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The Development of Bus Passenger Monitoring System Using IoT

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Abstract

The Fourth Industrial Revolution is expected to transform the way we live, work, and communicate. The issue of monitoring bus passengers is crucial because there are many cases, where the bus driver left behind the passenger at the rest and service station. This is due to the bus driver's negligence as the driver may be mistaken for the number of passengers on the bus after a stop and the urgency of the bus driver to arrive on time at the destination. Therefore, the development of a Bus Passenger Monitoring System using IoT will make it easier for the bus driver to monitor the number of a passenger after stopping by at the rest and service station. The purpose of this project is to develop a system that can identify the presence of passengers by using a Quick Response (QR) code system. This innovation uses generated QR code on the ticket and a scanner to retrieve the information needed. A bus monitoring mobile application was then developed for the bus driver for monitoring purposes. The mobile application will display the status of each seat in the bus by using three different identification colors which are red, green, and grey. When the passenger scans the ticket at the scanner on the bus, it will change the colour of the seat in the bus monitoring applications from grey to green meaning the passenger was already on the bus. If the passengers get down from the bus, they need to rescan the QR code and the identification colour change to red. This innovation was designed to give benefits for both bus drivers and the passengers as it will avoid leaving behind passengers and arriving at the destination on time. By using the current technology, the transportation service will be improved, and monitoring purposes will be easier thus it will reduce travelling delay.

Keywords: - bus monitoring system, bus passengers, QR code

1 Introduction

The Fourth Industrial Revolution, IR 4.0 is expected to transform the way we live, work, and communicate. There are 11 pillars in IR4.0, one of the pillars is the Internet of Things, IoT. IoT represents a system that consists of anything, and sensors attached to or combined with these things, connected to the Internet via wired and wireless network structure [1]. In simple words, IoT is an ecosystem of connected physical objects that are accessible through the internet. This technology is also projected to increase productivity and efficiency in any kind of application such as smart cities, smart homes, smart health monitoring, intelligent transportation, and smart environment [2]. Just by using a smartphone, users can control switches at home, plan trips using a navigation system, monitor a child's attendance at school, keep track of pets and much more. With these powerful technologies, IoT is now making it possible for monitoring to come to the end-user through wireless solutions connected. As the world's population grows, so does the demand for transportation, thus IoT plays a significant role in transportation systems by automating and smartening them.

The main modes of transport in Malaysia include buses, trains, cars and to an extent, commercial travel on airplanes. The public transport system is the most effective way for people to move from one place to another place. Based on the data from Agensi Pengangkutan Awan Darat (APAD) there are about 3800 express bus operating in Peninsular Malaysia [3]. Many of us have been using express bus service before, thus passenger safety is a major concern in the transportation sector.

Based on an article by New Straits Times dated 7 December 2017, a trader was sentenced to five days in jail and fined RM3,000 at the Magistrate's Court, for stabbing a bus driver who accidentally left him at the Rest and Relax, R&R in Alor Setar, Kedah, as shown in Figure 1.1 [4]. In January 2021, a man left behind in R&R chased the bus to the highway in heavy rain. Luckily one family lift the man who wanted to go to Johor to catch his bus at the highway [5].

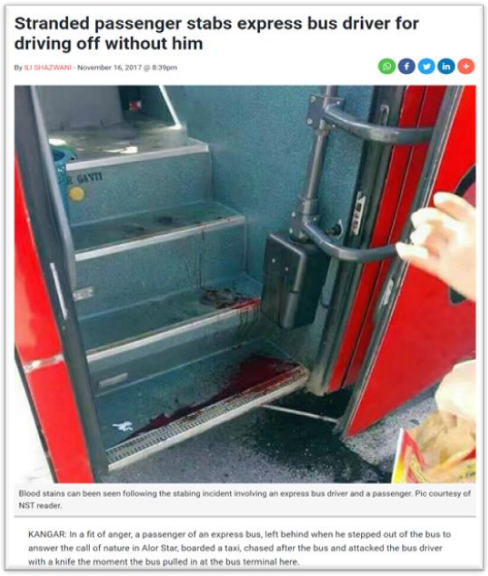

Figure 1.1 : An NST article "Stranded passenger stabs express bus driver for driving off without him" dated November 16, 2017 [4]

Lately, there have been some issues with bus passengers, this is due to the bus driver's negligence as the driver may be mistaken for the number of passengers or left unintentional. The issue of monitoring bus passengers is very important because there are many cases, where the bus driver left behind the passenger at the rest and service station. This is due to the bus driver's negligence as the driver may be mistaken for the number of passengers and the urgency of the bus driver to arrive on time at the destination. Therefore, the development of a Bus Monitoring System using IoT will make it easier for the bus driver to monitor the number of a passenger after stopping by at the rest and relax station.

1.1 Objectives

The main purpose of this innovation are as follows:

i. To develop a system that identifies the presence of passengers by using QR code
ii. to develop bus monitoring mobile applications that can show the status of each passenger.

2. Literature Review

Nayana and Bharathi (2018) present an "IoT based passenger Count System in Public Transports" to develop a smart system to keep track of passengers automatically using sensors [6]. This system uses two proximity IR sensors to indicate whether the passenger entering or leaving the bus. The total count is displayed on the Liquid Crystal Display (LCD) which is maintained by the driver.

Jafrul Islam Sojol et.al (2018) proposed a system with an automated passenger counting system using a pressure pad developed by them, Bluetooth HC-05 and a touch screen display interfaced with Arduino UNO [7]. The major disadvantage is the values obtained from the pressure pad will be inaccurate as it will also detect objects such as bags or trolleys if unknowingly placed by the travellers.

Rahmatulloh et. al (2020) has proposed a paper on "Applied Internet of Things (IoT): The Prototype Bus Passenger Monitoring System Using PIR Sensor" [8]. The IoT system uses PIR (passive infrared) sensors placed above passengers to detect movements made by humans alone. On a mobile device, the monitoring application will display data stored on Firebase.

Nasir et. al (2018), with "Automatic Passenger Counting System Using Image Processing Based on Skin Colour Detection Approach" presents an autonomous passenger counting system for fleet management by using image processing based on skin colour detection approach [9]. The passenger images have been processed with several image processing techniques such as the colour conversion of RGB to HSV colour image, image segmentation using thresholding technique, removal of noise or an unwanted object, and image smoothing. The researcher used MATLAB and Simulink as the programming tool and simulation platform.

3. Methodology

This project aims to develop a system that can show the presence of passengers by using a Quick Response (QR) code system. This innovation uses generated QR code on the ticket and a scanner to retrieve the information needed. A bus monitoring mobile application was then created for the bus driver for monitoring purposes. The mobile application will then display the status of each seat in the bus by using three different colours red, green, and grey. System architecture and the proposed solution of the process are addressed in this chapter. Process specification, data flow diagram gives the view of the project in brief.

3.1 Proposed System

In the proposed system, the occupancy of passengers in the bus is detected by the information stored in the QR code which communicates and sends data to the driver's bus monitoring mobile application consisting of the seat color representing the passenger. By using this technology, it is easy to keep track of passengers when they are boarded and alight from the bus. Figure 3.1 shows the proposed system for the development of a bus passenger monitoring system using IoT. The IoT concept developed involves hardware and software.

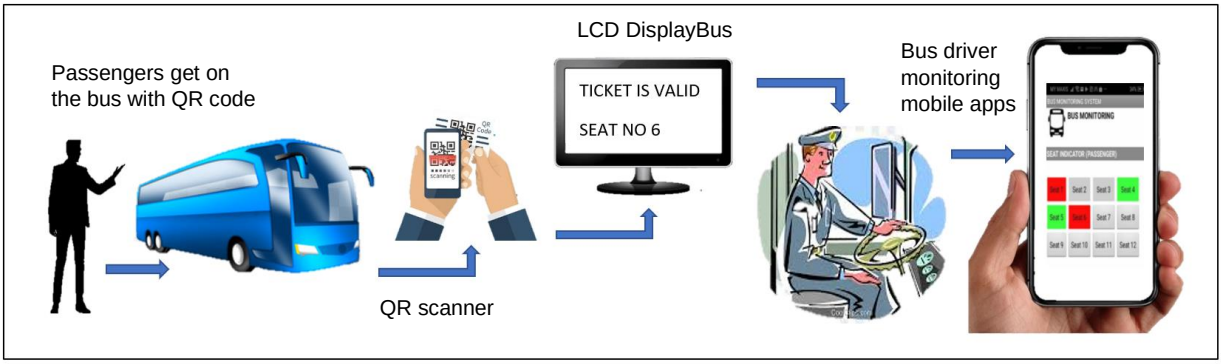

Figure 3.1 : A proposed system for the development of a bus passenger monitoring system using IoT

3.2 System Architecture

Figure 3.2 shows the project block diagram for Bus Monitoring System using IoT. The block diagram consists of three main sections which are input, process, and output. At the input section, a QR code that has been generated must be available to every passenger whether via printed ticket or online ticket. The bus needs a QR scanner that acts as a reader to scan each passenger's QR code to retrieve the passenger's data and seat assigned before transmitting to Arduino via Bluetooth.

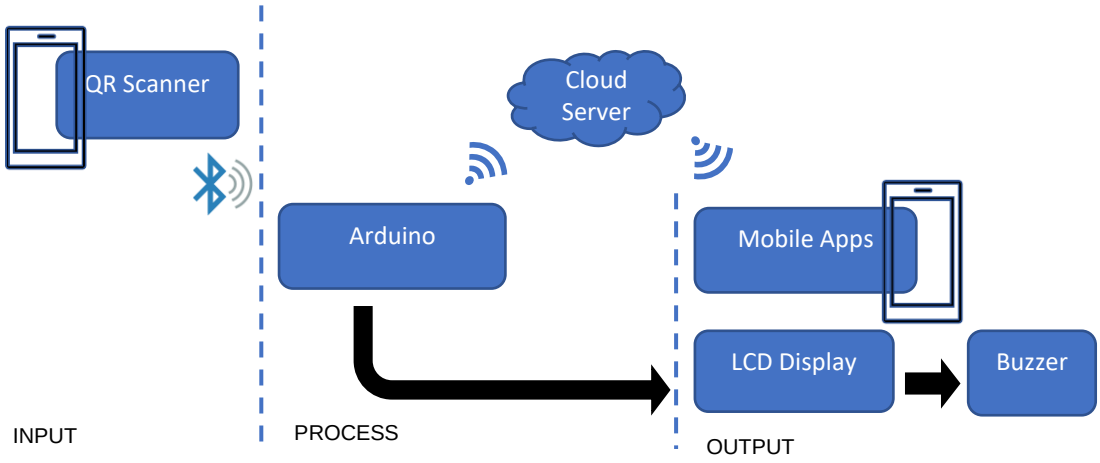

Figure 3.2 : Block Diagram for Bus Monitoring System using IoT

The process section consists of two components which is the microcontroller and networking platform. The Arduino UNO has been selected as a controller for this project. It is an open-source prototyping platform based on easy-to-use hardware and software based on Atmel's ATMEGA8 and ATMEGA168 microcontrollers [11]. The controller was programmed to control the input and output data for this monitoring system. Data transmitted from the QR scanner will be received by the Arduino, after the Arduino receives the passenger's QR code data Arduino will first read the serial number contained in each QR code. The data is then sent to the cloud, which acts as storage for this system. The cloud will be stored information on each passenger and the serial number for each passenger's QR code. Arduino will identify the serial number of this QR code at the cloud whether the serial number is valid or invalid.

At the output section, LCD will display the information provided by the microcontroller such as the passenger's name, seat number, and ticket status. If the ticket was not valid, the buzzer will alarm for 3 seconds indicating an alarm for both passenger and driver. On the driver's mobile phone, a bus monitoring application has been developed by using MIT App Inventor. The apps will show the output status of each passenger by using colour indicator. The overall circuit and programming were tested before the fabrication stage.

3.3 Flow chart

Figure 3.3 explains the flow chart of the proposed system, the process starts after the verification of the ticket, when the passenger enters with a valid ticket, LCD will display the information and the seat colour will change on the bus monitoring mobile application. If the passenger enters with the wrong ticket, the LCD display 'Invalid Ticker' and the buzzer will alarm for 3 seconds.

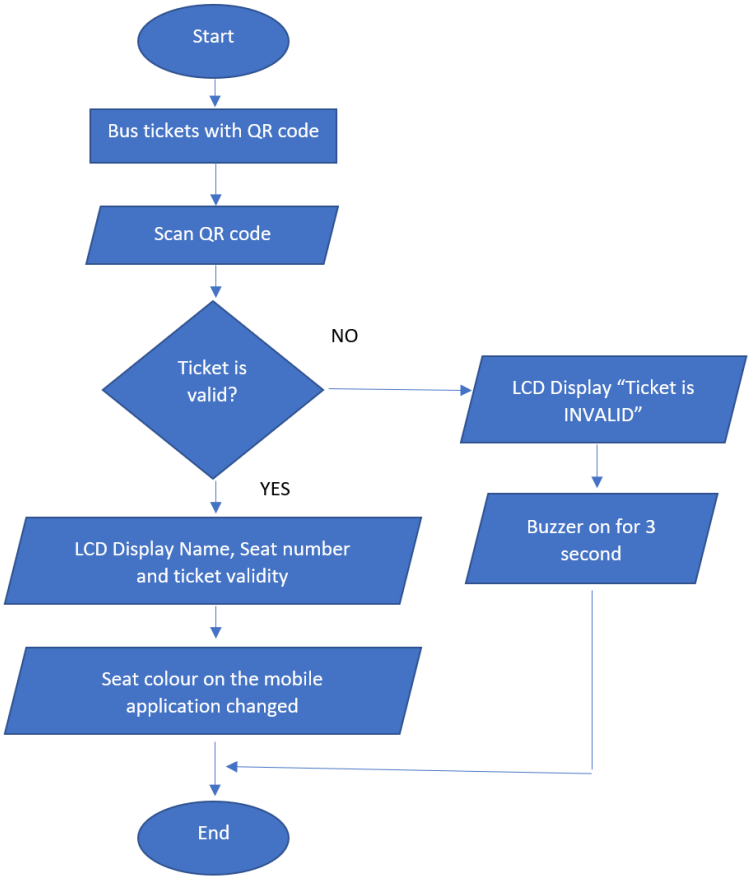

Figure 3.3 : System flow chart process specification

4. Finding and Analysis

4.1 Hardware Implementation

Figure 4.1 shows the hardware implementation of the project, it consists of Arduino Uno, Wi-Fi Module, Bluetooth Module HC-05, LCD display, buzzer, and mobile phone. Power is supplied to the Arduino board through the power supply unit, once the passenger scans the valid ticket, the system activated and retrieved the seating information. The data read were displayed on LCD. It will display the passenger's name, seat number and the status of the ticket whether it is valid or invalid. Finally, the output will be seen on the drivers monitoring mobile applications.

Figure 4.1: Hardware implementation of the project

4.2 Software Implementation

The two mobile applications have been developed for the proposed system are QR Scanner and Bus Monitoring Mobile Application. MIT App Inventor was used to develop the mobile application.

4.2.1 QR Scanner Mobile Application

A machine-readable code consisting of an array of black and white squares is typically used for storing URLs or other information for reading by the camera on a smartphone [12]. Functions as a QR code scanner, where it scans the QR code available to each passenger during the passenger get on the bus. To use this application, the Bluetooth and application must be connected, the Bluetooth module name is "HC-05". This application sends the QR code data to Arduino via Bluetooth. Figure 4.2 shows the interface apps for the QR scanner.

Figure 4.2: QR Scanner Mobile Application Interface

4.2.2 Bus Monitoring Mobile Application

The mobile app plays a vital role in remote monitoring and there are various apps development platforms such as MIT app inverter, Android studio and Blynk. MIT app inverter was a cloud-based tool with easy drag and drop options that were used for developing a mobile app for our proposed work [11]. Figure 4.3 shows the interface of the bus monitoring system application on the driver's phone.

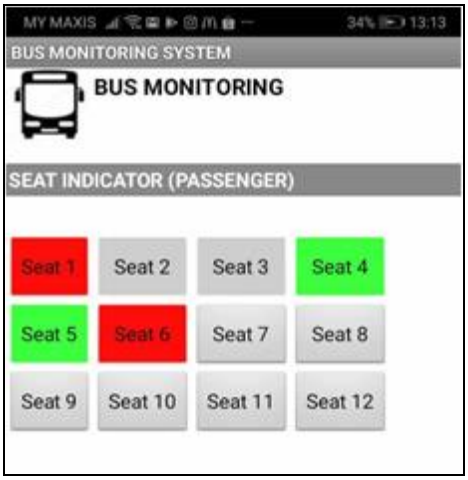

Figure 4.3: Bus Monitoring Mobile Application Interface

Results will be displayed through the different changed colour of the seat. Each colour represents a different meaning:

- Idle/grey colour means the seat is unoccupied;
- Green colour means the seat is occupied and the passenger was already on the bus; and
- Red colour means the seat is occupied but the passenger is still not on the bus.

When the passenger scans the ticket at the scanner on the bus, it will change the colour of the seat the bus monitoring applications from idle into green indicates the passenger was already on the bus. The bus driver can see the passenger status of each seat from this application. This monitoring system makes it easier for the bus driver to identify how many people are still not on the bus.

4.3 System Testing

The whole proposed system has been tested. Table 2 shows the result of each tested analysis. After the passenger scan the QR code, it will take about 2 seconds until the LCD display the status of the ticket. For bus monitoring mobile apps, it took about 6 seconds for the seat indicator to turn from idle colour to green colour. When the passenger gets off the bus, it took about 6 seconds for the seat indicator to turn from idle colour to green colour.

Table 2: Analysis of proposed system

Data Analysis	**Result**
Times delay to colour changed following the data accepted (based on the x service provider)	IN = 6 second OUT = 4 second
Times delay displaying the output on the LCD (based on the x service provider)	2 second
Range of Bluetooth connection between QR Scanner and Arduino	≤ 8.5meter

5. Conclusion

In recent years, the Internet of Things has developed very rapidly and has become a development trend to improve living conditions in the world. The issues of monitoring bus passengers are very important because there are many cases, where the bus driver left behind the passenger. Therefore, the development of a Bus Monitoring System using IoT will make it easier for the bus driver to monitor the number of passengers after stopping by at the rest and service station. This proposed system was designed to give benefits to bus express drivers, whereby it is easier to identify the status of each passenger by just looking at the phone application only. Besides, this innovation benefits the passengers as well because of the time saved in monitoring each passenger, the journey to the destination will run smoothly and on time. In addition, it at least can make the passenger feel safer and more comfortable as the bus driver will be more alert to their presence. Thus, passenger missed issues can be avoided by using this system and it will give benefits to both bus drivers and the passengers. By using IR4.0 technology, the transportation service will be improved and increase its efficiency.

Future implementation for the proposed system is to upgrade the mobile application with passenger counter and other related information such as estimated time arrival and the bus driver information detail. Further improvements such as adding up a speaker for the blind person can be applied to this system to enhance its performance. This proposed system can be used not only for transportation monitoring but also can be enhanced for human monitoring in schools, daycare centre or for cell monitoring.

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