IoT Bus Tracking System Localization via GPS-RFID

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***Abstract*—Bus transport is one of the important public transports in the city and a fixed-route bus is identified as the best and cheap sense to move around the city. Time is essential for daily public transport clients. In Malaysia, bus route applications and systems are still unplanned and bus schedules are hardly reached. Time is taken for route deviations and unwanted stops. This paper presents a mobile application that designs a monitoring bus tracking system and reduces passenger waiting time. The application is also able to count the problem of route deviations and unwanted stops by the bus driver. Global Positioning System (GPS) was built to locate the bus and RFID is used for bus identification. Bus information is stored in a cloud server with online access. Internet of things and with the mobile system was designed by using two ESP8266 Wi-Fi modules that separated the GPS and functions of sensors. GPS Neo-6m was used to track the bus route. RFID MFRC522 was used to send messages to bus users via online Blynk mobile Apps. The result presents a prototype of a mobile application. Testing of three locations of GPS latitude and longitude for bus A, B, and C were analyzed that presents 0 to 5 passengers on board. Passenger counter identification used two IR sensors to detect passengers going in and out of the bus. A combination of Internet of Things (IoT), GPS, and RFID is designed to track and monitor the bus. This project is essential where the GPS and RFID help both bus drivers and passengers save and planned their time where the system is easily accessed via internet connection.**

Keywords—GPS, RFID, Internet of Things, bus tracking system, mobile application, public transport

I. INTRODUCTION

The Internet of Things (IoT) is a fast expansion system used today in every sector. New possibilities are generated, and old issues are addressed with sophistication and convenience by extending the Internet and the Web into the physical environment[1]. Public transport like buses is important in the city to cater to the increase of people in the city that used the bus as their daily transportation. However, the most common issue that rises with city buses is unreliable timetables. This occurs because the majority of city bus passengers are workers, and waiting for buses at bus stops is inconvenient for them because time is of the essence. The Global Positioning System (GPS) is made up of a constellation of satellites that deliver signals to the Earth's surface. By monitoring the arrival timing of signals from four or more satellites, a simple GPS receiver, such as the one in your smartphone, can identify your location within 1 to 10 meters. Scientists can determine their positions down to centimeters or even millimeters using more advanced and more expensive GPS devices[2]. Tags or labels connected to the items to be recognized are used in a radio-frequency identification system. Interrogators or readers are two-way radio transmitter-receivers that send a signal to the tag and read its response. RFID tags are available in two types: passive and active. Passive tags receive energy from probing radio waves emitted by a nearby RFID reader. Lacking the existing system shows a bus passengers have lacked to estimate the time for the bus to arrive, the person just needs to wait for another one to arrive. Furthermore, a delay always occurs before the bus move on to the next stop and this happens at the previous stop because not all bus user arrived at the same time. Lastly, Route deviations and unauthorized stops cannot be spotted immediately, allowing for a slow response from the company.

The research aims to design an IoT system combined with GPS and RFID to track and monitor buses and passengers counter. The system is to allow efficient tracking which is more user-friendly, less cost and saves time. The GPS and RFID are combined on PCB as a complete unit to monitor and track in a single device. RFID tags are installed at the passenger and the receiver at the bus. The user or passengers can retrieve information of the bus location, occupied space, and time with applications from their mobile phones. Benefits of the developed tracking system which can be reduced the waiting time of bus passengers. Lastly, counter route deviations and unauthorized stops are identified through the mobile application. This research is significant which help to lead to the fast response from bus transportation company or user to act dynamically in optimizing the bus transportation in Malaysia.

II. LITERATURE REVIEW

A. Bus Tracking System

Public transportation has become an integral component of daily life. The majority of individuals use public transit to get from their residences to work or education. People can waste time on public transit due to unwelcomed delays. People also have a right to know where the bus is right now and how long it will take for the bus to arrive at the bus stop [3]. The bus is successfully tracked by utilizing a GPS module to get geographic coordinates and transmitting the data to a distant server through a Wi-Fi module [4]. Effective transportation systems allow for the efficient flow of goods and people, resulting in improved quality of life and societal social and economic progress. The transportation system is the system's beating heart. As the population grows, so does the number of vehicles on the road, resulting in increased traffic congestion. The optimal solution to this problem is the use of public transport. However, public transportation timetables are unpredictable, and waiting for a bus for an extended period is inefficient. However, a system that provides complete information, such as the number of buses that go to the required stop, bus numbers, bus timings, time taken for the bus to arrive, routes are taken by the bus, maps that guide passengers, and, most importantly, tracking real-time bus location coordinates and determining the correct time the bus will take to arrive at its bus stop would be ideal [5]. A basic bus tracking system has been developed where passengers used the tracking technology to locate the bus predetermined route. Today, with the emergence of the Internet of Things (IoT) technology, in addition to Radio Frequency Identification (RFID), developing such systems became feasible and cost-effective[6]. Research has presented the design and implementation of a comprehensive low-cost system based on IoT that allows schools, parents, and authorities to track the movement of children while in school buses or being transported in private vehicles in real-time. The system is based on off-the-shelf passive RFID readers that are installed within buses, next to bus stations, and pick-up points at school entrances. Another research has designed a system that gives continuous data about different boundaries of the vehicle like the area, the course, the speed, the rundown of travelers, the adherence of drivers to the calendar, and more. The system further permits the parents to be informed when their children's sheets the transport. In this system, we utilize Radio-Frequency Identification (RFID) and Global Positioning System (GPS) advancements, Global System for Mobile Communications (GSM), and associate them to a far-off worker over Wireless Fidelity (Wi-Fi). A GPS module is utilized to locate the current geographic directions of the vehicle's area[7]. Thus, the bus tracking technology also helps to increase children's safety. The GPS gives the vehicle's current location and the GPRS delivers the tracking information to the server, and an alarm message is delivered to the vehicle's owner.

B. *RFID UFH used for Bus Transportation*

Radiofrequency identification (RFID) is a significant aspect of our life. RFID boosts productivity and ease. Hundreds, if not thousands, of systems, employ RFID[8]. There are many different forms of RFID, but at the most basic level, we may split RFID devices into two categories: active and passive. Active tags need to be powered, so they are either linked to a power source or rely on energy stored in a built-in battery. The lifespan of a tag was restricted in the latter scenario by the amount of stored energy, which was balanced against the number of reading operations the device had to do. An antenna, a semiconductor chip connected to the antenna, and some sort of encapsulation make up a passive tag. The tag reader is in charge of supplying power to and interacting with the tag. The tag antenna collects energy and transmits the tag's ID which the operation is coordinated by the tag's chip. The encapsulation protects the antenna and chip from environmental conditions and reagents while maintaining the tag's integrity[9]. It comes with a reader that reads data from tags. Active RFID tags are used in car and object tracking systems, whereas passive RFID tags are utilized in vehicle and object tracking systems. The RFID system may operate at low frequencies of 30 kHz to 300 kHz, high frequencies of 3 to 30 MHz, or ultra-high frequencies of 30 MHz to 3 GHz [10]. Hatem and Habib created the bus management system utilizing RFID and the Wireless Sensor Network (WSN). The WSN network extends the detection range between the RFID reader and the tag [11]. According to the literature study, all of the above-mentioned monitoring techniques are costly and energy-intensive. Ultrahigh frequency (UHF) radio frequency identification (RFID) has become an effective accelerator for the internet of things because of desired qualities such as low cost, battery-free operation, and unique identification (IoT). In this paper, we offer a novel UHF-RFID-based real-time vehicle localization approach in GPS-less settings [12].

C. *IoT system for Bus Transportation*

IoT is powered by recent advancements in a range of electronics and communication technologies, but it also requires everyday goods like food, clothing, furniture, paper, landmarks, monuments, and pieces of art, among other things. These items, which function as sensors or actuators, can communicate with one another to achieve a common purpose [13]. A study of over 100 publications demonstrates the application of IoT in a variety of sectors, including fitness, sports, travel, and agriculture. The authors established the usage of GPS and RFID tags as the principal position tracking technique based on the transport domain survey. GSM/ GPRS has also been used in the form of SMS to transmit information to consumers [14]. Research has distinguished between Cloud and IoT based on characteristics like reachability, processing capacity, and the function of the internet, among others. The authors also discussed the benefits of combining cloud computing and IoT, dubbed CloudIoT. The advantages of combining the two technologies for large-scale data processing have also been discussed [15]. A study of how smartphone-based sensing is being used in intelligent transportation systems. For gathering traffic information, driving behavior information, and vehicle information, embedded sensors in smartphones such as accelerometers, gyroscopes, and global positioning systems (GPS) have been used [16]. The solutions given in the literature can be narrowly divided into solutions based on software and solutions supported by hardware.

D. *Mobile applications in Bus localization via GPS*

Smartphone apps-focused solutions have recently shown a fast development in many areas where sensing is faster and cloud-based accessed[17][18]. Passengers and their smart gadgets are utilized here to gather data for free. The suggested method is a software-only technique that employs the idea of mobile crowdsensing, in which individuals share data and extract information using sensing and computational devices to quantify and map phenomena of mutual interest. Urban Bus Navigator, an IoT-enabled navigation solution for urban bus users, is now available (UBN). To minimize overcrowding on public bus travels, UBN analyzes the wireless signals of mobile phones visible on buses to identify bus passenger crowds and give better reality-aware bus route advice [19]. The suggested system is reliant on the users' combined efforts. Instead of relying on GPS-enabled position information, the authors have available sensing resources such as cell tower signals, mobility status, audio records, and so on for participatory sensing. Another bus arrival prediction system has been demonstrated for Indian traffic circumstances [20].

III. Methodology

The method involved a designed prototype for hardware and system.

A. System Flow Chart

Fig. 1 shows a flow chart of a system in this project. When the bus starts to move GPS will detect the bus location. If the RFID reader detects it will send a message to the application to notify the user. IR sensor will detect if passenger going in or out.

B. Hardware and Software

1) Blynk Application

The cloud platform used was Blynk. Blynk is a new platform that lets you easily create interfaces for controlling and monitoring your hardware projects using your iOS or Android mobile. You may construct a project dashboard after downloading the Blynk software and arranging buttons, sliders, graphs, and other widgets on the screen. By using Blynk, the connection between Arduino and Wi-Fi module can be easily established. With both Arduino and Wi-Fi modules are connected to the internet, we can monitor the information by using a mobile application.

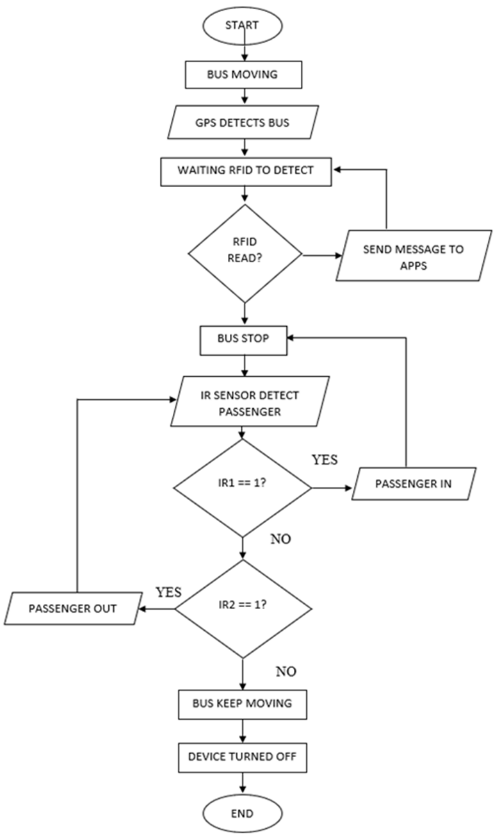


Fig. 1. Flow chart.

2) NodeMCU ESP8266

As a controller and a Wi-Fi module, the NodeMCU ESP8266 was utilized. Not only is it a low-cost open-source IoT platform, but it also contains software that works on systems ESP8266 Wi-Fi SoC and hardware based on the ESP-12 module. This component serves as the project's hub, connecting all of the other components and transferring data to the Blynk application. For this project, we used two of these to separate GPS and other sensor functionality.

3) IR Sensor

A piece of electrical equipment that detects and monitors infrared radiation in its surroundings. When an item gets close to the sensor, the LED's infrared light bounces off it and is recognized by the receiver. This component act as a counter for the passenger inside the bus for this project. There will be two IR sensors, one for passengers going in and another for passengers going out. To get the number inside the bus just simply subtract passengers going in and going out.

4) RFID MFRC522

An RFID reader, an RFID card, and a key chain are all included with the RC522. The RC522 reader module allows you to read and write data into these memory components. The reader can only scan passive tags that operate at 13.56MHz. Before arriving at each bus stop, this component serves as a card reader for the driver. There 3 bus stops for demonstration in this project which is bus stop A, bus stop B, and C. Other than that, there was also a special key that can be read if the bus was in trouble. All these cards and keys will notify the passenger via the Blynk application.

5) GPS Neo-6M

The GPS Neo-6M was used as a GPS component for this project. It provides GPS allocation and will be connected to NodeMCU WiFi Module. All the data will be stored via the Blynk Application.

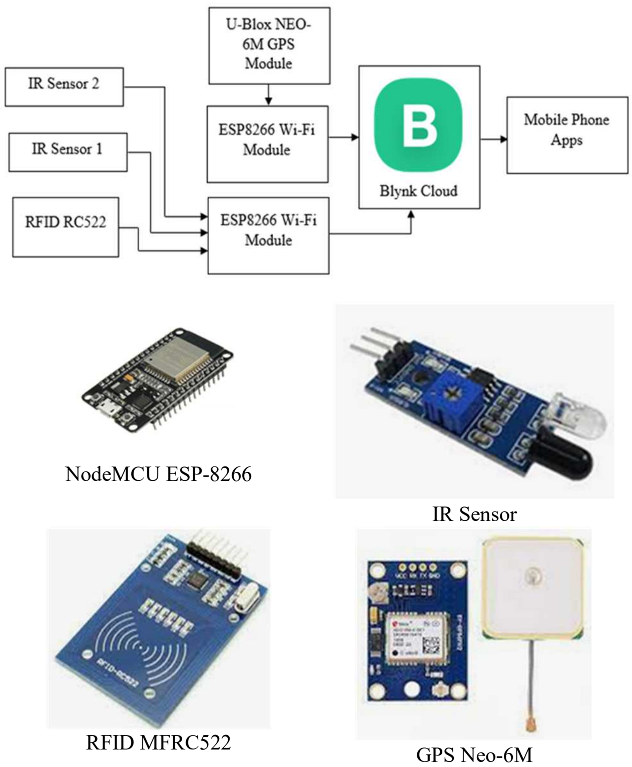


Fig. 2. Architecture diagram and components.

C. System Architecture Diagram

The GPS Neo-6M was used as a GPS component for this project. It provides GPS allocation and will be connected to NodeMCU WiFi Module. All the data will be stored via the Blynk Application. Fig. 2 shows the connection of multiple components to perform a specific task. In this project, two ESP8266 WiFi module was used to separate GPS and sensor functionality. Both eventually will be connected to Blynk Apps under the same authenticator code.

IV. Analysis and Result

This research has minimalized the time wasted for bus users while waiting for the bus to arrive where the designed system will alert the passenger with the localization of the bus and notify if the bus is near a bus stop. The location of the bus will be appeared in the mobile application of the use by using GPS. Moreover, the information about the availability of seats inside the bus will be sent to the Blynk application. Users can view the number of passengers inside the bus, latitude, longitude, LCD, and map to show the location of the bus.

A. Mobile Application Design

Fig. 3 shows the design of mobile apps of user's interface (UI) using Blynk for users to view. The black pin is for the location of the bus and the green pin is for the location of the user. The latitude, longitude, passenger count, and LCD message are displayed.

B. Data analysis

1) GPS and RFID

Fig. 4 shows the location of bus stop A. The latitude and longitude were 6.016716 and 116.122741, respectively. The white LCD has displayed "Bus Stop A Please Be Ready". RFID card ID for this message has been identified with number C6 F9 B8 2B.

Fig. 5 shows the location of bus stop B. The latitude and longitude were 6.016911 and 116.124275, respectively. The white LCD has displayed "Bus Stop B Please Be Ready". RFID card ID for this message was 55 04 89 2A.

Fig. 6 shows the location of bus stop C. The latitude and longitude shown 6.015006 and 116.123665. The white LCD has displayed "Bus Stop C Please Be Ready". RFID card ID for this message was C6 F1 B7 2B.

Table I shows the analysis movement of the bus for three(3) different bus stops. GPS produce different latitude and longitude for each bus stop. Messages on the LCD also has shown the different locations and latitudes with longitude numbers. This was due to different cards used on RFID readers and each card has a different ID.

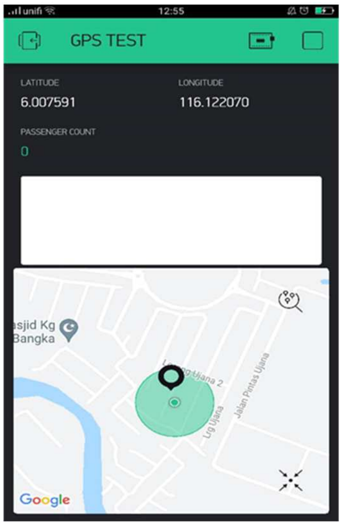


Fig. 3. UI of Blynk application.

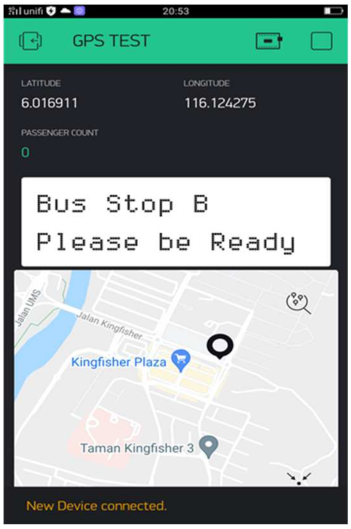


Fig. 5. Location and message for Bus Stop B.

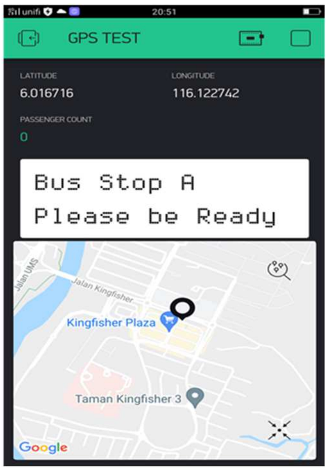


Fig. 4. Location and message for Bus Stop A.

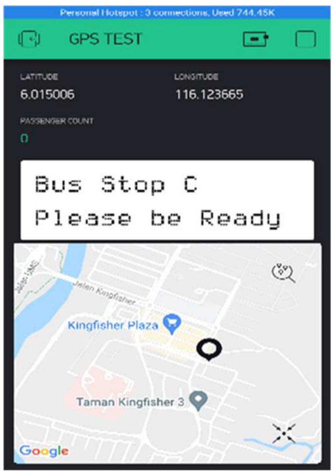
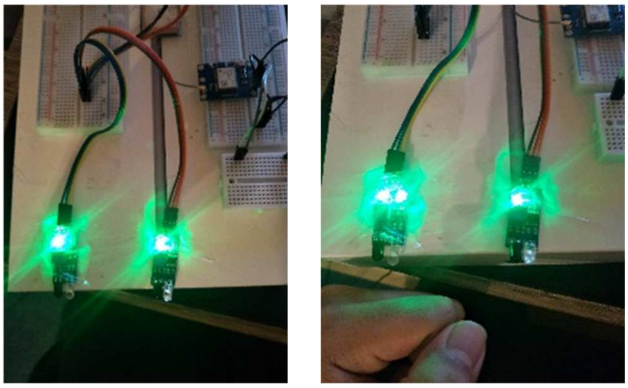


Fig. 6. Location and message for Bus Stop C.

TABLE I. ANALYSIS OF GPS AND RFID

Bus Stop	Latitude, Longitude	RFID Card No
A	6.016716, 116.122741	C6 F9 B8 2B
B	6.016911, 116.124275	55 04 89 2A
C	6.015006, 116.123665	C6 F1 B7 2B



(a) (b)

Fig. 7. (a) IS of IR sensor and (b) IS in Blynk Apps.

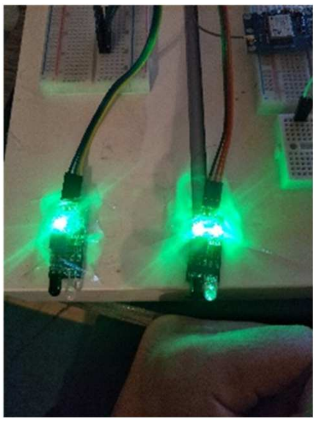


Fig. 8. IN the state of the IR sensor

2) Passenger counter

Fig. 7a and 7b shows the initial state of the counter. During the initial state, there was no object detected by IR sensors 1 and 2. Thus, the passenger count neither increases nor decreases.

Fig. 8 and 9 show IN the state of the counter. During IN state, only IR sensor 1 will detect an object. Thus, the passenger count will increase.

Fig 10 and 11 show the OUT state of the counter. During OUT state, only IR sensor 2 will detect an object. Thus, the passenger count will decrease.

V. CONCLUSION

In conclusion for this project, an application was developed that can extract information about the bus and notify the bus user and driver. By using GPS, the location of the bus can be viewed through the mobile application. Other than that, the availability of bus seats can be determined by RFID receivers and tags. Blynk cloud platform has been used the display the availability of bus seats. The information regarding the seats was sent through the mobile application to the driver. This can reduce the waiting time for the passenger since they can estimate the time of arrival of the bus before going to the bus stops. Furthermore, unwanted route deviations and unauthorized stops can be avoided. Therefore, the objectives were successfully achieved.

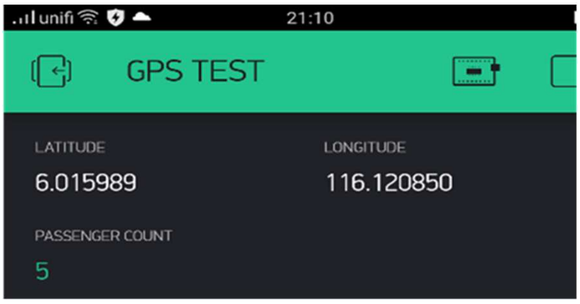


Fig. 9. IN state in Blynk Apps.

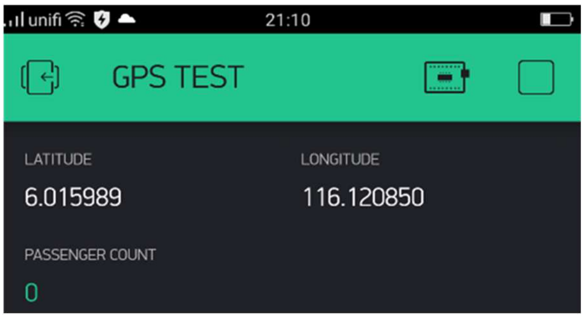


Fig. 10. OUT state of IR sensor.

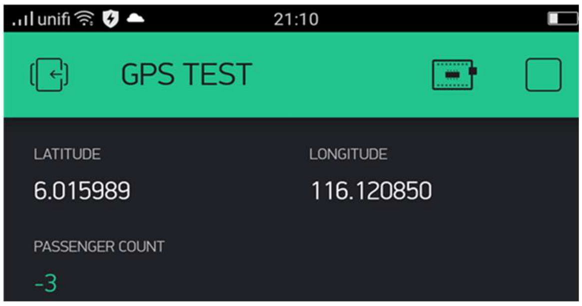


Fig. 11. OUT state in Blynk Apps.

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