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SMARTIBLE: Smart Ticketing Based On Bluetooth Low Energy

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Abstract - *Bus Rapid Transit (BRT) has been adopted by many metropolitans in the world to meet the growing demand on public transportation system. Implementation of Bus Rapid Transit (BRT) has greatly improved mass transportation, yet there is scope available to further improve experience of daily commuters and increase overall efficiency of the system. In this paper, a novel approach of bus ticketing system has been proposed that will significantly reduce the number of in-vehicle cash based ticketing and eventually convert it into fully automated system. The solution is based on latest advancement in low power wireless technology called Bluetooth Low Energy (BLE). Low cost, reliability and longevity makes it very attractive option as compared to RFID. The proposed solution aims to ease life of daily commuters and in-bus staffs. Furthermore it will support the digitization of the system and help in becoming truly smart city.*

Key Words: RFID, BLE, BRT, IOT, Mobility, Transportation, Rasberry Pi

1. INTRODUCTION

Human population is growing day by day and hence the number of travellers who depend on public transportation is also growing at almost similar pace. This continuous growth in commuters requires developing fast and very efficient public mass transportation infrastructure which can sustain for a few decades. Existing ticketing system used inside bus is not very commuter friendly and involves cash transaction which requires cash collectors. A crowded bus makes the ticketing process even more difficult and annoying for commuters. To improve the situation, a commuter friendly automated system is proposed in this paper. The proposed system will automatically detect identity of commuter on boarding event, calculated the distance travelled based on de-boarding event and then automatically calculate fare and deduct from commuter's account. Proposed system will also take care of fraud detection by detecting a commuter who travels without card balance and notify to enforcement department in real time.

The proposed bus ticketing system is based on new Bluetooth Low Energy (BLE) technology [1]. BLE is the power version of Bluetooth that was built to enable Internet-of-Things (IoT). It uses 2.4 GHz frequency band for communication. The new standard promises range upto 100 meter but the battery powered BLE device has range of about 15-20 feet which makes it ideal choice for short range personal area networks (PAN). Several wearable devices and mobile phones are available in the market which is based on this new standard.

2. RELATED WORK

Various automated wireless technology based ticketing system has been proposed in the past. A comparative study is presented in this paper [2]. RFID tag based bus ticketing system has been popular topic among researcher community and several papers have been published. Ahammed Aslam et.al[3] presented a fully automated, reliable, transparent and convenient system for ticketing in PTS. Saurabh Chatterjee et.al [4] suggest a commuter friendly automated traffic control system which will automatically detect a vehicle using the RFID tag installed in the vehicle and as soon as the vehicle passes by a reader, this process would lead to identification of each vehicle leading to better scheduling and efficient utilization of the resources. Md.Foisal Mahedi Hasan et.al [5] describes about the public transport ticketing system, dominating in the megacity Dhaka (Bangladesh) which leads severe fault in the system, hateful argument among community, dishonesty and most of all traffic blockage. This paper actually suggests a much more passenger friendly, automated system of ticketing as well as the credit transaction with the use of RFID based tickets. Varun Krishna K.G et.al [6] suggests the use of RFID technology to provide an efficient and enhanced automated ticketing system. One of the key issues associated with RFID solution is reliability in automatically detecting the passenger's presence and identification. Sriharsha Kuchimanchi [8] proposed Generic Atrribute (GATT) based ticketing profile which requires Bluetooth smart devices. The proposed solution requires connectivity between detector device and passenger handheld. Inspiration has been taken from these works in order to propose a low cost yet reliable system that can be implemented in BRT to save capital expenditure and deliver automated ticketing service.

3. PROPOSED SOLUTION

In this paper, BLE has been proposed as core wireless technology to implement automatic bus ticketing. There are two major components of the solution-IOT sensor and BLE tag. Buses in the BRT system will be fitted with two IOT sensors, one at entrance and one at the exit in order to quickly identify the commuter. Location of the bus can be identified either using in-built GPS device or alternative method presented here. One high range BLE node will be installed at each BRT stop and IOT sensor installed inside bus

is expected to detect it. In each data upload, sensor will include identity of last known BLE node.

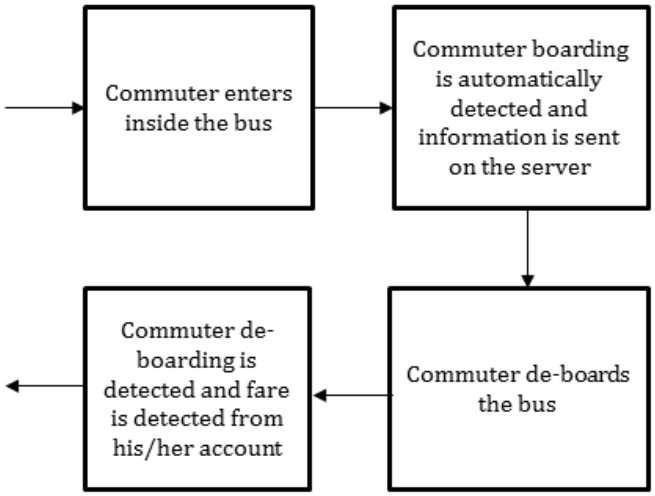

Fig -1: Automatic fare charging for commuter

Each commuter will have pre-charged BLE tag with unique identity which will be associated with his/her nation level unique identity such as social security number used in the US or Adhaar in India. The identity will be associated with his/her account with the BRT service provider. Commuter boarding and de-boarding of the bus is automatically detected and based on travelled distance and fare policy corresponding amount will be detected from associated account. In case, commuter account is not having enough balance or no balance and commuter is found to be travelling then the information is sent to enforcement engine which will be used by enforcement agency to ensure system is not abused.

3.1 System Architecture

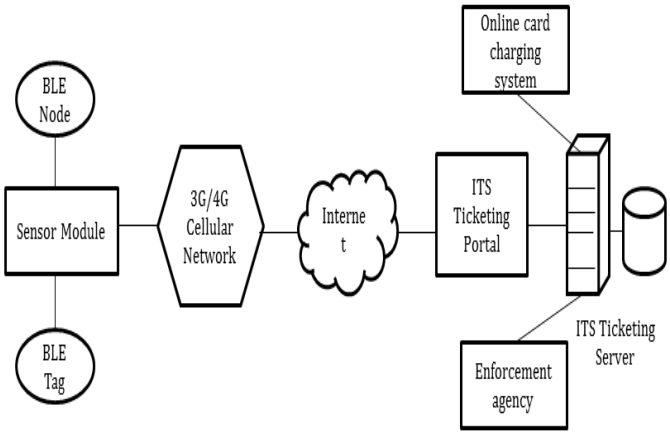

Fig -2: System architecture of proposed solution

The proposed solution consists of three different types of devices.

a. BLE Tags

BLE tags are low cost credit card size device as shown in the Figure 3 (a). BLE Tag can be carried by commuter while travelling in the bus. It has range of 15 feet and can be detected in a very crowded bus environment. The life time of these tags vary from 1 year to 3 years depending upon manufacturing design and type of battery.

b. BLE Nodes

BLE Nodes are small rugged hardware device powered by in-built battery. These devices are also called "beacon" and used in various location based application. In our proposed design we plan to use it for detecting and identifying bus stop and to calculate distance between any two bus stops. It will act economical and computationally more efficient in measuring distance travelled by a commuter.

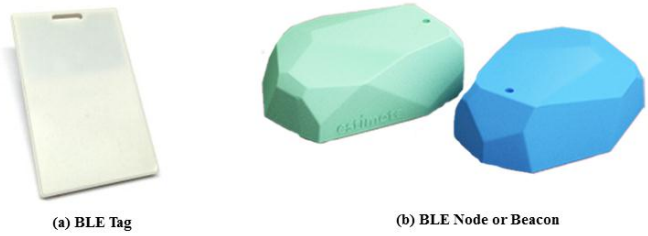

Fig -3: BLE Tag and Nodes

c. IOT sensor

IOT sensor is Internet enabled BLE integrated device. A prototype version of this sensor has been developed using Rasberry-Pi 2 embedded system [9], one CSR 4.0 USB dongle that is used for detecting BLE tags in the range and one 4G USB dongle for sending data to cloud server. An assembled kit of BLE IOT sensor has been shown in the Figure 4 below.

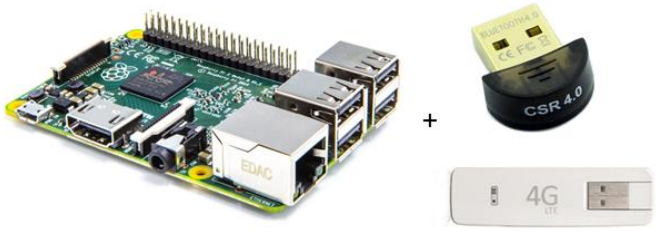

Fig -4: Components used for assembling IOT sensor

IOT sensor uses JSON format to upload detected commuted data to the server. Commuter data is uploaded over strict https channel and hence integrity check of the data is not required. Public cryptographic method is used to authenticate IOT sensor on the server. Likewise sensor also uses same method to authenticate the server.

3.2 Algorithm

a. Data Collector Module (DCM)

1. Receive data sent by IOT sensor module and perform authentication and authorization check
2. Format data before storing it in the database for further processing

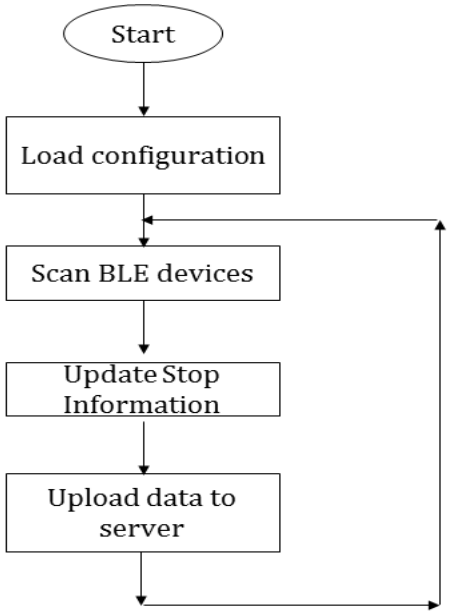

Fig -5: Flowchart of Sensor software module

b. Data Processing Module (DPM)

1. Read un-processed data from the database
2. For every detected tag, repeat steps 3-10
3. Retrieve account associated with a BLE tag
4. Calculate distance travelled by the commuter based on retrieved information
5. Calculate the fare to be deducted based on the pricing information stored in the system
6. if Account.Balancecommuter < Calculated Farecommuter; then
7. Send alert to commuter
8. Send notification to enforcement engine
9. else
10. Deduct fare from commuter account balance

3. CONCLUSIONS

Opening of commuter's account, assigning him/her a BLE tag and recharging of commuter's account has been kept out of the scope of this paper. Main contribution of this paper is to propose design of a fully automated ticketing system which is very user friendly, eases the load of in-vehicle ticket handling and slowly help migrate towards fully automated digital ticketing system. The recent advancements in BLE tag, IOT sensor and big data analytics have made it possible to design a system like one proposed in this paper. Future scope of this paper is to implement prototype and leverage data collected by the system to model solutions to real life problems such demand based scheduling of buses, live tracking and security.

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