The University Bus Tracking System Employs the Internet of Things

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DOI: https://doi.org/10.30880/jttr.2024.02.02.008

Article Info

Abstract

Transportation serves as an efficient means of travel. In the current age of globalisation, transit is essential for a nation's economic progress. The legal foundation for accountability in a public service company now mandates the provision of exceptional and high-quality service. At now, students, especially those lacking personal transport, depend on school-provided transit to traverse the campus. However, a problem arose when students could not access the position and location while the bus was in transit. Users experience challenges stemming from the unpredictability of the bus's arrival timetable, resulting in an indeterminate waiting duration. We created an Internet of Things (IoT)-based bus tracking system for Universiti Tun Hussein Onn Malaysia (UTHM) to address the issue. This system allows users to effortlessly obtain real-time data regarding the bus's present location, position, and projected arrival time at each stop. The investigator employed the Design Thinking Process (DTP) framework in this investigation. The procedure comprises five stages: empathy, decision-making, ideation, prototyping, and testing. The findings of the analysis confirm the successful development and intended operation of the system. Moreover, the system can accurately display the bus's position and location while also offering valuable information to users. The following questionnaire substantiates this assertion, indicating that 32 students, including 95% of the target demographic, exhibit confidence in the product's functionality. Ultimately, UTHM's IoT-enabled bus tracking system effectively accomplished all its established objectives.

1. Introduction

The highlighted issue pertains to the challenge students encounter when using the UTHM bus service. Students struggle with the inability to track the movement of the bus and determine its current position and location (Wardhany, 2020). Despite being provided with a bus schedule, traffic congestion and weather conditions can cause delays according to the specified times (Deng et al., 2020). This factor contributes to students arriving late for classes, lectures, and university activities, resulting in prolonged waiting periods (Nasrudin, 2019). Universities in Malaysia, including UTHM, widely utilize bus services to ease the mobility of students without personal transportation. We conducted this study to assist students in accessing the bus's current location, thereby facilitating their search for alternative routes in the event of any issues with the bus service. Before developing this project, we consulted previous studies and the latest technologies for bus tracking systems.

1.1 Public Transportation Environment in Malaysia

Transportation is a suitable method for humans to move from one place to another. In the era of globalization, transportation plays a very important role in the country's economic growth. Nowadays, providing excellent and quality service has become an official responsibility for public service companies, with the aim of improving performance and attracting the community to use it. According to Sakaran & Noor (2020), Malaysia places significant emphasis on service quality to persuade users to utilize public transportation. Therefore, public transportation plays a crucial role in this country, as it is the most practical option for the general public, particularly those residing in cities and students (Hashim, N, I, et al., 2019).

Arina Ishak (2019) demonstrated that user satisfaction with the Penang bus service is moderate, based on user perception. Meanwhile, user's express dissatisfaction with the service, citing a low level of service quality. The lack of notification to passengers regarding arrival times can cause congestion at bus stations or terminals. The 2020 Malaysian Transport Statistics report supports this by revealing a 50.46% decrease in the percentage of users utilising bus transportation services compared to the previous year, Ibrahim (2020) states that one of the reasons for the lack of willingness among users to use public transportation is due to the failure to provide quality services as expected by users. Users have assumed that the public transportation system is unreliable in terms of punctuality (Shelat et al., 2020). According to Ishak (2019), delays in public transportation, including buses, LRT, taxis, and aeroplanes, frequently occur and do not adhere to the scheduled times. Figure 1 shows the statistics of bus service usage from 2017 to 2019 (Agensi Pengangkutan Awam Darat, 2021).

Jenis Perkhidmatan	Perkhidmatan Umum	LEMBAH KLANG						Jumlah
		Perkhidmatan Lain-lain						
		Bas Pengantara MRT	Bas Smart Selangor	BRT Sunway	Putrajaya	GoKL	PJ Citybus	
2017	121,542,215	7,536,384	10,660,051	2,307,838	1,493,299	20,944,682	4,225,401	168,709,870
2018	105,320,756	16,807,137	14,445,813	3,603,510	810,420	20,801,718	4,726,842	166,516,196
2019	84,650,007	16,606,586	15,260,149	4,460,796	433,438	19,712,479	5,283,210	146,406,865
Jan	8,092,402	1,580,877	1,217,238	314,514	51,283	1,759,743	423,992	13,440,049
Feb	7,190,514	1,135,964	1,136,069	262,193	40,819	1,530,848	379,809	11,676,216
Mac	7,957,789	1,409,062	1,295,690	355,067	44,702	1,724,729	419,316	13,206,355
Apr	7,708,187	1,397,146	1,290,774	403,388	46,851	1,732,123	436,169	13,014,638
Mei	6,739,646	1,361,380	1,262,423	386,454	39,316	1,698,738	464,224	11,952,181
Jun	6,481,699	1,216,824	1,221,721	331,385	34,182	1,579,586	444,659	11,310,056
Jul	7,022,937	1,445,006	1,366,364	371,733	48,024	1,710,012	468,126	12,432,202
Ogos	6,835,124	1,372,752	1,267,912	414,749	39,586	1,620,772	479,329	12,030,224
Sep	6,359,606	1,327,902	1,308,793	390,508	22,334	1,554,529	455,465	11,419,137
Oct	6,970,455	1,542,135	1,397,898	446,366	23,466	1,639,259	434,404	12,453,983
Nov	6,676,468	1,434,766	1,258,835	416,647	22,752	1,586,932	425,460	11,821,860
Dis	6,615,180	1,382,772	1,236,432	367,792	20,123	1,575,408	452,257	11,649,964

Fig. 1 *Bus service usage statistics (Agensi Pengangkutan Awam Darat, 2021)*

1.2 Internet of Things (IoT)

Devices can become Internet of Things (IoT) devices via internet connectivity. This technology seeks to enhance consumer ease by linking ordinary devices to the internet. The essence of IoT can be categorised into three components: information collection and dissemination, data reception and response, and. Sensors generally operate as IoT devices that gather and transmit data. McClelland, 2020. Information can be transmitted and processed using either wired or wireless means. IoT devices generally link to computing systems because they can obtain data from any location at any time. From a communicative perspective, IoT devices utilise diverse protocols, including Wi-Fi and Bluetooth. Six categories of wireless IoT technologies exist, each possessing distinct advantages and downsides. The technology encompasses Low Power Wide Area Networks (LPWANs), cellular networks, Zigbee, Bluetooth and BLE, Wi-Fi, and RFID. Behr Technology Inc., 2020.

1.3 Global Positioning System

Vehicles, people, or any assets can obtain precise locations using the Global Positioning System (GPS). GPS is a navigation system that relies on satellites, also known as the Global Navigation Satellite System (GNSS). This GPS serves as an intermediary medium, aiding in the determination of the condition and location of a person or object (Wardhany, 2020). This GPS system consists of 24 active satellites orbiting the Earth. The distance positions for the orbit and satellites are also determined at 19,000 kilometres and arranged to ensure that every GPS user and receiver has a connection (Vatansever, 2019). This GPS provides coverage 24 hours a day. Data from this position will be recorded and stored in a tracking device or transmitted to a base or computer connected via GPRS, radio, or satellite. This scenario enables the display of the asset location on the map screen, either in real-time or through

track analysis. GPS tracking systems, in conjunction with GNSS networks via microwave signals, can furnish data on location, vehicle speed, direction, and time. Therefore, this system has the potential to provide real-time navigation information and travel history data. This GPS system can also function in several ways, including from a commercial perspective, where the GPS device records the current position during the vehicle's journey. Figure 2 illustrates the connectivity and functionality of the global positioning system.
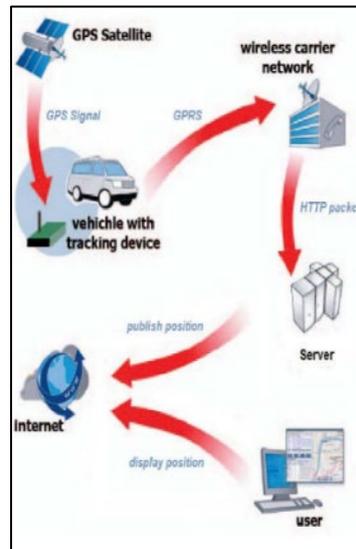
Fig. 2 *Global positioning system (Sumber: Oliveira et al., 2020)*

1.4 Wi-Fi

Wi-Fi, short for Wireless Fidelity, is a fast communication tool that enables devices to communicate with each other (Fauzi, 2019). Devices, including computers, televisions, and radios, typically use this function. Despite having internet access, cellular customers typically still use WiFi. The development of Wi-Fi now uses Wi-Fi version 6, which operates on two frequencies, 2.4 GHz and 5 GHz (Ruliyanta et al., 2022). This Wi-Fi network consists of two main components, namely the access point and the device that provides the Wi-Fi connection. Access points act as central hubs that connect to the internet via wired connections, such as broadband modems. It simultaneously transmits and receives data using radio signals, allowing devices within its range and environment to access the internet. This is the best way to send data from the central hub to the local/cloud database via Wi-Fi (Domínguez & De Jesús Mateo Sanguino, 2019). The advantage of using Wi-Fi is the ability to provide a wireless Internet connection to low-cost and fast traffic that does not require high quality of service. (Oughton et al., 2021). Conversely, systems such as Wi-Fi lack vulnerabilities. Almost every modern smartphone incorporates a WiFi receiver. He made Wi-Fi an attractive base for navigation purposes. Wi-Fi signals have excellent specifications for navigation (Korogodir et al., 2019). Only if the router fails to function or a high number of users are using the broadband application at the same time can it cause disruptions and loss of connection.

1.5 Microcontroller

Using a microcontroller as the primary component in a control system is crucial for controlling the circuits within it. The microcontroller's tasks include processing signals coming from the transmitter and receiver subsystems and coordinating the activities of the components (Misra et al., 2020). The design of microcontrollers enables all devices to function as a single system, thereby providing smart services. Microcontrollers consist of hardware and software components. The microcontroller receives sensor data for processing. Microcontroller units have the advantages of low power consumption, affordability, programming flexibility, and quick time to market (Oliveira et al., 2020). Microcontrollers, a type of small microcomputers on integrated circuits, are designed to perform control functions and roles in electronic systems. Microcontrollers integrate a central processing unit (CPU), memory, input, and output into a single chip (Ibrahim, 2019). Devices such as consumer electronics, industrial control systems, automotive, and medical devices, among others, widely use microcontrollers.

1.5.1 Arduino Microcontroller

The Arduino board offers significant advantages globally, serving as a programmable platform that facilitates versatile programming, configurable signal kinds, and seamless integration with existing systems (Kaswan et al.,

2020). The Arduino microcontroller is an open-source apparatus that can be readily programmed and modified at any moment. Arduino was initially launched in 2005. Ismailov & Jo'Rayev (2022) assert that the Arduino microcontroller may acquire information via its inputs and outputs, thereafter transmitting outputs based on the acquired data. The predominant microcontroller boards in Arduino are derived from the Atmel AVR family, including the Arduino Uno and Arduino Mega, while other microcontroller architectures are also represented. Figure 3 illustrates the diversity of Arduino components.

Fig. 3 *Arduino components (Ismailov & Jo'Rayev, 2022)*

Commonly utilised microcontrollers comprise Arduino, Raspberry Pi microcontroller boards, and 8-bit microcontrollers for sensor operation (Wu et al., 2020). Arduino boards can be utilised to upload new code using a USB wire. The Arduino IDE offers a streamlined integrated platform compatible with nearly all personal computers, enabling users to program Arduino using C or C++ programming languages (Ismailov & Jo`Rayev, 2022).

1.6 ESP8266 NodeMCU

The ESP8266 is a Wi-Fi module that functions as an Arduino processor. The ESP8266 Node MCU is a development module from the ESP-12 ESP8266 IoT (Internet of Things) platform family (Saidatin et al., 2020). The ESP8266 in version 1.0 is of the ESP-12E type, which is considered more stable than the ESP-12 (Hertanto et al., 2021). The ESP866's best feature is its onboard processing and storage, which it can integrate with sensors and IoT devices (Roy & Singh, 2019). ESP8266 also offers a complete Wi-Fi network solution that allows it to host applications containing all Wi-Fi network functions and other processing. Figure 4 shows the function of each pin of the ESP8266 NodeMCU component.
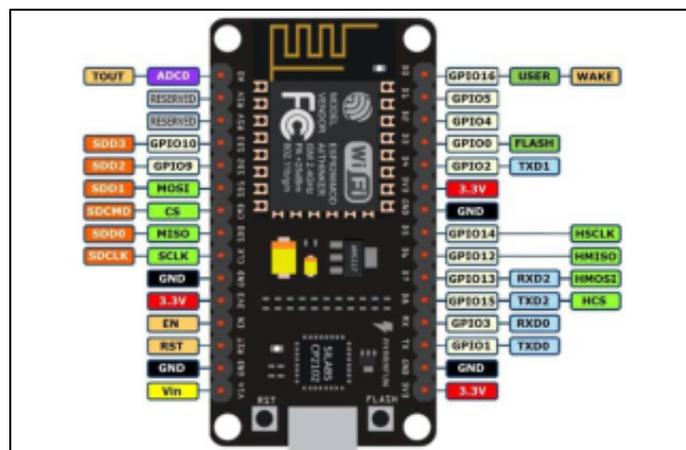

Fig. 4 *ESP8266 NodeMCU module (Sumber: Saidatin et al., 2020)*

Table 1 explains the specifications of the ESP8266 odeMCU, which involve operating voltage, output voltage, and component pin usage. This specification is important to ensure that the use of this component can be

optimized. Meanwhile, Figure 5 illustrates the working concept of the ESP8266 NodeMCU module, which consists of several stages of operation.

Table 1 *ESP8266 NodeMCU specifications (sumber: Afandi et al., 2021)*

Part	Explanation
Microcontroller	Tensilica 32-bit RISC CPU Xtensa LX106
Operation voltage	3.3V
Input voltage	7-12V
Pin I / O Digital (DIO):	16
Pin Input Analog (ADC)	1
UART	1
SPI	1
Flash memory	4 MB
Antenna	PCB
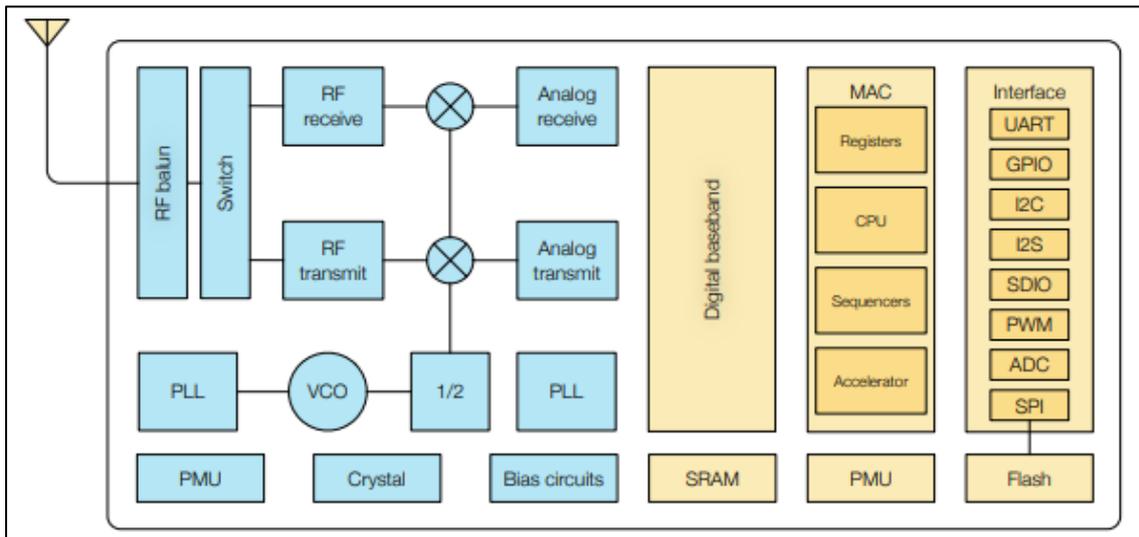
Fig. 5 *Block diagram of the ESP8266 NodeMCU module (Miah et al., 2019)*

1.7 Blynk Application

Blynk is an open and interoperable application programming platform for IoT that allows users to collect, store, analyze, visualize, and act on sensor and actuator data. Blynk can work with various types of Arduino, esp8266, NodeMCU, Raspberry Pi, Electric Imp, mobile applications, and websites. (Waginodkk, 2020). Blynk is also interpreted as a platform that uses iOS and Android applications to control Arduino, Raspberry Pi, and others using the Internet. Blynk is an easy-to-use digital dashboard system that can be used on most hardware. In 2014, Blynk pioneered a no-code approach to building IoT applications and gained global attention for mobile app editors. Figure 6 explains that the Blynk application is an application that can be controlled through a programming code uploaded via a microcontroller.
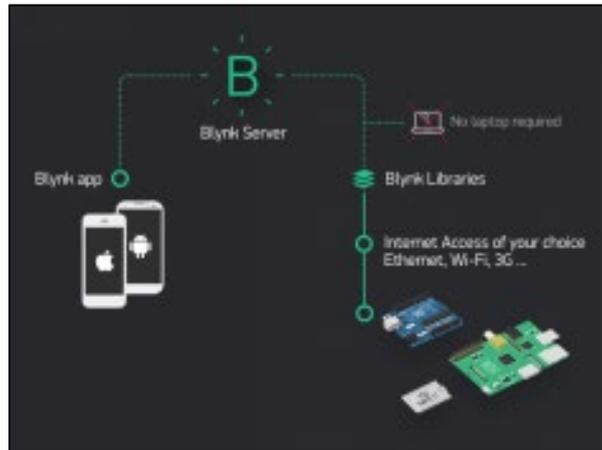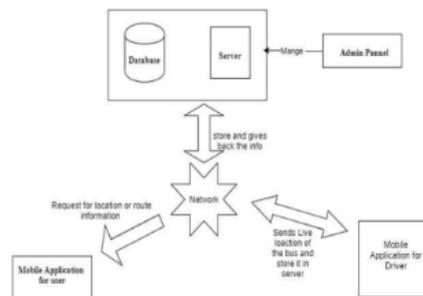
Fig. 6 *Blynk application process (www.blynk.cc, 2017)*

1.8 Comparison of GPS Technology in Vehicle Monitoring

Sources of information related to previous studies need to be taken into account and utilized in developing this project. Several past and existing studies and developments are undertaken to obtain additional information and improve the product to be developed. Table 2 Comparison of GPS technology in vehicle monitoring obtained through previous studies.

Table 2 *Comparison of GPS technology in vehicle monitoring*

| Study	Research Findings
Sonawane, A., Bhanushali, A., Gogri, K., & Khairnar, M. (2020). Real-time bus tracking system. *Int J Eng Res Technol (IJERT)*, *9*(06), 2278-0181.	The city experiencing congestion and a high population density using the bus service causes traffic jams, resulting in long waiting times. Therefore, this system is developed using GPS as the foundation and an Android application. It helps users check the bus location. Future improvements will involve developing a GPS and GSM monitoring system with a high-speed processor.
Gull, H., Aljohar, D., Alutaibi, R., Alqahtani, D., Alarfaj, M., & Alqahtani, R. (2021, June). Smart School Bus Tracking: Requirements and Design of an IoT-based School Bus Tracking System. In *2021 5th International Conference on Trends in Electronics and Informatics (ICOEI)* (pp. 388-394). IEEE.	The school bus is an easy option for parents to send their children to school. However, there are still parents who consider it unsafe. The emergence of computing and IoT technology solves this problem where the system will detect the bus location, which can also be updated by parents to monitor the bus's movement.

S. A. Saad, A. '. B. Hisham, M. H. I. Ishak, M. H. M. Fauzi, M. A. Baharudin and N. H. Idris, "Real-time on-campus public transportation monitoring system," 2018 IEEE 14th International Colloquium on Signal Processing & Its Applications (CSPA), Penang, Malaysia, 2018, pp. 215 - 220, doi: 10.1109/CSPA.2018.8368715

The role of the transportation information system in displaying estimated time of arrival (ETA) is very important for enhancing the level of user and passenger satisfaction, especially for university buses, as students commute from one place to another around the campus. This system consists of three categories: detection devices, web applications, and bus arrival time estimation.
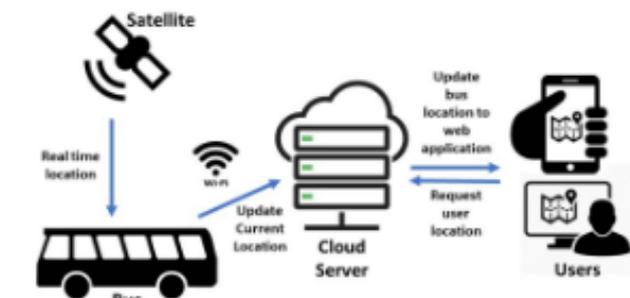
1.9 Conclusion

After conducting a thorough examination of the pertinent literature, it has been determined that a bus tracking system that is based on the Internet of Things (IoT) must incorporate a number of crucial components, including GPS, Wi-Fi, Microcontroller, and Cloud Storage technology, all of which are integrated into the network. There are a number of components that must be present in order to ensure that this system is able to carry out its functions to the fullest extent of their capabilities. Some of these components are Internet of Things devices, GPS modules, and the ESP8266 NodeMCU. By utilising satellite-guided global positioning system modules, it is possible to determine the locations of Internet base stations with an astonishing degree of precision. The Internet of Things (IoT) technology enables users to link commonplace devices to the internet, which enables them to conveniently access internet-based bus trip navigation and schedules. This technology also enables users to effortlessly access the internet. This technology makes campus bus transportation more efficient and convenient for university users. It helps students, instructors, and staff plan their travels with real-time tracking, reducing wait times and delays. Smartphones and computers make bus locations, arrival times, and schedules easier to access. This boosts university happiness and convenience. Improved Resource Allocation: IoT helps university officials manage bus routes and scheduling. Real-time data can optimise bus allocations, cut fuel costs, and improve route efficiency for sustainability. Safety and Security: The technology can monitor buses in real time, ensure they follow their routes, and speed up emergency response times. and Scalability and Future Potential: IoT-based bus tracking systems can be integrated with smart campus technologies like smart parking and ride-sharing platforms. Users can also boost demand prediction and congestion reduction with the data. In summary, an IoT-based University Bus Tracking System offers a sophisticated, dependable, and effective transportation solution, advantageous for both consumers and the institution through the utilisation of real-time data and automation.

Acknowledgement

Conflict of Interest

The authors declare no conflict of interest regarding the paper's publication.

Author Contribution

*The authors confirm contribution to the paper as follows: **study conception and design:** Ikhwan Hafiz Bahrum; **data collection:** Ikhwan Hafiz Bahrum; **analysis and interpretation of results:** Ikhwan Hafiz Bahrum; **draft manuscript preparation:** Ikhwan Hafiz Bahrum. All authors reviewed the results and approved the final version of the manuscript.*

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