Volume: 28, Issue: 1
Page: 31-40
2023

International Journal of Science and Business

Journal homepage: ijsab.com/ijsb

# Web-based Bus Tracking System in the Internet of Things IoT

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## Abstract

Public transportation has become integral to daily life, as individuals rely on it to commute between their homes, workplaces, and colleges. However, unnecessary waiting times during transport often result in time wastage. Students frequently find themselves in lines, longing to know the whereabouts of buses and their estimated arrival times at the bus stop. To address these issues, this study presents the development of a web-based system that highlights the routes taken by each bus during its journey. Integrated with Google Maps, the system enables students to conveniently access the routes and schedules of buses. The system provides users with information, including real-time updates on the bus's live location, displayed on the map interface. The system offers additional details about the bus driver, such as their names, phone numbers, bus numbers, and start and end times of their shifts. Users can access this information from anywhere, whether they are at home, work, or college, utilizing the web-based application and an internet connection. Also, a QR code scanning feature is available at bus stops, allowing people to quickly access the desired information. By implementing this system, users, particularly students, gain enhanced visibility into bus routes and schedules, enabling better planning and minimizing waiting times. The web-based platform offers convenience and accessibility, empowering users to make informed decisions about their journeys. The integration of live bus tracking, driver information, and QR code scanning improves the overall user experience and provides a comprehensive solution for public transportation users.

IJSB
Accepted 29 July 2023
Published 31 July 2023
DOI: 10.58970/IJSB.2203

ISSN: 2520-4750 (Online) 2521-3040 (Print)



**Keywords:** *Public transportation, web-based system, bus tracking, Google Maps integration, real-time information, QR code scanning.*

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### 1.1 Introduction

Public bus transportation systems have a direct effect on the economic growth of a province. Planning, tracking, and improving bus transport are some of the most important issues for the public transport industry (SL & Samsudeen, 2016). Public transport is widely used in many countries as a mode of transportation, especially by citizens, students, and workers who rely on well-planned and frequent public transport systems. All institutions and individuals need to track their vehicles (Nair et al., 2018). However, public transportation is a major concern and is increasingly significant in how people commute within their communities. It is an extremely economical means of transportation due to factors such as traffic congestion and road works. However, most buses experience delays during their journey, causing people to wait for extended periods at bus stations without knowing when the bus will arrive. Individuals who rely on public transport at home can determine the arrival time of a specific bus at a particular location and plan their departure accordingly (Kumbha & Salune, 2015). Nowadays, smartphones have become the primary communication tool and encompass a wide range of functions, including internet browsing, media playback, GPS location tracking, and more. With the increasing globalization of technology, certain vehicles are being equipped with built-in tracking systems designed for security purposes. Among these technologies, GPS stands out as a highly useful device capable of providing precise time and location information anywhere. The GPS relies on wireless data transmission through technologies like Wi-Fi and the Internet. The utilization of internet-based technology has gained popularity due to its cost-effectiveness, convenience, and reliability in data transmission and reception. Google Maps, has emerged as a widely used application that offers users accurate location and time information (Kamisan et al., 2017).

### 1.2 Research Gaps

College bus operations face various unpredictable factors that can impact their movement throughout the day. These factors include traffic congestion, unexpected delays, fluctuations in passenger demand, irregular vehicle dispatching times, and other incidents. As a result, many students and staff members frequently experience lateness in arriving at college, as they opt to wait for the bus instead of considering alternative transportation options (Patel et al., 2015). Therefore, the facilities arranged by transport systems for passengers are significant. Transport systems are required to offer two types of services (Eken & Sayar 2014):

1. Information regarding routes and schedules, including maps, timetables, and details about connections.
2. Fundamental information such as fare policies and station locations. This information is provided through various means: (a) Conventional methods of delivery involve printed maps, schedule cards, and "rider guides," which are typically distributed physically on buses and at important transit points. (b) Similar to other forms of information, the majority of distribution has shifted to the Internet. Nowadays, almost all transport systems offer service information on their websites, allowing users to access it electronically or print it at their convenience, be it at home or in their workplace. (c) intermediary distribution platform has become more prevalent in recent times.

### 1.3 Research Objectives

In this study, a web-based system is developed to highlight the paths taken by each bus during its journey. Students will have the ability to view the route and schedule of each bus, which is integrated with Google Maps. The system displays detailed information about bus drivers, including their names, phone numbers, bus numbers, current locations, and timetable showing the arrival times of each bus at every bus station. Users can access this information from anywhere, whether they are at home, work, or college, using the web-based application and an

internet connection. Furthermore, people can also scan a QR code at the bus stop to access the information.

### 2.1 Literature Review

Over the years, extensive investigations have been carried out on the Vehicle Tracking Information System and its diverse range of applications. Numerous methodologies have been employed to accomplish the primary objective of delivering comfortable travel experiences. The majority of research in this domain is centered around utilizing GPS technology to track vehicles. Moreover, successful deployments of systems incorporating General Packet Radio Service (GPRS) have been accomplished (SL & Samsudeen, 2016). Guo et al. (2012) proposed a design for integrating the Victoria Regional Transit System with appropriate communication technologies and to develop a corresponding Smartphone app. This smart bus system enables users to access real-time passenger information, including schedules, trip planners, bus capacity estimates, bike rack availability, and bus stop locations. Users can conveniently access this information through their Smartphones, computers, and bus stops, enhancing the overall travel experience and facilitating informed decision-making (Eken & Sayar, 2014).

Chi-Wah (2013) developed a simple bus-tracking system that proved to be effective in enhancing transportation efficiency. an application called the "Real Time Web-Based Bus Tracking System" which aims to decrease the waiting time of bus users who are located remotely. This system enables the tracking of buses at any given location and time. The system stores all current bus information on a server and provides access to remote users through a web-based application (Sonawane et al., 2020). The tracking system can provide real-time information about the location and route taken by a vehicle, which can be accessed from any remote location. Additionally, the system includes a web application that allows users to obtain the precise location of a target. It is designed to function effectively regardless of weather conditions, enabling continuous tracking. Kannaki et al. (2014) proposed a bus monitoring system based on GNSS technology. The primary goal of this system is to minimize the waiting time of passengers at bus stops by sending them information about the bus locations via SMS. They developed a GNSS-based web application that displays the real-time location of buses on Google Maps, including their speed (Kumbhar et al., 2016).

The system "A Smart Bus Tracking System based on location-aware service and QR code" was implemented by (Eken & Sayar 2014). In their research, they developed a bus tracking system where passengers with smartphones could scan QR codes placed at bus stops to access information such as estimated bus arrival times and the current location of the bus. However, one limitation of this project was that the user had to be physically present at the bus stop to scan the QR code (Sonawane et al., 2020).

The train timetable site of National Rail Enquiries displays all trains that are currently approaching a specific station. Trains and stations are presented using distinct colors. The trains' movements are nearly in real-time or even faster if users activate the speed-up option (Eken & Sayar, 2014). The authors suggested a system for monitoring buses and providing real-time information to passengers. This system allows users to track the current location of buses and provides estimated arrival times at various stops along their routes. To determine the bus position and current route, a link updater is utilized. The control unit updates the estimated arrival time and shares this information with passengers through display boards located at bus stops (Kumbha & Salune, 2015).

### 3.1 System Architecture

The proposed system is composed of four stages, depicted in Figure 1. These stages include:
1. User access: Users can access the system either by visiting the website online or by scanning QR codes located at bus stops. This allows users to list buses based on their preferences.
2. Bus search and timetable display: The system enables users to search for available buses and view their corresponding timetables.
3. Bus route highlighting: The system highlights the paths that buses traverse on Google Maps, providing a visual representation of their routes.
4. Bus driver information: The system displays information about bus drivers, including their phone numbers, bus numbers, names, and the time each bus takes to reach each bus stop during the journey.
Finally, the system displays the best route and sends it to interested passengers, ensuring they have access to the most suitable route for their journey.

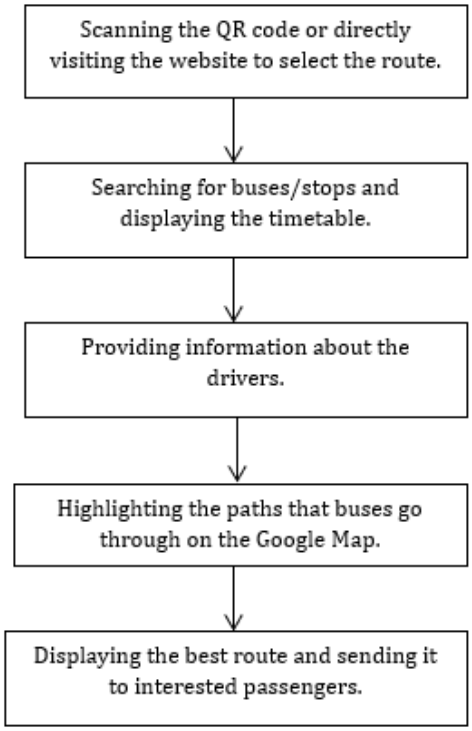


Figure 1. System Architecture of Bus Tracking System

### 3.2 Internet of Things IoT

In the past few decades, there has been a continuous evolution of the Internet. Initially, the Internet mainly consisted of the World Wide Web, which comprised interconnected HTML documents built on top of the Internet architecture (Whitmore et al., 2015). The Internet of Things (IoT) facilitates the integration of various sensors and objects that can communicate with each other without human involvement. The IoT encompasses physical devices, including sensor devices, which monitor and collect diverse data on machines and human social activities (Yan et al., 2014). The emergence of the IoT has brought about a continuous and universal connection among individuals, objects, sensors, and services. The primary goal of the IoT is to establish a network infrastructure equipped with compatible communication protocols and software, enabling the connection and integration of physical/virtual sensors, personal computers (PCs), smart devices, automobiles, and household items like refrigerators, dishwashers, microwave ovens, food, and medications, regardless of time and network

availability. The advancement of smartphone technology allows numerous objects to be incorporated into the IoT through various smartphone sensors. However, the increasing demands for the widespread implementation of the IoT also raise significant security concerns (Alaba et al., 2017).

### 3.3 Medium of Deployment

The Internet of Things (IoT) encompasses a diverse range of devices and technologies, leading to various mediums of deployment. there are three common mediums used in the deployment of IoT systems (Suresh et al., 2014):

1. The IEEE 802.11 standard, commonly referred to as "Wi-Fi," is a globally recognized wireless technology that enables the transmission and reception of data, signals, commands, and various other types of information. The simplicity and cost-effectiveness of installing and maintaining Wi-Fi devices have contributed to their widespread adoption. Nowadays, Wi-Fi networks are commonly found in public spaces, educational institutions, healthcare facilities, and more. This widespread availability of Wi-Fi networks presents a significant advantage for the Internet of Things (IoT), which relies on extensive network coverage. The existing scope of Wi-Fi networks in various locations provides benefits for IoT deployments that require ubiquitous connectivity (Suresh et al., 2014).
2. ZigBee IEEE 802.15.4: One notable advantage of ZigBee compared to Bluetooth and Wi-Fi is its lower cost, making it more feasible for deployment in IoT applications. Various industries such as industrial automation, healthcare, telecommunications, and retail outlets are experiencing significant growth in the adoption of ZigBee technology (Ahamed, 2009).
3. Bluetooth: Bluetooth's ability to provide seamless interconnectivity has become increasingly important in the IoT domain. Originally designed for device-to-device communication and connecting devices such as PCs, cars, smartphones, and tablets, Bluetooth has facilitated a significant increase in the number of interconnected devices in the modern world. Many researchers predict that Bluetooth will play a crucial role in the trillion-dollar IoT market in the future (Chadha, Singh, & Pardeshi, 2013).

### 3.4 Smart Environment

In today's automated society, a smart environment is highly desirable. It involves integrating computers, smartphones, and the internet into our everyday activities. The Internet of Things (IoT) enables the creation of a smart environment by connecting various devices and systems. While the term "Smart City" typically refers to urban development and infrastructure, in the context of IoT, it signifies the automation of an entire city through internet connectivity (Suresh et al., 2014). This includes controlling traffic signals, monitoring pollution levels, and implementing various applications (Kotsev et al., 2016). Sensors play a critical role in IoT deployment within a smart city, supporting automation systems that form the backbone of its economy. Examples include tracking vehicle parking, monitoring building vibrations, managing traffic, disaster recovery, waste management, and supply chain management (Suresh et al., 2014). A smart city encompasses numerous automation systems that improve efficiency and quality of life for its residents (Alaba et al., 2017).

### 3.5 Methodology

The implementation of a web-based bus tracking system in the Internet of Things (IoT) brings several benefits to the public transportation industry. By leveraging technologies such as Google Maps and real-time location sharing, the system enhances the tracking and monitoring of bus transport. Here are the key points:

1. Customized Bus Route Visualization: The system utilizes Google Maps to highlight bus routes, allowing users to easily trace the path of each bus that operates within Erbil City. The map

differentiates between various bus lines, ensuring that users can focus on the specific routes they are interested in. This customization enhances user experience and provides a clear visual representation of bus routes.
2. Real-Time Bus Location and Estimation: The web-based program provides users with the live location of buses. By leveraging Google's live sharing location feature, bus drivers can share their precise location in real-time. Users accessing the web-based program can view the exact location of buses on the map. Additionally, the system estimates the time taken by the bus to reach its destination, providing users with real-time information to plan their journeys effectively.
3. Web-Based Program Development: The web-based program is developed using JavaScript, a popular programming language for web development. JavaScript enables the creation of an interactive and user-friendly interface. Users can access the program via the internet and view the routes of each bus. The program also displays information about bus drivers, such as their phone numbers, and bus numbers and it provides the duration of the beginning and endpoint.
4. Barcode e QR Code: A barcode is a graphical symbol that is attached to objects and can be scanned by a barcode scanner. Barcodes have been in use since the early 1970s and are now widely used for object recognition in various industries. They gained global popularity with the implementation of automated checkout systems in retail stores. Barcodes can be easily implemented and provide a straightforward method for identifying and tracking objects.

## 4. Results and Discussion

In this study, we implemented a bus tracking system using web development techniques, with Google Maps integration to highlight paths taken by each bus and enable live sharing of bus locations. The system aimed to enhance public transportation services by providing real-time information to users and improving overall efficiency and convenience. However, the system highlights the paths that each bus takes, facilitating the user in determining which buses they should use to reach their destination. Our implementation followed a multi-layered architecture, consisting of a backend system, frontend interface, database management, and integration with the custom Google Maps. These components worked together to create a comprehensive bus tracking system. Figure 2. displays the overall system diagram.

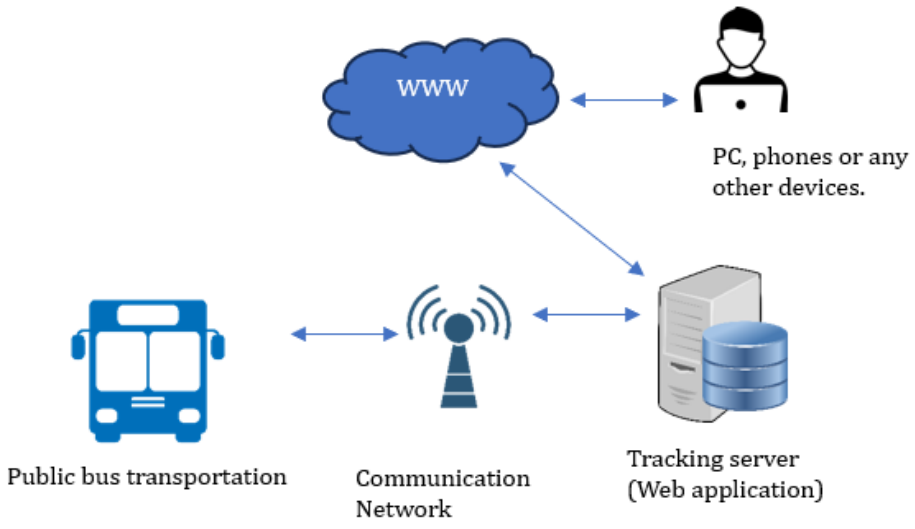


Figure 2. The Over All System Diagram

1. Backend Development

The backend system is responsible for storing and managing bus-related data, including routes, schedules, and live location updates. Java programming languages and frameworks are used. Web-based interfaces were designed to facilitate communication between the frontend and backend systems.

2. Frontend Development

The Frontend interface is designed to provide a user-friendly experience for bus tracking. We utilized HTML and CSS to build interactive components that allowed users to search for buses, select routes, and track bus locations in real time. Google Maps is seamlessly integrated to display the map interface and visualize the bus routes. As shown in Table 1, and Table 2.

**Table 1. Bus Schedule For Gulan str. In Erbil City.**

| Bus No. | Bus Stop 1 | Bus Stop 2 | Bus Stop 3 | Bus Stop 4 | Bus Stop 5 | Bus Stop 6 | Bus Stop 7 |
|---|---|---|---|---|---|---|---|
| Bus 1 | 7:00 | 7:02 | 7:04 | 7:06 | 7:08 | 7:10 | 7:12 |
| Bus 2 | 7:12 | 7:14 | 7:16 | 7:18 | 7:20 | 7:22 | 7:24 |
| Bus 3 | 7:24 | 7:26 | 7:28 | 7:30 | 7:32 | 7:34 | 7:36 |
| Bus 4 | 7:36 | 7:38 | 7:40 | 7:42 | 7:44 | 7:46 | 7:48 |
| Bus 5 | 7:48 | 7:50 | 7:52 | 7:54 | 7:56 | 7:58 | 8:00 |
| Bus 6 | 8:00 | 8:02 | 8:04 | 8:06 | 8:08 | 8:10 | 8:12 |
| Each trip for each bus takes 12 minutes to complete its journey. | | | | | | | |

**Table 2. Information about Bus Driver**

| Driver Name | Phone Number | Bus Number |
|---|---|---|
| Ahmad | 075077701011 | 22-B 1111 |
| Ali | 075077702022 | 22-B 1112 |
| Taha | 075077703033 | 22-B-1113 |
| Sami | 075077704044 | 22-B-1114 |
| Muhammed | 075077705055 | 22-B-1115 |
| Barwar | 075077706066 | 22-B-1116 |

4. Integration with Google Maps

The integration of Google Maps played an essential role in our system. This allows the user to highlight the paths taken by each bus, using polylines on the map. Users could visualize the routes and understand the bus path. The bus markers on the map were dynamically updated with live location data, ensuring that users could track the buses in real time. Figure 3 shows the routes highlighted in blue, which represent the path taken by the 40-meter bus during its round.

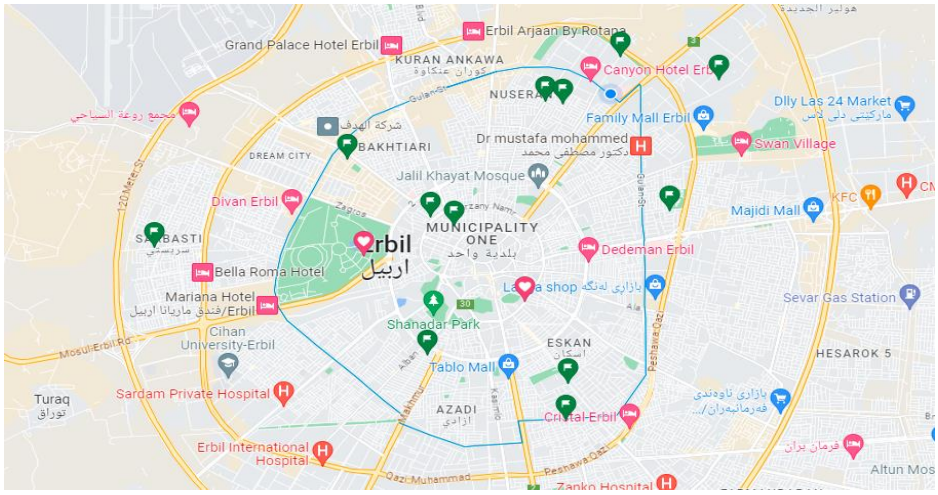


Figure 3. Highlight the Paths that Buses Go Through During Their Trip.

## 5. Conclusion

In conclusion, this study successfully developed an extensive web-based system that enhances the bus tracking experience for users. By highlighting the paths taken by each bus during its journey in Erbil city which is integrated with Google Maps, students have convenient access to route and schedule information. In comparison to previous studies, the current study's contributions lie in its comprehensive and user-friendly approach to bus tracking. While some past studies may have explored basic tracking features, the web-based system developed in this study offers a more extensive and integrated solution. By combining bus tracking data with Google Maps, the system provides users with an effortless experience, allowing them to visualize the paths taken by each bus. This integration with a widely used mapping service enhances the accessibility and flexibility of the system for users. The system provides real-time updates on the live location of the bus, ensuring users stay informed throughout their journey. The system goes beyond basic tracking features by giving additional information about bus drivers, including their names, phone numbers, bus numbers, and start and end times. Users can access all relevant information from any location with an internet connection, whether they are at home, work, or college. This empowers users with the convenience of planning their journeys effectively and staying informed about bus statuses and schedules. Overall, this study demonstrates the value of implementing a web-based bus tracking system that integrates with Google Maps. The system provides users with a comprehensive and user-friendly interface, ensuring they have all the necessary information. By improving route visibility, real-time tracking, and access to driver details, this system enhances the overall bus travel experience for students and other users. Future enhancements and expansions can be explored to further optimize the system's functionality and address the changing requirements of public transportation users.

## Future Work

Expanding on future work, the web-based bus tracking system will include:

1. user accounts to provide passengers with personalized profiles. These accounts will allow users to input and update their personal information, including names, contact details, and preferred destinations. To further enhance the user experience and safety, the system will integrate location-sharing functionality for users who opt to share their real-time location during their journeys.
2. Passengers will have the option to link their preferred payment methods, such as credit cards, mobile wallets, or digital payment platforms, to their user accounts. This will facilitate seamless and secure payment for bus fares directly through the system, eliminating the need for physical cash transactions and enhancing the overall user experience.
3. The implementation of user accounts and personal data collection, data security, and privacy measures will be a key focus for future work. The system will explore integration opportunities with broader smart city initiatives. By collaborating with other smart city components, such as smart traffic management systems and intelligent infrastructure, the system can optimize transportation operations, reduce congestion, and enhance overall urban mobility.

## Acknowledgment

*I would like to begin by expressing my deepest gratitude to the Almighty God for His blessings, guidance, and unwavering presence throughout the journey of writing this article. His divine grace has been the foundation of my strength, inspiration, and perseverance. I am immensely grateful to my supervisor, Mohammed Nasseh, for their exceptional guidance, support, and expertise. Their invaluable mentorship and insightful feedback have shaped this article into its final form. I extend my heartfelt appreciation to Lebanese French University for providing me with the platform and resources to pursue my research and education. I am grateful for the*

*opportunities and experiences that Lebanese French University has provided me. To my beloved family, I express my deepest gratitude for their unwavering love, encouragement, and understanding. I would also like to extend my thanks to the journal International Journal of Science and Business IJSAB for recognizing the significance and quality of this research and publishing it. Furthermore, I want to acknowledge the contributions of all the individuals, colleagues, and friends who have provided support, constructive discussions, and feedback throughout the course of this research. Their insights and collaboration have enriched the content and strengthened the overall impact of this article. In conclusion, I am profoundly grateful to God, my supervisor, my university, my family, and the journal [Journal Name] for their unwavering support, guidance, and belief in me. Their contributions have been instrumental in the completion of this article, and I am honored to have had the opportunity to work with such exceptional individuals and institutions. Thank you all from the bottom of my heart.*

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**Cite this article:**

**Zina Balani & Mohammed Nasseh Mohammed** (2023). Web-based Bus Tracking System in the Internet of Things IoT. *International Journal of Science and Business,* 28(1), 31-40. doi: https://doi.org/10.58970/IJSB.2203

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