An Intelligent Bus Status Informing Scheme Exploiting Smartphone Application

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Abstract

In this paper, we propose an intelligent bus status informing scheme based on smartphone application to increase convenience of public bus system by providing the seating capacity and number of passengers of the coming buses to waiting persons at the bus stop. The proposed scheme not only provides a real-time information of the number of passengers in the bus, also helps people to know whether the coming bus is crowed or not in advance. With this information, therefore, people who are waiting at the next stops can avoid the crowded situation and the safety accidents and also can select alternative transportations, which make the bus system run more quickly and efficiently. The proposed scheme is developed as a prototype and its effectiveness is validated with experiments to show the possibility of implementation.

Keywords: *ITS, passenger counting, Hi-pass, IR sensor, RFID*

1. Introduction

According to a survey in 2011 year, the number of citizens using public transportation is about to ten millions every day in Seoul, Korea [1]. In particular, the congestion at the bus stop during rush hour is becoming more and more serious and frequently it causes passengers to be stranded at bus stops and delays public transportation system.

For improving safety, reliability, efficiency and quality of public transportation, information and communications technology based on intelligent transport systems (ITS) is considered to be utilized on transport infrastructures and vehicles [2-4]. Now citizens are enjoying the integrated public transport service regardless of regions or means of transport. The intelligent transport services will reduce commuting time and improve the satisfaction of citizens. In addition to, the bus information system can also provide users with real-time location information and expected arrival time of buses, which saves waiting time and improves punctuality via smartphone [5-11].

Passengers are often stuck at the bus station because all the passengers have to touch their transportation card to the card reader one by one. The more passengers get on and off, the more boarding time is and thus more delay is caused. To resolve this issue, a passenger automatic counting scheme and a hi-pass scheme based on the RFID

technology are introduced to increase efficiency of the public bus system for fast getting on and off passengers [12].

While the passengers are waiting for a bus at the bus stop, however, it is difficult to know if the bus is crowded or not. Therefore, the unnecessarily waiting phenomenon occurs if the coming bus is already full and it cannot carry more passengers at next stop. This situation limits the possibility of any passengers to use other alternative public transportations such as subways and taxis, and eventually it causes the inefficiency of the entire transportation system.

In this paper, an intelligent bus status informing scheme based on smartphone application is proposed. With the proposed scheme, the real-time information of the number of passengers on the bus can be obtained and sent to the bus application in the smartphone of each user. Thus, it not only saves the time of passengers but also enables to create profits through effective vehicle deployment and management of their employees for large-scaled transport companies [13]. In the proposed scheme, a new type of RFID reader device and a new bus application for smart phones are developed and the effectiveness of proposed scheme is validated through experiments to show the possibility of implementation.

The rest of the paper is organized as follows. In Section 2, the proposed system is described. In Section 3, the prototype implementation is discussed and the performances of the proposed system is evaluated and reviewed. Finally, our concluded remarks are summarized in Section 4.

2. System Description

For automatic counting system, the IR sensor is set up on the front door and back door of the bus and a micro-processor counts the number of boarding and alighting passengers, respectively. Once the bus door is closed, the IR sensor detects the number of passengers on the bus by computing how many people get on or off the bus at each stop and send the information of number of passengers to the centralized server. Finally, the information is transmitted from the server to the smartphone of each user by the current communication network.

By checking the bus application, the screen will show the information of number of passengers in the coming bus. With this information, people who are waiting at the next stops can avoid the crowded situation, safety accident, unnecessary physical contact and theft that are very easy to happen in a crowded bus in advance. Therefore, the ‘Smart Transit’ concept can be applied.

In addition to the counting scheme, a hi-pass system based on the RFID technology is designed. When the tag and reader are in close proximity, the reader can detect and recognize the transportation card information to complete the payment process automatically without touching card on the reader.

The schematic of proposed system with various data flow is shown in Figure 1. The proposed system consists of the Hi-pass, automatic counting system and smartphone application for informing arriving bus information.

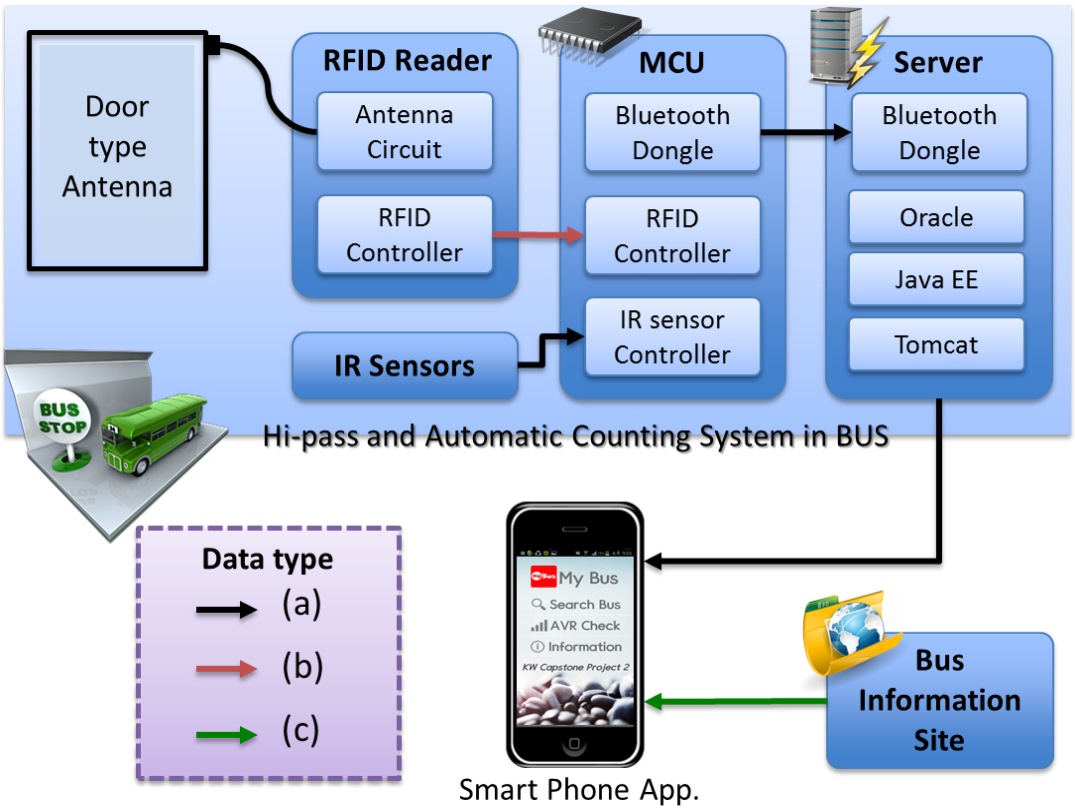


Figure 1. Schematic of proposed system with various data flow (a) the number of passengers, (b) RFID, and (c) bus information

First of all, the Hi-pass and automatic counting system in the bus consists of RFID antenna, RFID reader, IR sensors and a micro-processor unit (MCU) for device control. For passenger hi-pass system, the antenna coil has been designed as the size of the door. RFID reader includes antenna circuit and RFID controller. To receive RFID tag information, universal asynchronous receiver/transmitter (UART) controller is connected with RFID controller. For passenger automatic calculation part, IR sensor controller can estimate a free ride and count the number of passengers in the bus. IR sensors consist of ST-1KLA and EL-1KL2. ATmega128 processor is chosen for the proposed system.

The data transfer is implemented between the MCU and a server. The centralized server is built using the Database10g created in Oracle which enables us to develop the smartphone bus application by using eclipse, java, etc.

For the smartphone application, data is sent from the centralized server to the smart phone of each user by the current communication network. Combined with bus route HTML source extracted from the bus information website, the number of passengers on the bus and scheduler will be displayed on the screen. Therefore, the smartphone application of proposed scheme have both the function of existing bus application and the function of checking how many people are in transportation system.

3. Prototype Implementation of Proposed Scheme

3.1. Passenger hi-pass scheme

Since the communication between the reader and tag is accomplished through antenna coils, it is important to design a proper antenna circuit for the proposed system. The operating frequency of the Tag card from Philips Corporation is 13.56MHz. As for the frequency is 13.56 MHz, the wavelength is 22.12 meters and it is difficult to form a true antenna for most RFID applications. To resolve this problem, a small loop antenna circuit that is working at the frequency is used. This type of antenna is called a magnetic dipole antenna. To use the antenna conveniently on the bus, in the proposed scheme, the diameter of coil is set as 0.07cm and the number of turns equals to 2. The width of coil is set as 80cm and the length of coil is set as 200cm. Therefore, the inductance of rectangular loop coil is given by

$$L = \frac{0.0276(\mathrm{CN})^2}{1.908\mathrm{C} + 9\mathrm{b} + 10\mathrm{h}}\ (\mu\mathrm{H}) \tag{1}$$

Once the inductance is determined, the resonant capacitance is calculated from the following equation:

$$C_T = \frac{1}{4\pi^2 f_{tuned}^2 L_T} \tag{2}$$

In practical applications, the distributed capacitance is present between turns. The distributed capacitance in a typical tag antenna coil is a few (pF) and increases with operating frequency of the device. In this design, the parallel resonant circuit, which has maximum impedance and a minimum current and maximum voltage at the resonance frequency, is assumed. Figure 2 shows the rectangular antenna and distributed capacitor between coils.

To ensure whether the circuit is tuned to the resonance frequency for a maximum performance of the antenna, the performance of the antenna is tested by an oscilloscope. Figure 3 shows that it has maximum amplitude in the resonance frequency.

Figure 2. Rectangular antenna and distributed capacitor between coils

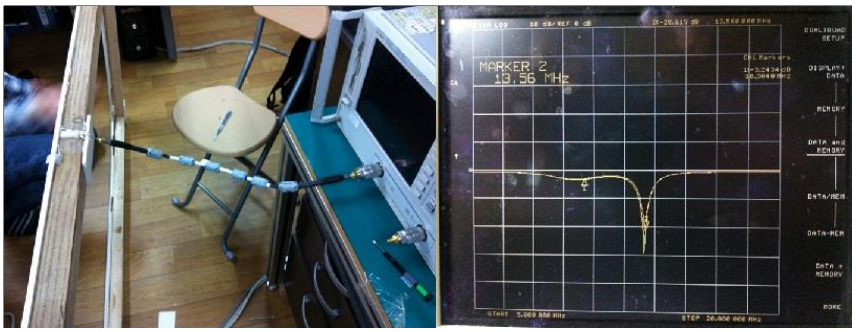


Figure 3. Performance test of the antenna

The recognition program from FirmSYS Corporation is used to read and record the identity number of card and appreciates ISO-form. The ISO 14443 is utilized to monitor the incoming and the outgoing number.

3.2. Passenger automatic counting scheme

IR sensor module can decipher a free ride and count the number of passengers who are taking bus. As it passes through the sensor, the LED and LM324(OP-AMP) start to work. As shown in Figure 4, the proposed scheme is installed with two sets of parallel IR sensor for boarding passengers and departing passengers, respectively. The recognition sequence used to distinguish the LM324's output is sent to the processor for data processing. When the IR sensor is in close proximity to the cash expenses box, which means the passenger is getting on or off the bus, the sensor operates AND operation. Otherwise, the buzzer is ringing. Bluetooth module is used for communication between the processor and the PC Interface. From the Figure 5, we can see that the cumulative number of passengers is changing as the motion of tag card is detected. In this stop, the number of passengers getting on the bus is 8 and the number of passenger getting off the bus is 2. Note that the number is changed with the following sequence: 1, 2, 1, 2, 3, 4, 5, 6, 7, 6. Therefore, 6 passengers are left in the bus. In this case, the initial occupants are assumed to be 0. Finally, the total sum of passengers on the bus will be sent to the mobile servers promptly after closing the bus door at each stop.

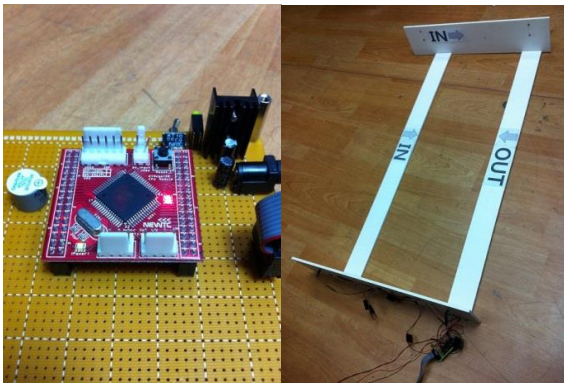


Figure 4. Passenger counting scheme

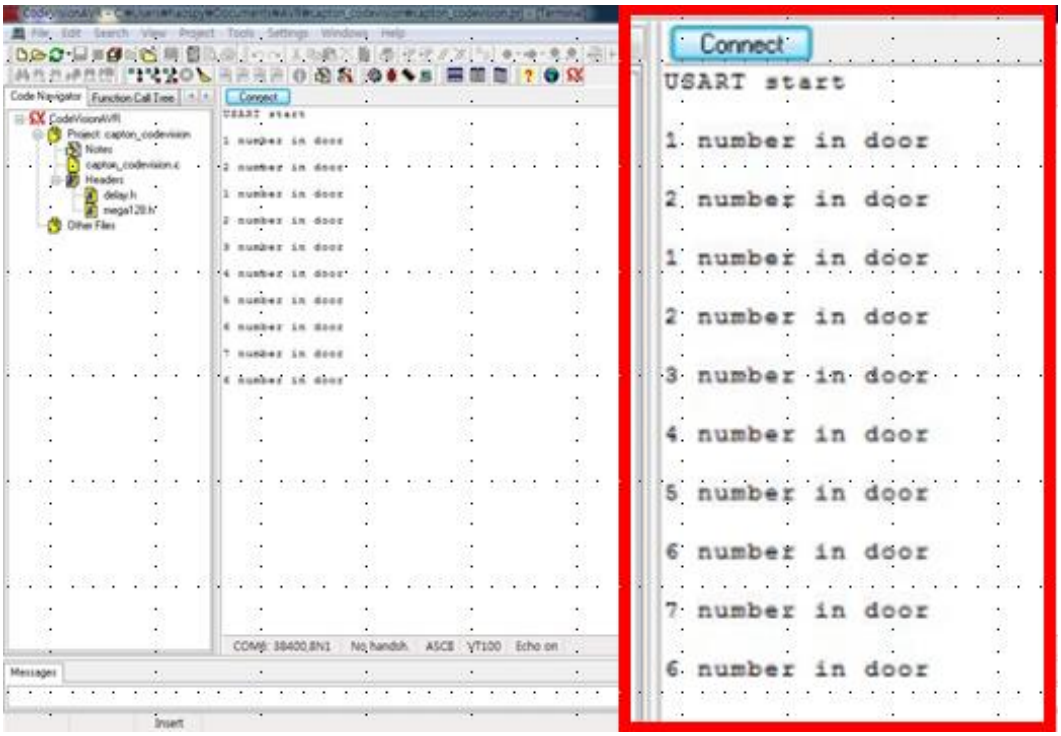


Figure 5. Monitoring program for passenger counting

3.3. Server for smartphone application

The bus information is transmitted to the server and the data is transformed into HTML for smartphone application. The server was implemented by using tomcat6 and eclipse, JAVA EE. data base (DB) made using Oracle 10g. The tomcat implements the Java Servlet and the JavaServer Pages (JSP) specifications from Sun Microsystems, and provides a 'pure Java' HTTP web server environment for Java code to run.

The Figure 6 shows the sample code for saving the number of passengers to DB, which changes the passenger numbers from 10 to 20 for bus 1137.

```
--sql
create table buspgrno(pgrno integer NOT NULL, code varchar2(20));
insert into buspgrno values(10, 'bus1137');
update buspgrno set pgrno=20 where code='bus1137';
commit;
```

Figure 6. Sample code for saving the passenger number to DB

The DB produces the HTML code as soon as it receives the passenger number by JAVA. When the IP address of server is approaching, the passenger number will appear in the smartphone application screen. The Figure 7 shows the sample coding for smartphone application screen.

```
<%@ page language="java" contentType="text/html;charset=euc- kr" %>
<%@ page import="java.sql.*,java.util.*" %>
<% Class.forName("oracle.jdbc.driver.OracleDriver");
String url = "jdbc:oracle:thin:@localhost:1522:ora11"
String id = "scott"
String pw = "tiger"
Connection conn = DriverManager.getConnection(url,id,pw);
Statement stmt = conn.createStatement();
String Query = "Select pgrno from buspgrno where code='bus1137'"
ResultSet rs = stmt.executeQuery(Query);
while(rs.next()) %>

<html>
<head></head>
<body> <table class="title">
        <tr><td><%= rs.getString(1) %></td></tr></table>
</body>
</html>
<%      rs.close();
        stmt.close();
        conn.close(); %>
```

Figure 7. Sample code for producing the HTML code from DB

3.4. Smartphone Application

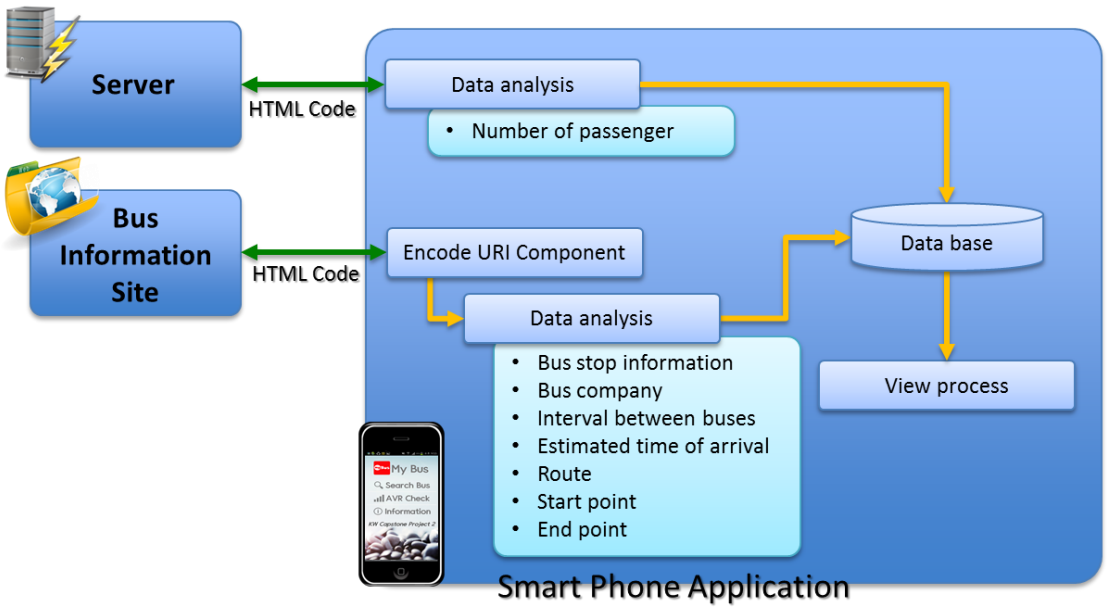


Figure 8. Data flow

Figure 8 shows the data flow of the smartphone application. The information for current bus is transformed into HTML code, such as departure station, terminal, estimated time of arrival, route, interval between buses, bus stop information from the

bus information site, and the number of passengers. All the information is stored in the data base. After inputting the route and stop number by the user, the corresponding information can be called from the DB. Among the information, the encode uniform resource identifier (URI) component is used for transforming enough data, which is from uniform resource locator (URL) address for DB. By touching the screen menu, users can connect to the corresponding URI and get the HTML source to extract parts of the information. If there is no internal DB portion, the processed data will be saved in the DB of smartphone. Otherwise, smartphone connects to DB to get the desired information. In last, a handler is generated in the activity for the display of the processed data on the screen connecting to XML.

After getting the information form the server, the number of passengers on the bus can be displayed on the AVR screen. As shown in Figure 9, for example, there are 60 passengers in this bus.

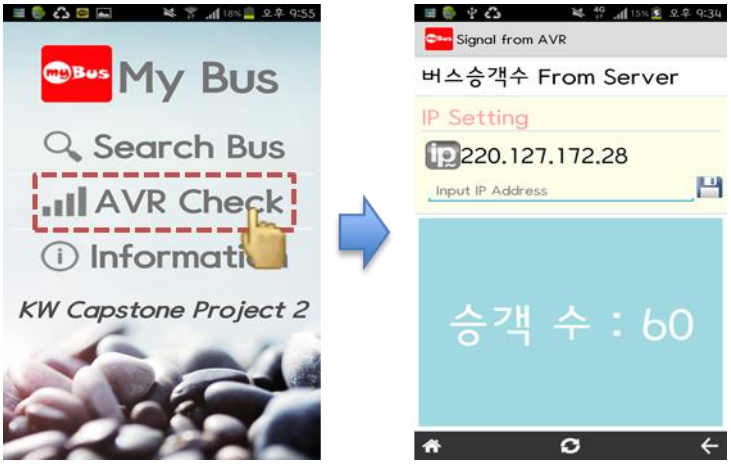
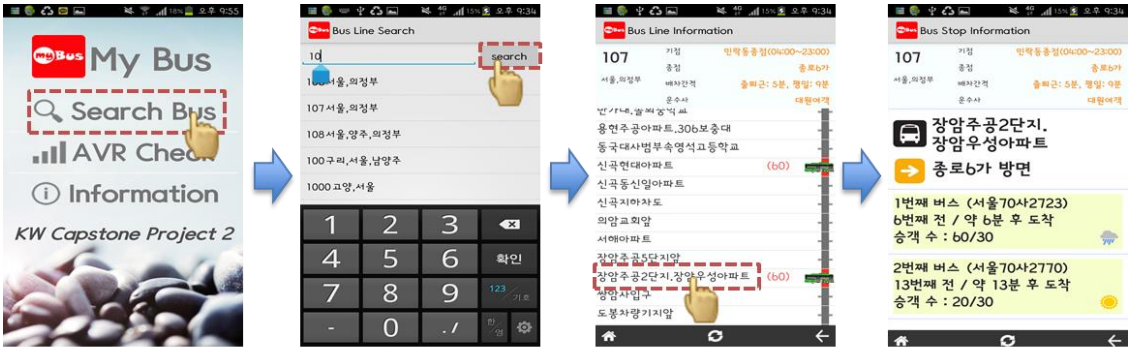


Figure 9. Initial pages from AVR screen



(a) (b) (c) (d)

Figure 10. Usage example with processing screens (a) initial screen, (b) bus searching screen, (c) screen for the detailed route information of the selected bus, and (d) screen for the coming bus information with number of passengers

Figure 10 shows a usage example of the application with processing screens. When people press the search bus button in the initial screen of (a), the bus searching menu

where passengers can type the bus number, which they are looking for, will appear in the next interface as shown in (b). In (c), after selecting the desired bus number, passengers are able to get the detail route information of each bus including the station of departure and terminal, location information, schedule and number of passenger numbers of each bus. Comparing to the current bus applications, (d) shows the new bus application, which not only shows the route and schedule, but also can give the seating capacity and passengers of the approaching buses. Based on this information, people can know if the bus is crowed or not in advance, avoiding the unnecessarily waiting phenomenon occurs especially at rush hour. Large-scaled transport companies also enable to create profits through effective vehicle deployment and management of their employees.

4. Conclusion

In this paper, we propose an intelligent bus status informing scheme based on smartphone application to increase convenience of public bus system by providing the seating capacity and number of passengers of the coming buses to waiting persons at the bus stop. The proposed scheme utilizes RFID technology and a smart server for benefitting both the passengers and public transport companies. The proposed scheme not only provides a real-time information of number of passengers in the bus to each user by the smartphone application, also helps people to know whether the coming bus is crowed or not in advance. The application can be linked with the websites that have the database of buses in Seoul City. Beyond that, the system also can send the real-time temperature, humidity and air flow condition in the bus with the help of sensors. Thus, the proposed scheme makes the bus system run more quickly and efficiently.

Acknowledgements

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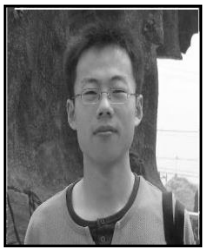

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