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Public Transit Cashless e-Ticketing and Real-time Location Tracking

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***Abstract*—Public transport has becoming a part of day-to-day life. Most of the people are using public transport to commute various places. But, there are many problems faced, such as hassle of loose coins, irregular fare rates, wastage of time, etc. These can be reduced when the cashless e-ticketing and location tracking is implemented in the public buses. This research paper proposes a survey on various existing systems to identify the issues, study about it and develop a product that could overcome the problems.**

***Keywords*—Cashless e-ticketing system, real-time location tracking, e-wallet payments, GPS**

I. INTRODUCTION

Our country is moving towards the digital currency to make transactions easier, faster and accurate. Also, the revenue management is easier for the government as all the records are maintained in the database [16] [21]. In recent times, some other countries like Kenya and Singapore have implemented cashless e-ticketing using smart cards [1] and other sensors like RFID tags [18], NFC [3], etc. However, these could cost more and could be more difficult to implement in our country where population is very huge. Thus, we need to use the existing resource and make best use of it. In India, metropolitan cities have more population and well-educated people when comparing to other rural areas [20]. Also, people from these cities are widely using the public buses to commute various places for work.

Electronic ticket is a form of digital ticket that does not require any paper printed form of ticket [22]. It was first widely used in airlines and then it came to every other department like buses, trains, hotels, etc. We can get this electronic ticket, when we have access to any of the online payment solution [16]. This is commonly called as the digital currency [21] which is a fast and a secured mode of transferring money. This is the future of payments and the same is being implementing across the nation. The payments in India is now authenticated using the Aadhaar credentials [15] [19]. In India, Aadhaar "Know Your Customer" is now used widely by many organizations to simply verify, authorize and authenticate the user. The steps are becoming very less and simple. Currently, the Aadhaar system [15] [19] has the vital role with which every other service is being linked.

Location tracking is becoming very popular these days with the ability of GPS modules [5] [6]. The tracking of locations in real-time has becoming easy through various ways. Google Maps API is used to integrate the facility of tracking the buses, trains and other vehicles in map view with web [5] or mobile applications [6]. It would be convenient if we could know when public transits will arrive at our location and could plan accordingly.

When cashless e-ticketing in government buses with real-time tracking is implemented, it makes our daily basis more comfortable and easy to commute by minimizing the issues. But, there might be no such systems with these two features included. Also, in India, we have Aadhaar [15] [19] linked with banks, ration card, mobile number and much more. With these we do not need to manufacture smart cards or RFIDs, instead we can use existing resource and save the revenue. This idea could be implemented if there is a proper survey made on these two domains along with security for data privacy.

A. *Contributions and Organization of the Survey*

In this paper, we provide a detailed review of available literature on Public Transit Cashless e-Ticketing and Real-time Location Tracking. We have analyzed the existing systems and the technology to

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overcome the existing issues and to reuse the proposed algorithms. In Section II, we have categorized the literature based on the Cashless e-ticketing process. The real-time location tracking is reviewed on Section III. We provide the analyzed information on exiting works such as technology and module used, its advantages and disadvantages in both Section II and III. In Addition, the security in networking for cashless e-ticketing process is discussed in the Section II itself. Finally, we conclude our research paper in the Section IV.

II. CASHLESS E-TICKETING

The smart card system is currently introduced in many areas in Kenya, the system followed there is Matatu e-ticketing System [10]. This project implemented the cashless ticketing [21] in the public transit like metro bus and trains. The system has solved many problems and has many benefits for passengers like time-saving and convenient travel, cashless ticketing, reduced frauds and actual fare rates [21] [10]. The Matatu owners can track how much they have earned and manage their revenue [10]. But this project has some challenges such as fake smartcards, increased transaction time, expensive to implement as they use smart cards, difficult to maintain the database [10].

The ticket fare processing is inspired from Mohamed Mezghani's EMTA system [7]. The project [7] used the distance based fare processing in three ways, Check-in/Check-out (CICO), Walk-in/Walk-out (WIWO) and Be-in/Be-out (BIBO). The fare processing used is based on the fare records at different stages in different cities. The advantages of this system are ease-of-use, equity, simple revenue collection, reduced fraud. This system includes different types of tickets like single tickets, multiple tickets, single mode, multi-mode, season tickets, etc. It also includes several modes of payment such as cash, tokens, paper tickets, magnetic strip tickets and other types of modes [7]. For electronic ticketing in public transport this system uses the electronic machine to swipe the smart cards and provide the ticket which increases the implementation cost [1]. However, this system has some issues in fares calculations, business model, changes or modifying the fare policies, need of smart cards and reading machine. About 71% of total population uses smart cards [1], 65% people uses Near Field Communication [3] and 24% uses RFID [18].

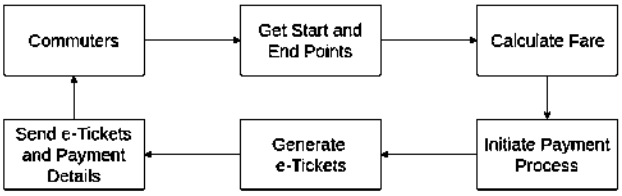

Fig. 1.1 General Process of cashless e-ticketing

The project [4] proposes the usage of sockets and its deployment related to network programming. The client server applications use sockets to exchange data by communicating with each other. Limi Kalita describes that Java supports network programming, and the same is preferable because of its platform independent [4]. It can handle common problems very efficiently, that occur during I/O and network operations which is an advantage of Java. Client Server Communications are explained briefly which describes servers are super computers which offer required services to clients [6]. TCP [25] and UDP [25] have been used in client server communication to exchange data between each other. The main advantage of using TCP is that it is a connection oriented protocol where the data transfer is reliable, no data loss occurs [25]. The main disadvantage of UDP protocols is that it is connectionless protocol where the data transfer is not reliable, and loss of data can occur [25]. The author discusses some examples that an electricity network works with sockets, a telephone network works with sockets likewise a computer network uses socket APIs [6]. [14] discussed about a system, GSM based AMR has low infrastructure cost and it reduces man power. The system is fully automatic, hence the probability of error is reduced. The data is highly secured and it not only solve the problem of traditional meter reading system but also provides additional features such as power disconnection, reconnection and the concept of power management. The database stores the current month and also all the previous month data for the future use. Hence the system saves a lot amount of time and energy. Due to the power fluctuations, there might be a damage in the home appliances. Hence to avoid such damages and to protect the appliances, the voltage controlling method can be implemented.

Mukund R. Joshi et al. the authors proposed a paper on Network Security and Cryptography [9]. The

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paper tells us about how and why network security is playing a vital role in information security. Network Security is very important when it comes to information security, because it has the responsibility of securing the data passed through a wireless network. Network Security uses Cryptography [9] [12] to secure data transmissions. The paper describes briefly about the cryptographic principle and cryptosystem types [9]. All encrypted data must contain some redundancy which is the principle of cryptography. Cryptographic system provides privacy and authentication [12] in communications which is the main use of it. Symmetric and Asymmetric cryptosystems are the two types of cryptosystems explained in the paper. The authors have also explained about the two cryptographic models namely, symmetric and asymmetric encryptions and the algorithms used [9]. Authors use public, private and shared keys to encrypt and decrypt the data for secure transmission. The various algorithms used for network security are DES, RSA, HASH, MD5, AES, SHA1 and HMAC [12].

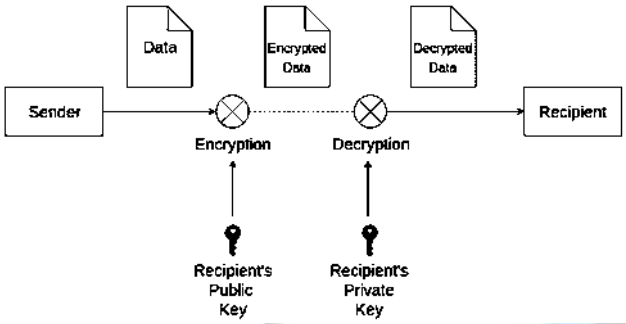

Fig: 1.2 Network Communication and Security

Sachin Taluja et al. The authors have surveyed papers on network security, threats and firewalls [12]. Network security is very important, when it comes to designing a network [25]. Because it has the policies and procedures to protect devices in network from threats as well as to prevent the unauthorized users from accessing the network [26]. The authors say that day by day, the number of network attacks increases so it is necessary to enhance the security by performing various tasks using firewalls [12]. They have described the important features of network security such as user and data authentication, data integrity, confidentiality and availability. User and data authentication is used to check whether the user is an authenticated person or not to access the data which increases security strength. Data integrity [12] is used to maintain and provide assurance to the accuracy and consistency of data which helps in storing, processing and retrieving of data, which are the advantages. Availability [12] makes the network available to the user anytime. The authors have described about various types of network threats [12] [26] such as adware, backdoor trojans, Boot Sector Viruses, Cookies, Document Viruses, Email Viruses, Phishing, etc. They have discussed about firewall and their types. Circuit level firewalls, Application level firewalls, Packet filtering firewalls are the three types of firewalls used in network security [12] [26].

III. REAL-TIME LOCATION TRACKING

The real-time location of the buses can be tracked using the Global Positioning System (GPS) and General Packet Radio Service (GPRS) where the GPRS is used to find the area using the cellular tower signal and the GPS is to find the precise location of the vehicle [13]. Then the value of latitude and longitude are used to locate the bus in the Google Maps API [6] [11] [13].

S. Sahitya et al, use GPS-634R GPS sensor to locate the vehicle, and they believe that the sensor is a highly integrated module with the ceramic antenna [13]. They use the GPRS [8] to easily track in which area the vehicle is, and use it to update the latitude and longitude to the server in real-time [13]. But the implementation cost is high as it uses the different sensors and compatible motherboard to support it.

In modern vehicles mainly cars, the manufacturers are integrating the inbuilt GPS navigation system using the Google Maps API v3 [6], the GPS sensor is linked with the mobile operator's Gateway GPRS Support Node (GGNS) [6] [8]. This system [6] uses Google Maps API v3 [6] [13] to pinpoint the marker in the map to show where the vehicle is currently located. The hardware components such as ARM7TDMI [2] microcontroller a low cost and low power consumption chipset, EM-406A as GPS sensor [6]. The advantages of this system are open source, low cost efficient and it has some limitations as it could stop the updating process of the vehicle's location to the server when there is no cellular connectivity [6].

Manini Kumbhar et al. proposed the web based tracking of the buses, they use three models such as 1) bus model which has GPS sensor [5] for location detection and use of Subscriber Identity Module (SIM)

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[24] to transmit the location data to the server, 2) central control unit which acts as a admin module and 3) user module which is a simple web based application to find the real-time location of the buses [5]. The main advantage of this system is it provide the facility to track the bus location with almost accurate results. But the disadvantage is the usage of MySQL as a database which is slows down the process because it has some stability issues.

Vehicle tracking can also be achieved by sending the real-time location access via Short Message Service (SMS) [17]. Vinay Kumar has proposed his project based on the accidental alert and real-time tracking of the vehicle. When there is any conflict the current location of the vehicle data is fetched by the GPSs module and the sent to the server by GSM connection [8]. Also, it uses the SMS functionalities to alert the owner of the vehicle.

Sean Barbeau et al. proposed dynamic real-time location data using the mobile phone's GPS. They use algorithm to reduce the number of unwanted GPS fix and optimize the speed to find the location of the mobile phone accurately. To increase the efficiency of the battery life and accurate GPS fixes they have presented two algorithms called Critical Path (CP) algorithm [17] [23] and location-aware state machine algorithm. The CP algorithm filters the data points which is then sent to the server. The location-aware state algorithm manages the number of re-calculation rate [17]. They minimize the data array of locations and show the results without affecting the routes and locations. Thus, the with smaller data transfer and minimal usage of GPS sensor. They withstand the mobile battery charge without avoiding it to drain faster.

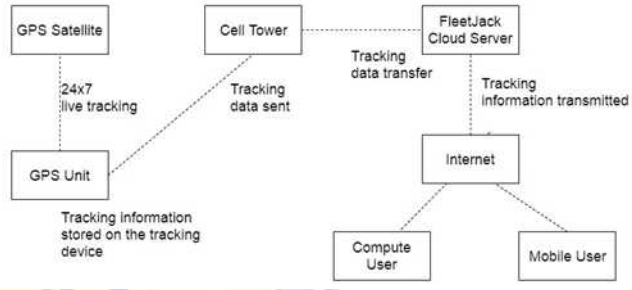

Fig 1.3 General Location Tracking Process

TABLE I: Summary on cashless e-ticketing

References	Technology	Devices	Performance	Payment models
Matatu e-Tickeing System [10]	-Contact based Smart cards -RFID tags	-Smartphones -Vending machines	-Contact based smartcards increase delay in processing -Information retrieving Performance improved with RFID	-Check-in/check-out (CICO) -Walk-in/walk-out (WIWO) -Be-in/be-out (BIBO)
EMTA [7]	- Contactless Smart cards -Contact-based smartcards (ISO7816) -NFC -RFID -Proximity (ISO14443) -Vicinity (ISO15693)	-Smartphones -Vending machine -Sony FeliCa -MiFare -Calypso Microprocessor	-EEPROM chips used in contact-based smartcards has limitation in memory -2 KB to 4 KB memory used in chips which is sufficient to store all information -NFC works on 13.56 MHz frequency which has faster communication in compared with other technologies used	-Be-in/be-out (BIBN) -Check-in/check-out (CICO)

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TABLE II: Summary on Realtime Location Tracking

References	Modules	Sensor	Programming Languages	Performance	Accuracy
Dynamic Management of Real-Time Location Data on GPS-Enabled Mobile Phones	-UDP protocol	-Mobile GPS	-JAVA ME	-Energy consumed by the sensor is less. Because, GPS fix occurs at an interval of 15 to 30 seconds which is highly energy efficient.	-Not Real-time, as server updates for every 60 seconds. -Sending only 20% GPS fixes on an average -Critical points and location aware state machine algorithms are used for the better accuracy
A Theoretical Model of GSM Network Based Vehicle Tracking System [8]	-SIM -GSM (Majority used instead of GPS)	-GPS (used for support)	-Any Language	-25 MHz GSM band with duplex channel uses 200 kHz FDMA frequency. They are divided in 8 time slots with 4.615ms which is very faster	-Timing Advance (TA) information gives roughly confines an area of 550m x 550m -SIM locality is found with cellular network, which is not that much accurate when compared with GPS tracking. -Position accuracy increases with increase in Timing Advance (TA) number
Real Time Web Based Bus Tracking System [5]	-Bus Module -User Module -Admin Module -GPRS	-GPS	-C# -Visual Studio 13 -MySQL	-User friendly -Sometimes database becomes unstable if there is high traffic	-Updates in real-time -Location tracking is accurate as it uses dedicated GPS attached in a vehicle
Design and Implementation of Real Time Vehicle Tracking System [17]	-GSM -Google Maps -SMS	-GPS -Bluetooth	-C -Assembly Language -Android JAVA -Keyhole Markup Language (KML)	-Comparatively, lower performance as the VTS kit uses basic microcontroller	-High Accuracy since it fetches exact location from GPS satellite when the accident occurs

IV. ANALYSIS

The Tables I and II describes about the various parameters that are used in different papers. Table I explains the differences in the technology used, devices, performance and the payment models for the cashless e-ticketing system. And, Table II explains the differences in modules, sensors, programming languages used, performance and the accuracy of the GPS locations for real-time location tracking.

V. CONCLUSION

As we have surveyed many papers related to cashless e-ticketing and real-time location tracking, every paper and references have some merits and demerits. In future works, this paper would be helpful to overcome the issues of those existing projects.

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