RFID Technology on Tracking and Monitoring Applications

V. Priyashman, W. Ismail and J.H. Khor

Abstract This paper presents the impact of passive radio frequency identification (RFID) technology with Java Database Connectivity (JDBC) for the application of campus bus tracking and student monitoring. In this research, the system is developed to track USM charter buses which operate on a selected route and to monitor the number of students using a tagged bus. The system composes of 3 main mechanisms; passive RFID tags at ultra-high frequency (UHF) together with the support of a passive RFID reader and a JDBC-based back-end database system that records the detected data. The proposed system will eliminate the need for manual data recording in tracking a tagged vehicle or monitoring the passenger's ridership pattern.

Keywords RFID · UHF · JDBC · RDBMS

1 Introduction

RFID-enabled applications have grown at a tremendous rate with system deployments in some industries such as pharmaceuticals, healthcare, transportation, retail, defense, and logistics [1–5]. The involvement of RFID plays a prominent role in areas that comprises of tracking, monitoring, and managing items that move between different physical locations.

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1.1 Problem Statement

Chartered bus services in USM were created to provide a safe and fast transport facility to its users. The growing number of students has increased the demand for more charter buses to accommodate their traveling needs. While financial constraints are an issue to address the supply on the growing demand, problems such as traffic congestion, bus breakdowns, and crowded buses are affecting the traveling time of students. Furthermore, the number of students boarding the buses at bus stops throughout the campus are not recorded, making it impossible to identify crowded spots. Paper and pencil monitoring of the charter buses has been less affective in curbing the said problems. The departure time of the buses cannot be accurately determined as the buses only depart if a significant number of seats are taken. By providing to the waiting students an estimated arrival time of the buses, the students will be able to identify both the time and number of buses that will be arriving at the bus stop. This will be valuable information in case of a missed boarding opportunity. The record of the number of students boarding or alighting the bus will provide an approximate crowd estimation on the bus stops. By using this particular information, the authorities will be able to provide an adequate number of buses for the particular bus stop.

1.2 Related Works

There are several RFID-based tracking systems which are both available in commercial and research domain. A combination of multiple technologies for an intelligent bus monitoring and management system is introduced in [6]. The system has been developed using RFID, GPRS, GPS and GIS where the former three constitutes into one system which will be installed inside the bus. A few studies have incorporated RFID technology and have integrated communication technologies in vehicle management systems (VMSs) [7, 8]. An online bus information system which adopts RFID and Zigbee has been introduced in [9]. A mobile RFID system was also realized to ensure the safety of the vehicles, in which RFID technology was embedded with Web-GIS [10].

1.3 Objective

This research proposes a purely RFID system without the integration of any other communication technology that is capable of resolving the said problems in 1.1. As the bus passes through the route, the RFID reader which is placed at selected checkpoints, will capture the tag ID from the bus and inserts it into the database which can be viewed by the end user. The recorded data is then used to display the

estimated arrival time of the tagged buses. The RFID reader which is installed inside the bus will detect the number of students boarding and alight the vehicle. RFID API is the middleware of the RFID system. It fetches the information captured by the reader and before sending to the end user [11, 12]. The API developed by Java is flexible as it is not fixed to one operating systems and can support heterogeneous readers.

The paper is organized as follows: In Sect. 2, the system design and development are explained. The results of the data collected by the database are investigated in Sect. 3. Finally, the conclusion will be drawn in Sect. 4.

2 System Design and Development

Figure 1 depicts the overview block diagram of the bus tracking system. The RFID windshield tag contains the vehicle ID, and the middleware of the system controls the information that is being inserted into the database. The database system will then update the display which will then show the estimated arrival time of the bus from the tagged checkpoint. The rectangular patch antenna and the reader have been installed in two areas of the campus.

The overview of the student tracking system is presented in Fig. 2. Currently, students of USM main campus are using contactless PVC cards as their matric card. As the tag comes within the proximity of the reader, the middleware of the system passes the information to the database after some data filtering. The database can be remotely accessed by the end user.

2.1 Pilot Test Set-up

The checkpoints at Indah Kembara and Fajar Harapan were chosen due to the fact that all the buses of USM will pass these two checkpoints before reaching the destination. Two tags, each programmed with a unique ID, PKU717 and PKU818

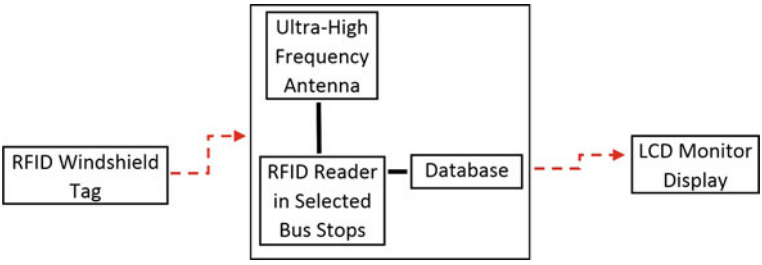

Fig. 1 Framework diagram of bus tracking system

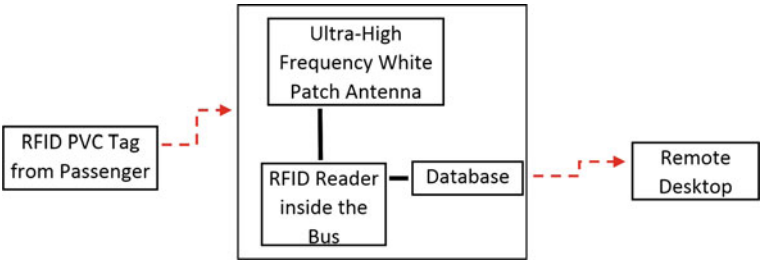

Fig. 2 Framework diagram of student tracking system

were attached to the middle and front door of the bus. The arrival time of the buses after passing each checkpoints was manually recorded. The time is then estimated by taking the average of all the recorded data before setting it into the system. The pilot test has several parameters and configurations which needs to be addressed before conducting:

- Fixed Parameters = Position of Reader, Reader Antenna and Orientation of Tag.
- Uncontrollable Parameters = Distance between tag and reader, boarding/alighting delay by students.
- Arrival time Estimation:
  - Tag Detection Time at Check Point 1: C_1
  - Tag Detection Time at Check Point 2: C_2
  - Arrival Time: C_3
  - Time Taken from Check Point 1: $C_3 - C_1$
  - Time Taken from Check Point 2: $C_3 - C_2$
  - Estimated arrival time from Check Point 1: 12 min
  - Estimated arrival time from Check Point 2: 3 min
  - (+ve Delay) = Bus arrives earlier than estimated by the system.
  - (–ve Delays) = Bus arrives later than estimated by the system.

3 Results and Discussion

The proposed research is to enhance the efficiency of chartered vehicle services in USM, and the objective of this application is to record the movement of the buses automatically without the need of manpower. The involvement of a GUI for the proposed system hides the implementation details of the system, with no prerequisite skills required for a particular user to use the system [13]. Figure 3 illustrates that once a tagged bus passes through a selected checkpoint, the interface will show the detected tag ID and stores it in the back-end database.

Fig. 3 Application with detection from both tag IDs

Both buses will be traveling separate routes scheduled by the authorities and the arrival time for both buses depends on the distance of the route taken by the bus.

The delay times of the tagged bus before reaching its destination after passing each of the checkpoints were measured. As represented in Fig. 4, both positive and negative delays have been recorded from both checkpoints. The high number of students boarding could cost some form of expected delay. A few more negative delays were measured from checkpoint one and two in which one of the reasons is the traffic. The route after passing checkpoint two also leads to one of the entrances of USM, and a large number of volumes of vehicles in the road will delay the

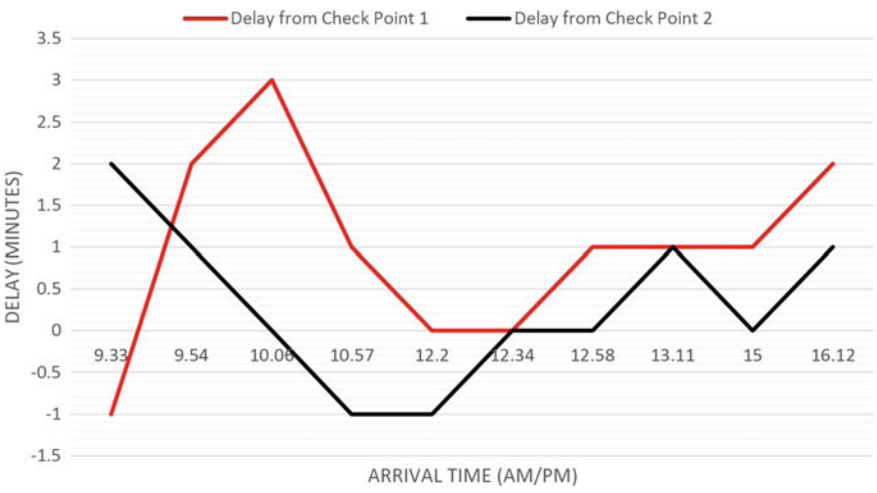

Fig. 4 Graph of delay versus arrival time of bus

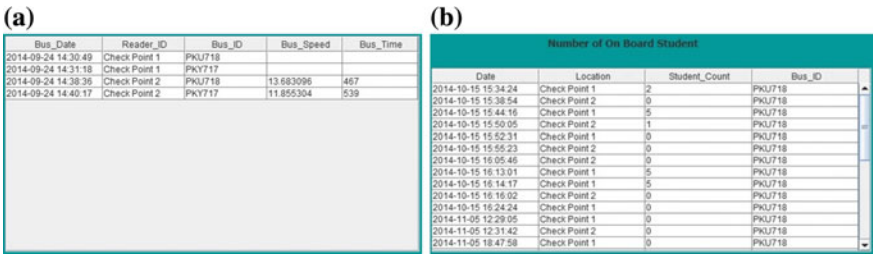

Fig. 5 **a** Report GUI for bus tracking application. **b** Report GUI for student tracking application

movement of the tagged bus. As the buses only moves if a considerable number of seats on the bus are taken, this causes a delay for passengers waiting at the next stop.

The captured bus IDs which were stored in the database, can be viewed from the GUI displayed in Fig. 5a. Based on the report, both buses has traveled on both checkpoints with the speed and total time calculated after passing checkpoint two. The speed calculated relies on the time traveled from checkpoint one to checkpoint two, and it is a record to be viewed by the authorities in making sure the buses are moving according to the appropriate speed. As shown in Fig. 5a, the speed of PKU718 is 13.683 m/s, which is approximately 49 km/h and the second bus, PKY717 is 11.855 m/s, which is close to 43 km/h. This reading will be supervised, and the drivers will be informed if the buses are driven beyond the required speed limit.

Figure 5b displays the ridership pattern of students obtained from the database through the GUI. The report presents information regarding the date, time, location, the number of students and bus id. The authorized personnel can choose on viewing three different categories which consist of “Boarding”, “Alighting”, and “OnBoard” and this will give an overall view to the authorities regarding the ridership pattern of students. As depicted in Fig. 5b, the student count shows the number of students on board for the bus with tag ID PKU718 throughout a period as the bus passes both checkpoint one and two.

4 Conclusion

A form of tracking and monitoring system incorporating RFID technology has been presented in this paper. The proposed research can be a platform for promoting local technologies expertise and also a guideline to the other universities and institutions with similar needs or customization according to their specific requirements.

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