MULTIDISCIPLINARY APPLIED RESEARCH AND INNOVATION
e-ISSN: 2773-4773

MARI

Vol. 6 No. 4 (2025) 330-336
https://publisher.uthm.edu.my/periodicals/index.php/mari

Smart Bus System & Bus Tracking for UTHM Pagoh Residential Students

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DOI: https://doi.org/10.30880/mari.2025.06.04.047

Article Info

Received: 1 September 2025
Accepted: 15 October 2025
Available online: 1 December 2025

Keywords

Bus tracking, real time update, RFID, UTHM, Smart Bus

Abstract

To ensure that students can travel between college and campus comfortably, students can use the bus system and the tracking system. Travel is made easier with system security measures and information updates. For example, the bus tracking system uses NEO 6M GPS and ESP 32 to provide real-time updates via Telegram, to inform students of buslocation and arrival time. Information system with LCD display that displays travel routes and other updates. Furthermore, the security system uses RFID for UTHM student ID authentication using the student matrix card and a motion sensor (PIR) to detect any movement after the bus door is closed. This project aims to develop a Smart Bus system that combines these qualities to deliver accurate location data as well as safetransit. Two main systems have been built, one for user safety using RFID and PIR, and one for information with LCD display and GPS. This integrated solution simplifies and improves transportation for UTHM students and it can also be used in the workplace.

1. Introduction

Smart bus tracking systems have enhanced public transportation by using IoT and real-time data for accurate locations and schedules, improving reliability and user experience [1]. Global projects using GPS, GSM [2],[3], IoT for safety [4], Arduino for low-cost solutions [5], and dedicated trackers [6] show the technology's wide usability. Mobile app-based tracking highlights its ongoing evolution [7]. The Smart Bus System for UTHM Pagoh Residential Students addresses campus transport challenges by integrating an LCD Bus Information System, RFID and PIR sensors for safety, and GPS with ESP32 for real-time tracking via Telegram. It improves efficiency, safety, and convenience, with future upgrades planned for emergency alerts and stronger connectivity.

This project has an objective to deliver where it can create a sophisticated Bus Information System that uses LCD to provide the latest updates on bus schedules and routes. Additionally, it is committed to developing a robust Bus Security System that incorporates advanced RFID and PIR sensors to ensure comprehensive passenger safety. Furthermore, our objectives include implementing a highly efficient Bus Tracking System that leverages GPS technology and an ESP32 microcontroller for accurate real-time location monitoring. These efforts are set to significantly improve the reliability of bus services and improve safety measures for passengers. As for the project, I hope that this project meets all the objectives that have been set in the end.

2. Materials and Method

There are several methods that need to be adopted to perform this task successfully. This Smart Bus and Detection System is designed to facilitate bus users in Pagoh UTHM.

- Neo 6m GPS moduleESP 32
- Radio Frequency Identification (RFID)
- LED
- Buzzer
- Liquid Crystal Display (LCD)
- PIR Sensor

2.1 Materials and components

This research consists of software and hardware for the development of Smart tracking systems in real time. Based on Table 1, the following is an explanation of each component and materials used to produce this project

Table 1 *List of materials and components*

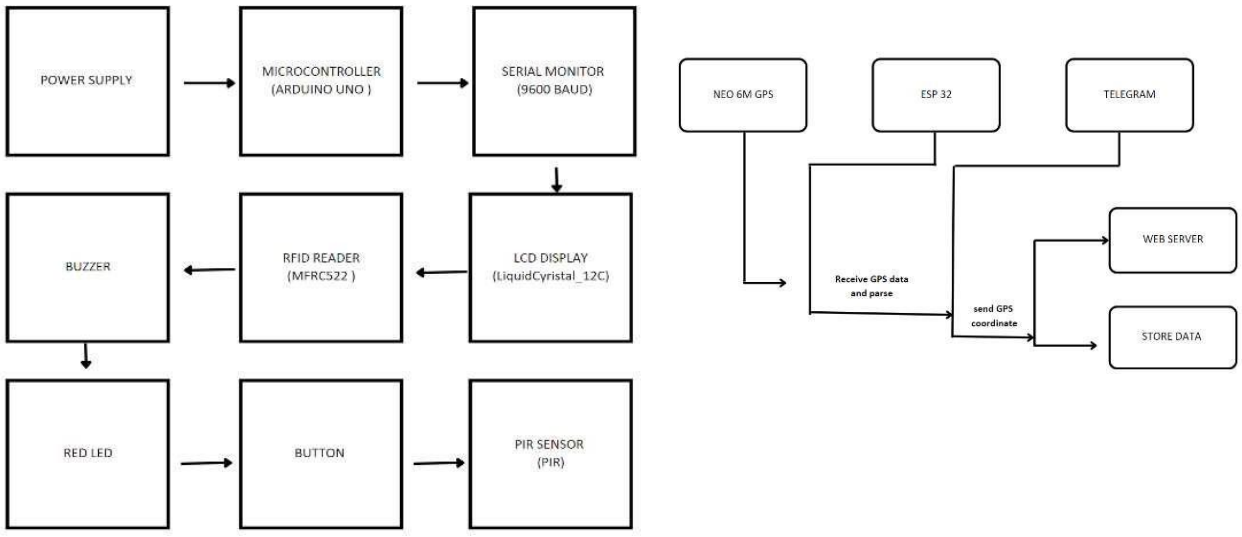
No.	Item Name	Quantity	Description
1.	Neo 6m GPS module	1	To get the GPS data
2.	ESP 32	1	As a microcontroller connect with the GPS
3.	Radio Frequency Identification (RFID)	1	Module & role as identification passenger
4.	Green LED 10mm	1	Will light up when the correct card is
5.	Buzzer	1	Scanned & sound every time the wrong card
6.	Liquid Crystal Display (LCD)	1	Scanned & display the information of the bus
7.	PIR Sensor	1	As a security system
8.	Power bank 5v	1	Power supply

2.2 Methodology

In developing Smart Bus and Tracking System, we have relied on important tools like Arduino IDE for microcontroller programming and Wokwi for simulation, which are essential in achieving our project effectively. Smart Bus components integrate RFID technology for secure access control, LCD displays for real-time updates on schedules and routes, and PIR sensors to improve passenger safety. Meanwhile, the Tracking System uses advanced ESP32 and GPS modules to provide accurate location tracking, ensuring efficient bus management and reliable service delivery. Looking ahead, we intend to further enhance the system's capabilities with features such as automatic emergency notification for better safety response, enhanced user connectivity options and the use of sustainable technology to promote efficiency and environmental responsibility in campus transportation solutions at UTHM Pagoh.

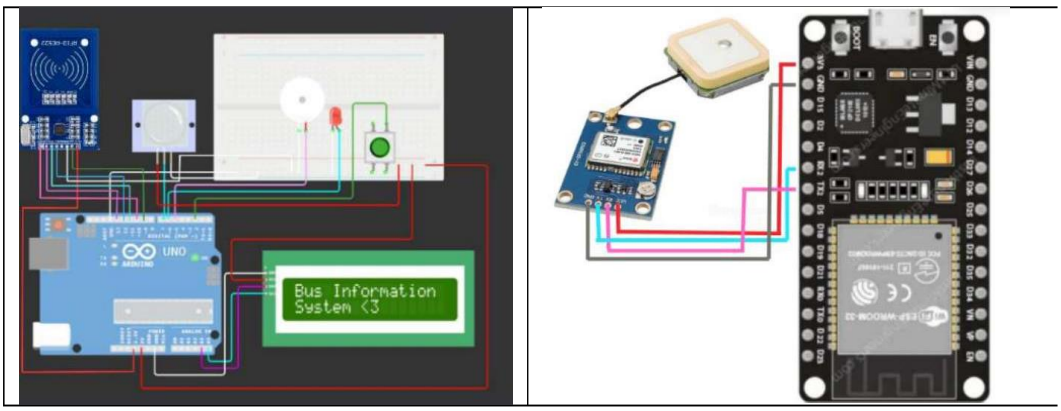
Based on Fig. 1 below, it shows two pictures where there are (a) and (b). (a) is a block diagram of a smart bus system. All the components need to be connected to a microcontroller, i.e. Arduino Uno, to create this system. The order of this system has also been shown there because each component has a different function and needs to be activated in order. Next (b) is a smart tracking system, it results from the combination of NEO 6M GPS and ESP 32 as the main component of this system. Next it is also integrated with IoT, where GPS data will be given to telegram. data will only be released when the user sends a "location req" message.

Based on Figure 2, which illustrates the implementation of two different systems, (a) illustrates a smart bus system where various components are closely connected to an Arduino Uno microcontroller. First, the RC522 RFID module, integrated with SDA, SCK, MOSI, MISO, RST pins, and powered by 3.3V, improves security and access control. At the same time, LCD displays, PIR sensors, LEDs, buzzers and push buttons are strategically connected to facilitate passenger interaction and system feedback. After that, (b) showcases the advanced bus tracking system, combining NEO-6M GPS module with ESP32. Operating on UART communication, the TX and RX pins of the NEO-6M connect seamlessly to the ESP32's RX2 and TX2 respectively, enabling real-time location tracking. Integrated with IoT capabilities, the dissemination of GPS data via Telegram is only initiated upon receiving a "location req" message, ensuring efficient and secure transit management.



(a) (b)

Fig. 1 *Block diagram for (a) smart bus system; (b) Smart tracking system*



(a) (b)

Fig. 2 *Implementation for (a) smart bus system; (b) bus tracking system*

3. Result and Discussion

The prototype in Fig. 3 Smart Buses and Tracking Systems represent important advances in campus transportation management. Highlighted by punch holes, it showcases the integration of carefully designed components. Each component has also been labeled in the diagram. Providing real-time updates on timetables and routes, the system not only addresses bus management challenges but also promises significant improvements in service reliability and user experience. The prototype underscores its potential to revolutionize campus transit, illustrating a robust solution poised to streamline operations and foster a safer and more accessible transportation environment.

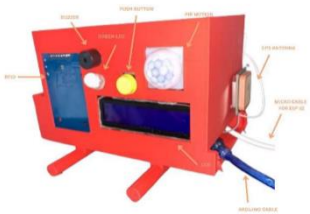


Fig. 3 *Project prototype*

Table 2 briefly assesses the functionality of the Smart Bus System, verifying all aspects of the test. Testing, RFID card detection, LCD display, button navigation, PIR sensor activation, system integration and serial

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communication all successfully produce the correct output. These results confirm the system's reliability and effectiveness in improving campus transportation management, ensuring smooth operations and user satisfaction.

Table 2 *The effectiveness of the bus system*

Test Case	Description	0/ 1	Actual Outcome
RFID Card Detection	Verify RFID card detection and authentication.	1	Correct UID displayed, access allowed.
LCD Display Functionality	Ensure LCD displays initial messages and updates.	1	Messages displayed correctly. Backlight turned off after timeout.
Button Navigation	Test button navigation through LCD menu states.	1	Successfully navigated through all states.
PIR Detection	Simulate motion to trigger PIR sensor.	1	Message displayed; buzzer sounded.
System Integration	Verify components work together seamlessly.	1	All components integrated without issues.
Serial Communication	Monitor serial output for event messages.	1	Motion detection message sent correctly.

Table 3 presents the survey findings regarding the perceptions and preferences of UTHM Pagoh students towards the Smart Bus System. The majority (81%) of students indicated Point K as their main destination, highlighting the focal point for routes and bus services. Additionally, 76.2% specifically chose Point K as their main checkpoint, emphasizing its importance in planning their daily commute. A total of 82.9% of students chose the bus time between 7:30 - 8:30 AM, highlighting the peak demand period for campus transit. However, there is a significant awareness gap regarding the UTHM bus detector in Figure 4 where 64.3% of students are unaware of its existence, indicating the need for better communication and education about the features and benefits of the system. Despite this, an overwhelming 81% of students agree that the Smart Bus System improves their bus experience, reflecting positive expectations for improved service reliability and overall user satisfaction. The main reason for this study to be produced is to narrow the scope of this project and only take data in block k up to the college only, at the same time wanting to know more about bus knowledge. It has also been proven that this system is worthy of being applied to students because many want to accept this system as their facilities.

Fig. 4 show the web base maps for UTHM Pagoh which have seven check points: Katerina KK, Block K, Block G, Hentian Shared Facility, Dewan Auditorium, Block B, Katerina KK. Bus will be following the check points for the students to get notification, when the bus will be arrived for the check point especially during peak hour.

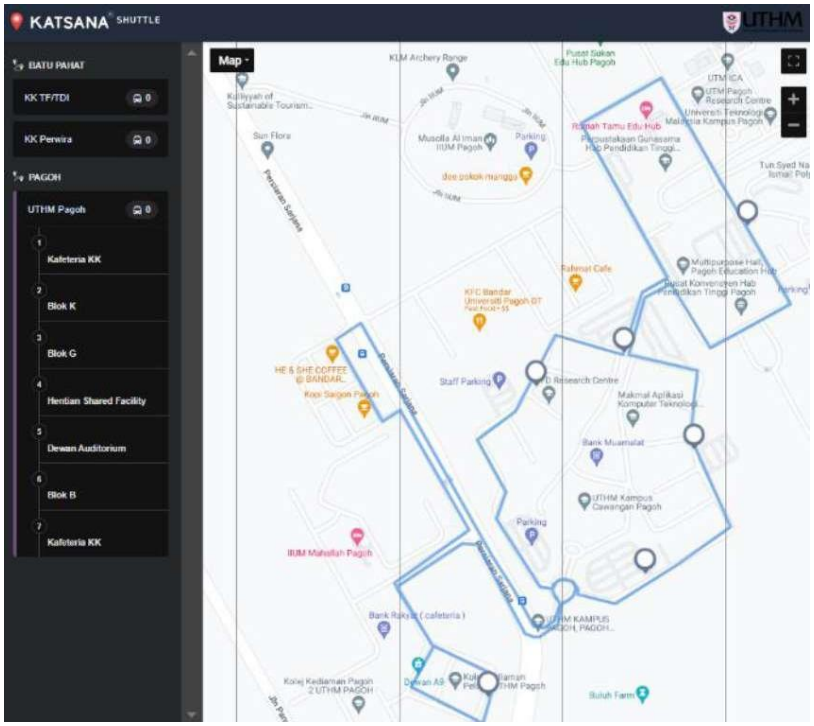


Fig. 4 Web base maps

Table 3 *The outcome of survey*

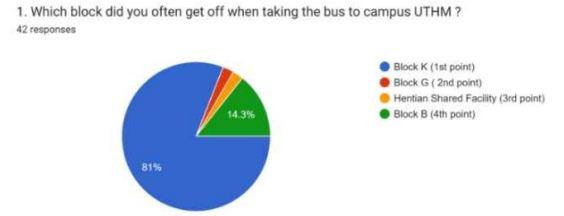
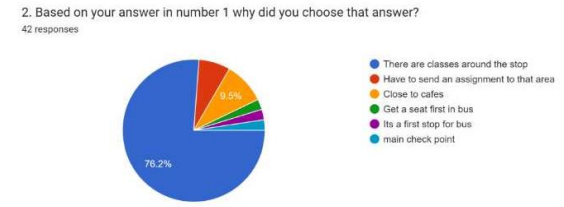
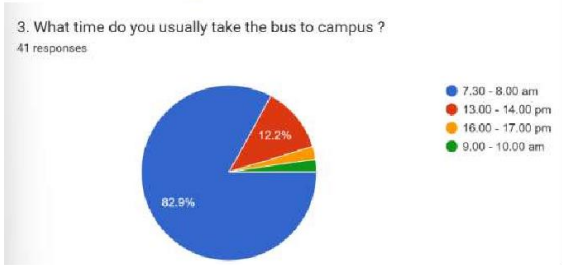
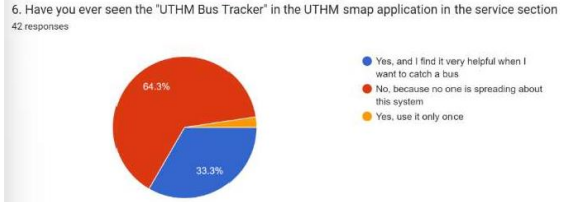
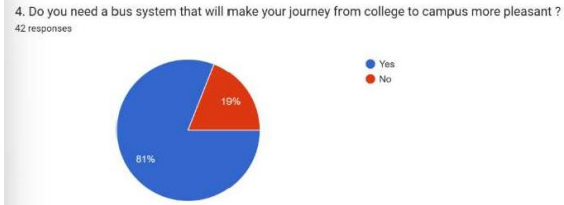
Survey results	Findings
	Most UTHM Pagoh students will stop at Point K as their main destination
	Based on question number 1, a total of 76.2 students have chosen that point as the main check point.
	A total of 82.9% of students choose the bus time between 7.30 - 8.30 as the time they always take the bus to campus
	There is a big difference between those who don't recognize this UTHM bus tracker which is 31%
	Majority agree that have a system bus will make the feel pleasant taking the bus

Table 4 outlines the operational scenario for the Smart Bus Tracking System, detailing how ESP32 and NEO-6M GPS integration with Wi-Fi connectivity manages GPS data requests. When activated, the system lights up an LED to indicate successful GPS data acquisition, immediately sending the coordinates to the Telegram chat set on the Fig. 4. On the other hand, without a data request, the LED remains off, accompanied by a notification in Telegram informing the user of the absence of GPS data. This integrated approach ensures efficient communication of real-time bus locations, improving service reliability and user experience in campus transportation management.

Table 4 *The status of tracking with telegram*

Test scenario	ESP 32	NEO-6M GPS	LED	Expected output
GPS data request	Connected to Wi-Fi	GPS data available	ON	GPS data sent to Telegram chat

GPS data do not request	Connected to Wi-Fi	GPS data not available	OFF	"GPS data not updated yet." message sent to Telegram

Based on the data and results presented in Table 2 and Table 3, the Smart Bus and Tracking System designed for UTHM Pagoh shows significant effectiveness and user acceptance. The system's robust performance in RFID card detection, LCD display functionality, button navigation, PIR sensor activation, and seamless integration of components emphasize its reliability in improving campus transportation management. Next, the survey findings highlight the preferences of students who choose Point K as their main destination and specific bus schedules, showing the benefits of customized services. However, 31% have a significant lack of awareness about the bus tracker that has been produced on the Smap under services website, indicating that we need to disseminate this system more often so that all students can use this facility. Table 4 reinforces the system's ability to deliver real-time GPS updates via Telegram upon user request, it also leverages ESP32 and NEO-6M GPS technology effectively. Overall, this integrated approach not only promises to improve service reliability and user experience but also sets the precedent for smarter and more efficient campus transit solutions.

4. Conclusion

In developing Smart Bus and Tracking System, we have relied on important tools like Arduino IDE for microcontroller programming and Wokwi for simulation, which are essential in achieving our project effectively. Smart Bus components integrate RFID technology for secure access control, LCD displays for real- time updates on schedules and routes, and PIR sensors to improve passenger safety. Meanwhile, the Tracking System uses advanced ESP32 and GPS modules to provide accurate location tracking, ensuring efficient bus management and reliable service delivery Looking ahead, it is recommended to further enhance the system's capabilities with features such as automatic emergency notification for better security response and better security. Additionally, incorporating enhanced user connectivity options will ensure a smoother and more user-friendly experience. We also propose to focus on the use of sustainable technology to promote efficiency and environmental responsibility in campus transportation solutions at UTHM Pagoh. These improvements will not only increase the reliability and efficiency of transportation.

Acknowledgement

The authors would also like to thank the Centre for Diploma Studies, University Tun Hussein Onn Malaysia for its support.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Khairunajlaa Zamri, Nur Azliza;* ***data collection:*** *Khairunajlaa Zamri;* ***analysis and interpretation of results:*** *Khairunajlaa Zamri, Ahmad Fahmi Iman;* ***draft manuscript preparation:*** *Khairunnajlaa Zamri, Nur Azliza Ahmad. All authors reviewed the results and approved the final version of the manuscript.*

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