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RFID-based Bus Ticketing System

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Abstract: In the daily operation of the public transport system, the movement of buses is uncertain because of conditions such as traffic congestion, unexpected delays, irregular vehicle dispatching times, and other incidents. Such uncertainty results in passengers having to wait for their bus to arrive at the bus stop. This paper proposes a new system based on RFID, in which each commuter owns a smartcard fitted with an RFID tag having a unique ID. This card is scanned by the RFID reader at the entrance and again at the exit, and the fare corresponding to the distance travelled is deducted from the commuter's account. The system uses Google's General Transit Feed Specification (GTFS), making it adaptable to any transit system for which a GTFS feed is available. In addition, the commuters can track the position of their desired bus in real time through an Android app, and get an occupancy estimate of the bus. The proposed system aims to increase customer convenience and eventually eliminate the use of paper tickets in transit systems.

Keyword: RFID, Ticket issuing, Android, GTFS, Raspberry Pi.

I. INTRODUCTION

In the daily operation of the public transport system, the movement of buses is uncertain because of conditions such as traffic congestion, unexpected delays, irregular vehicle dispatching times, and other incidents. Such uncertainty results in passengers having to wait for their bus to arrive at the bus stop. Much has been done in the field of transit. Developments have been seen but none of these developments have a clear vision. The proposed system is inclusive of all the requirements, in a single package. The following four areas are the subject of a lot of theorizing –

- Live tracking
- E-ticketing
- Crowd tracking
- Tracking transit stops

The proposed system integrates all of these sub-systems in a single, deployable, tangible solution for public bus systems, in order to simplify and convenience all the parties involved. We will be looking at the literature on these areas and comparing them in the following sections.

II. RELATED WORK

E-ticketing systems

S Karthick and A. Velmurugan [7] proposed to use GPS on the user's phone to validate the tickets. There is a security problem with this approach. The GPS location on the user's phone can be easily spoofed. The authors use a cloud database for storing the tickets. This is a very good way to achieve some security principles. However, it suffers from the same problems every cloud service suffers, like needing persistent internet connectivity for issuing tickets. It may not be available with all the users. The authors also propose using QR codes for tickets. While it works on basically any device with a screen, there are limitations to QR codes which cannot be ignored.

Arnau Vives- Guasch, Maria-Magdalena Payeras-Capell`a et al [9] define the following security goals for an e-ticketing system-

- Authenticity: e-tickets should take measures to avoid falsification.
- Integrity: an issued ticket cannot be further modified by anyone.
- Reusability: Overspending should be prevented for a one-time-use ticket.
- Expiry date: a ticket could be only valid during a time interval.
- Offline: The system must work without a persistent internet connection.

Wei Jeng Wu and Wei Hsun Lee [11] describe an e-ticket system which works in two phases: OTA ticket-provisioning and offline authentication. To enable offline authentication, the design of the e-ticket consists of two parts: A Content part having details such as seat number, date, time etc, and a Security part contains sensitive data such a ticket ID, one-time certificate for the ticket, IC serial number. The Security part of the ticket is encrypted with the public key of the server. The reader is pre-installed with this key and uses it to to decrypt the Security part, hence validating the ticket offline.

Md Foisal Mahedi Hasan, Golam Tangim et al [6] mentions a system where every commuter needs to swipe a card over the reader on boarding the bus. After the card is validated by the reader, the commuter needs to manually input his current location and his destination in a keypad near the reader. Hence the system increases the time to issue a ticket. Concept of GPS is not used to detect the commuter's location. This system is highly not feasible in a crowded environment. A screen at every bus stop will notify the passengers, the departure time of the last bus of any route. If an agency has a bus service that the buses

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come after each 20 minutes, from the screen above the waiting passenger will surely know when the last bus departed and after how long the next bus is coming. This system uses the amount from the card itself.

Saurabh Chatterjee and BalramTimande [4] propose a system where a commuter swipes a card over a reader after boarding and before alighting the bus. At both the times GPS module inside the bus marks the source and the destination of the commuter and money is deducted from the card as per the fare rate depending on the distance travelled by the bus (i.e. source to destination as marked by the GPS module).
K. T. Patil, Dipti Mehendale et all [12] propose to issue tickets via a phone application through internet. User is asked to enter his location and destination manually. Ticket issuing involves the database server and the application server which increases the computational part of the system. This system needs persistent internet connection for downloading the ticket on the phone application.

Live-Tracking
L´aszl´oBarab´as, R´eka-Andrea K´aroly et al [1] define a framework for live tracking. The authors suggest having a movement simulator for testing, a server for tracking the data in a centralized manner, and using Google Maps API for displaying the map. The paper fails to utilize the GTFS standard created for storing transit data, and instead uses a different format for storage.

Tracking Transit Stops
One of the objectives of the proposed system is to be adaptable to any city. With that in mind, a standard format is needed to store the information regarding the specific city, information like the transit stops, routes, etc. Google has developed such a format, called the GTFS, or the General Transit Feed Specification. It is a widely adopted industry standard. The General Transit Feed Specification (GTFS) defines a common format for public transportation schedules and associated geographic information. GTFS ‘feeds’ allow public transit agencies to publish their transit data and developers to write applications that consume that data in an interoperable way. A GTFS feed is composed of a series of text files collected in a ZIP file. Each file models a particular aspect of transit information: stops, routes, trips, and other schedule data. [13] uses static GTFS data in order to get transit information.

III. SYSTEM DESIGN

The buses in the transit system will be fitted with two RFID readers, one each at the entrance and exit. The buses will also have a GPS device which will report the location of the bus to the server in real time.

Each commuter will have a smartcard containing an RFID tag with a unique ID, which will be associated with his account with the transport service provider.

The system also features an Android application for commuters to check the location and occupancy estimate of buses they intend to board.

On boarding a bus, the commuter scans this card at the RFID reader at the entrance. The tag ID is sent to the server and the balance in the commuter’s account is deducted by the fare from his source stop to the last stop on the route. At his destination stop, he scans the card at the RFID reader at the exit, and an amount corresponding to the stops remaining on the route is added back to his account.

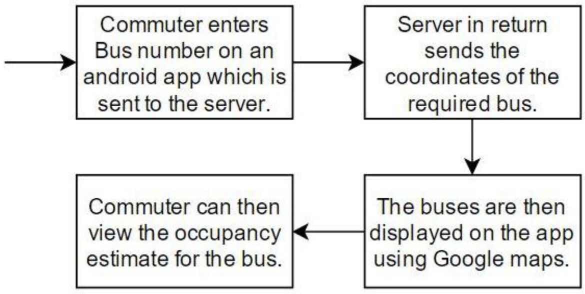

Figure 1: Flow at commuter-side (Android app)

The GPS devices in the buses periodically report the bus’ location to the server. In addition, the ticketing records are used to generate an estimate of occupancy in a particular bus.

The commuter enters the bus number of the bus he is interested in into the Android application and is presented with a map view of all the buses with that number currently running. He selects one and is shown the occupancy estimate of the bus.

The system also has a Ticket Checker to ensure that commuters do not board/disembark the bus without scanning their cards. The Ticket Checker will have a device with an RFID reader and will randomly check commuters’ cards during and/or after transit. The device will retrieve the commuter’s most recent ticket records from the server, which will show whether he has ‘purchased’ a ticket for the current journey.

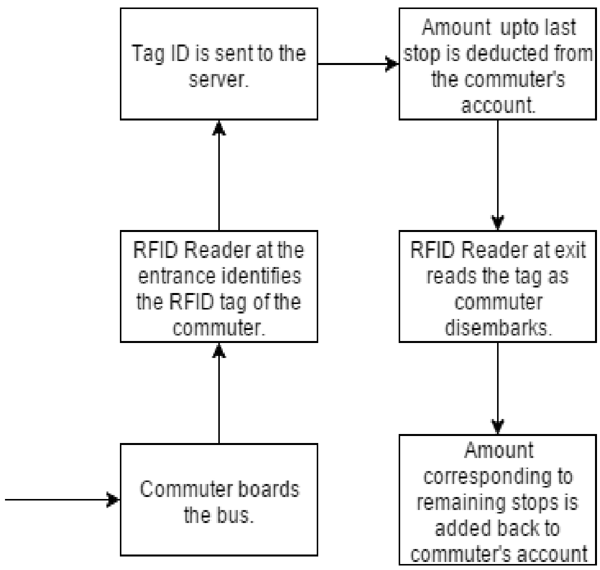

Figure 2: Ticketing flow

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IV. CONCLUSION

A lot of research in the field of RFID has been conducted in the recent years, leading to the many new applications based on RFID. Smart Bus Transit System enables commuters to travel hassle-free. The ticketing is seamless. Making public transport more convenient makes it more accessible, thus leading to increased usage. Traffic is a growing problem in major cities and effective use of public transport is one of the solutions. A convenient and easy-to-use public transport system helps alleviate this problem. It also modernizes the public transport infrastructure. Since everything becomes digital, it becomes possible for service providers to collect data, and thus make business decisions based on the needs. The system also makes a paper-free system possible, which is the general direction all organizations are going in. Since the system works on standard data format for transits, it is extremely easy for service providers to integrate this system into their existing infrastructure.

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