tax Collection System

In the proposed system, The Bluetooth devices have to be placed inside the vehicle (BV_x) and on the Toll Plazas (BP_x). The Working Module is shown in fig 4. The BV_x acts as a Broadcaster and broadcasts the data at regular intervals. The BP_x is a Bluetooth Receiver which receives the packets advertised by the BV_x. When the BV_x enters into the range of BP_x deployed at the Toll Plaza, The BV_x broadcasts the data. The BP_x receives the packet and verifies the data with the

database. According to the vehicle type (car, bus, truck etc.), toll tax amount will be deducted from the linked prepaid account. The account will be updated with remaining credits. Though the system broadcasts the vehicle related data, only the authorised receivers can use the information and make the payment from the prepaid account. If the data broadcasted by BVx doesn't match with the database, The system will notify the vehicle for manual payment(see in figure 5). The Prepaid Account associated with the system is like a Wallet which people can recharge online. For any balance related queries, customers can contact the associated customer service number to get information regarding toll amount deduction, timings etc.

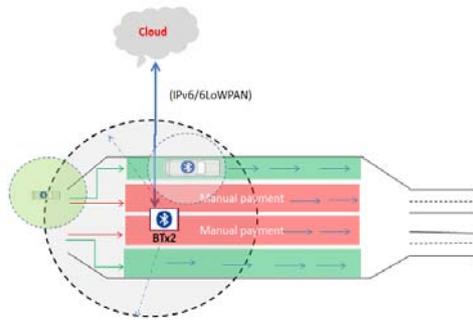


Fig. 4 Working Module of toll tax collection

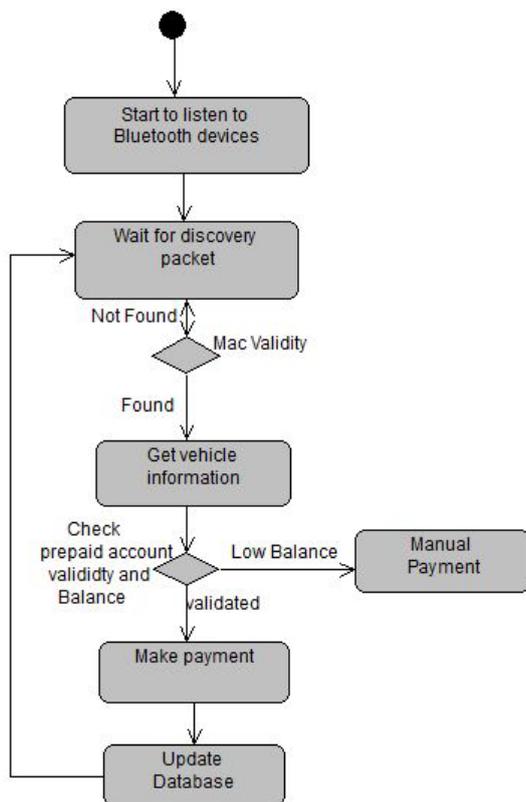


Fig. 5. Flowchart for toll tax collection based on Bluetooth advertising

V. CONCLUSION

The system is expected to be fully automated, reliable, transparent and convenient. The whole system can also be used in vehicle on highways, their toll payment and in the railway ticketing system with small or no modification. The System is more convenient than the traditional paper based toll collection as it saves sufficient time resulting in low traffic

jams, less fuel wastage and more importantly provides security. In the future, we are looking to implement the system in Public Transport system in smart and connected cities to allow passengers get notifications regarding the Bus timings, nearby locations, automatic fare collection etc.

VI. REFERENCES

- [1] The Time's of India paper, "India loses Rs 60,000 crore due to traffic congestion: Study" may 31, 2012".
- [2] The Economic Times paper, "Delays at toll cost Rs 87,000 crore every year "may 31, 2012".
- [3] Kalantri, Rakhi, AnandParekar, AkshayMohite, and RohanKankapurkar. "RFID based toll collection system." International Journal of Computer Science and Information Technologies 5, no. 2 (2014): 2582-5.
- [4] Salunke, Pranoti, PoonamMalle, KirtiDatir, and JayshreeDukale. "Automated toll collection system using RFID." Journal of Computer Engineering 9, no. 2 (2013): 61-66.
- [5] Hasan, MdFoaisalMahedi, GolamTangim, MdKafiul Islam, MdRezwanulHaqueKhandokar, and ArifUIAlam. "RFID-based ticketing for public transport system: Perspective megacity Dhaka." In Computer Science and Information Technology (ICCSIT), 2010 3rd IEEE International Conference on, vol. 6, pp. 459-462. IEEE, 2010.
- [6] Kaur, Mandeep, ManjeetSandhu, Neeraj Mohan, and Parvinder S. Sandhu. "RFID technology principles, advantages, limitations & its applications." International Journal of Computer and Electrical Engineering 3, no. 1 (2011): 151.
- [7] John, Linda, DebyaniMitra, and Sayli More. "AUTOMATIC TOLL COLLECTION USING QR CODE SCANNING." 23 March, 2016
- [8] Anwer, M. Shahid, and Chris Guy. "A survey of VANET technologies." J. Emerg. Trends Comput. Inf. Sci 5, no. 9 (2014): 671.
- [9] KA Hafeez, L.Zhao, B. Ma, JW. Mark, "Performance Analysis and Enhancement of the DSRC for VANET's Safety Applications," IEEE Trans. on Vehicular Technology, Vol. 62, Issue. 7, pp.3069-3083, 2013.
- [10] Madhavi, MrRajendra H., and MrMitesh P. Pedhavi. "Intelligent Highway Toll Tax System And Surveillance Using Bluetooth And OCR." International journal of advanced foundation and research in science and engineering, vol 2 , special issue, 2016
- [11] Raza, Shahid, PrasantMisra, Zhitao He, and Thiemo Voigt. "Bluetooth smart: An enabling technology for the Internet of Things." In Wireless and Mobile Computing, Networking and Communications (WiMob), 2015 IEEE 11th International Conference on, pp. 155-162. IEEE, 2015.
- [12] www.bluetooth.com, Bluetooth 5 is available, Nov 2016
- [13] Bluetooth SIG. Bluetooth Specification Version 4.2 [Vol 0]. Bluetooth Specification, December 2014. [https://www.bluetooth.org/en-us/specification/adopted-specifications Online; accessed 12-7-2015].
- [14] M. Aiello, R. de Jong, J. de Nes, "Bluetooth Broadcasting: How far can we go? An experimental study.," in Int. Conference on Pervasive Computing and Applications (ICPCA'09) IEEE Computer., 2009.
- [15] Brauer, Sebastian, et al. "On practical selective jamming of Bluetooth Low Energy advertising." Standards for Communications and Networking (CSCN), 2016 IEEE Conference on. IEEE, 2016.
- [16] Michalevsky, Yan, SumanNath, and Jie Liu. "MASHaBLE: mobile applications of secret handshakes over bluetooth LE." In Proceedings of the 22nd Annual International Conference on Mobile Computing and Networking, pp. 387-400. ACM, 2016.
- [17] Ito, Atsushi, et al. "A study on designing ad hoc network protocol using Bluetooth low energy." Cognitive

- Infocommunications (CogInfoCom), 2016 7th IEEE International Conference on. IEEE, 2016.
- [18] Somkuwar, Akshay, et al. "Review on Data Analysis & Broadcasting Using Ibeacon Technology." (2016).
- [19] Choi, Moonok, Jinsoo Han, and Ilwoo Lee. "An efficient energy monitoring method based on Bluetooth Low Energy." Consumer Electronics (ICCE), 2016 IEEE International Conference on. IEEE, 2016.