International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Developing a Vehicle Monitoring and Tracking System using the Internet of Things (IoT)

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Submitted: 03/02/2024 **Revised**: 11/03/2024 **Accepted**: 17/03/2024

Abstract— Public transportation plays a vital role in daily life, serving as a key mode of transportation for individuals traveling between their homes, workplaces, and educational institutions. However, the inconvenience of extended waiting times for transportation often leads to time wastage. Many students frequently experience prolonged waiting periods at bus stops, eager to know the real-time location of buses and their estimated arrival times. To address these challenges, this research introduces the creation of an online system designed to visualize the routes taken by each bus during its journey. Integrated with Google Maps, this system enables students to easily access bus routes and schedules. The platform provides comprehensive details, including up-to-date information on the live location of buses displayed on the map interface. Additionally, the system furnishes supplementary information about bus drivers, encompassing their names, contact numbers, bus identifications, and the start and end times of their shifts. Users have the flexibility to access this data from any location, whether it's from their residence, workplace, or educational institution, using the web-based application and an internet connection. Moreover, a QR code scanning feature is available at bus stops, facilitating swift access to the desired information. By implementing this system, users, especially students, benefit from improved visibility into bus routes and schedules, enabling effective planning and minimizing wait times. The online platform delivers convenience and easy access, empowering users to make well-informed decisions regarding their journeys. The integration of real-time bus tracking, driver details, and QR code scanning significantly enhances the overall user experience, presenting a comprehensive solution for public transportation users.

Keywords— (bus tracking, Google Maps, Live Location, IoT, Smart environment, monitoring)

I. INTRODUCTION

The economic progress of a region is significantly impacted by the presence of efficient public bus transportation systems. A critical focus within the public transport sector is on proper planning, monitoring, and enhancement of bus services [1]. Public transportation is extensively utilized across many nations, particularly by citizens, students, and professionals, emphasizing the need for well-organized and frequent public transit networks. Effective vehicle tracking is essential for both organizations and individuals [2]. Public transit remains a major concern and continues to play a vital role in the daily commute of community members. Given challenges like traffic congestion and road construction, it remains an exceptionally cost-effective mode of transport. However, delays in bus schedules are commonplace, leading to prolonged waits at stations without clear arrival information. Those dependent on public transport can now ascertain the expected bus arrival times and plan their journeys accordingly, especially from the comfort of their homes [3]. In the modern era, smartphones have become ubiquitous, offering diverse functionalities such as internet browsing, media playback, and GPS location tracking. As technology advances globally, certain vehicles are being equipped with integrated tracking systems primarily for security purposes. Notably, GPS technology stands out for its ability to provide precise time and location details from anywhere. GPS relies on wireless data transmission through technologies like Wi-Fi and the Internet. The integration of web-based technologies is gaining traction due to its cost-efficiency, ease of use, and reliable data transmission and reception. An example of this is the widely adopted Google Maps application, providing users with accurate location and timing details [4].

Throughout the day, college bus services encounter numerous unforeseeable elements that can influence their operations. These elements encompass traffic congestion, unanticipated delays, fluctuating passenger demand, inconsistent vehicle dispatch times, and other occurrences. Consequently, many students and faculty members frequently face delays in reaching college, as they choose to wait for the bus rather than exploring alternative transportation choices [5]. Therefore, the amenities provided by transportation systems to passengers hold significant importance. Transport systems are obligated to deliver two kinds of services [6]:

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Providing information about routes and schedules, inclusive of maps, timetables, and particulars about connections.

Furnishing essential details like fare regulations and station positions. This data is disseminated through different means: (a) Traditional delivery methods involve printed maps, schedule cards, and "rider guides," usually distributed physically on buses and at major transit points. (b) Analogous to other forms of information, the majority of distribution has transitioned to the Internet. Presently, almost all transport systems present service information on their websites, enabling users to access it electronically or print it at their convenience, whether at home or at their workplace. (c) Intermediate distribution platforms have gained prevalence in recent times.

In this research, an online system is designed to showcase the routes followed by each bus during its trip. Students will be able to observe the route and timetable of every bus, seamlessly integrated with Google Maps. The system exhibits comprehensive details about bus operators, encompassing their names, contact numbers, bus IDs, present location, and schedules indicating bus arrival times at each bus station. Users can avail of this data from any location, whether they are at home, work, or college, through the online application and an active internet connection. Moreover, individuals can swiftly access the information by scanning a QR code at the bus stop.

II. LITERATURE REVIEW

Over time, thorough research has been conducted concerning the Vehicle Tracking Information System and its extensive array of applications. Various methodologies have been utilized to achieve the primary goal of enhancing travel convenience. The majority of research in this field revolves around the use of GPS technology for vehicle tracking. Additionally, effective implementations of systems integrating General Packet Radio Service (GPRS) have been achieved [1].

During 2012 authors presented a blueprint for integrating the Victoria Regional Transit System with suitable communication technologies and creating a corresponding smartphone application[7]. This intelligent bus system allows users to access real-time passenger data, encompassing schedules, trip planners, bus capacity estimates, bike rack availability, and bus stop locations. Users can easily access this data through their smartphones, computers, and bus stops, enriching the overall travel experience and facilitating well-informed decision-making [6].

In 2013 authors implemented a straightforward bus-tracking system that proved to be effective in optimizing transportation efficiency. They developed an application named the "Real Time Web-Based Bus Tracking System," aiming to reduce the wait time of bus users in remote locations[8]. This system permits the tracking of buses at any given location and time. All current bus data is stored on a server and made accessible to remote users via a web-based application [9]. The tracking system possesses the capacity to furnish real-time data about a vehicle's location and route, accessible from any remote place. Additionally, the system includes a web application that enables users to obtain precise target locations. It is designed to operate effectively in diverse weather conditions, ensuring continuous tracking.

In 2014 authors proposed a bus monitoring system based on GNSS technology [10]. The primary objective of this system is to minimize passenger wait times at bus stops by sending them bus location information via SMS. They designed a GNSS-based web application displaying real-time bus locations on Google Maps, along with their speed [11].

A system called "A Smart Bus Tracking System based on location-aware service and QR code" was established by [6]. In their research, they conceived a bus tracking system, allowing smartphone-equipped passengers to scan QR codes at bus stops to access data like estimated bus arrival times and the bus's present location. However, a limitation of this project was the necessity for users to be physically present at the bus stop to scan the QR code [9].

The National Rail Enquiries train timetable portal exhibits all trains approaching a specific station. Trains and stations are depicted using distinct colors. The trains' movements are almost real-time or even faster if users activate the speed-up option [6].

The authors recommended a system for bus monitoring and real-time information dissemination to passengers. This system enables users to track buses' present locations and provides estimated arrival times at various stops along their routes. To ascertain the bus's position and current route, a link updater is employed. The control unit updates the estimated arrival time and communicates this information to passengers via display boards at bus stops [3]

III. SYSTEM ARCHITECTURE FOR BUS TRACKING SYSTEM

A. The proposed framework consists of four stages, as illustrated in Figure (1). These stages are outlined below:

1. User Accessibility: Users can enter the system by either accessing the website online or scanning QR codes positioned at bus stops, enabling them to compile a list of preferred buses.
2. Bus Search and Timetable Presentation: The system empowers users to explore available buses and observe their respective schedules.
3. Bus Route Accentuation: The system emphasizes the routes taken by buses on Google Maps,

providing a graphical representation of their journeys.

4. Bus Operator Details: The system exhibits specifics about bus operators, encompassing their contact numbers, bus IDs, names, and the time each bus takes to reach every bus stop during the journey.

In conclusion, the system showcases the most optimal route and forwards it to interested passengers, ensuring they possess the most fitting route information for their travel.

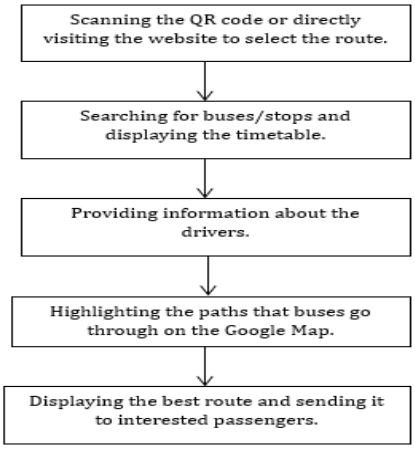

Figure (1): Architectural Overview of the Bus Tracking System

B. Internet of Things IoT

In recent decades, the Internet has undergone continuous transformation. Initially, it primarily constituted the World Wide Web, consisting of interconnected HTML documents integrated into the Internet architecture [12]. The Internet of Things (IoT) facilitates the integration of diverse sensors and objects for autonomous communication. IoT includes physical devices, such as sensors, that monitor and collect a wide array of data related to machinery and human social interactions [13]. The rise of IoT has established persistent and global connectivity between people, objects, sensors, and services. The central objective of IoT is to create a network infrastructure equipped with compatible communication protocols and software, fostering the linkage and integration of physical/virtual sensors, personal computers (PCs), smart gadgets, vehicles, and household appliances like refrigerators, dishwashers, microwaves, food, and medicines, regardless of time and network availability. The progression of smartphone technology has enabled the integration of numerous objects into IoT through various smartphone sensors. However, the growing push for widespread IoT implementation also brings forth notable security apprehensions [14].

C. Methodology

Introducing a web-based system for tracking buses within the Internet of Things (IoT) offers numerous advantages to the public transportation sector. By making use of technologies like Google Maps and real-time location sharing, this system greatly enhances the monitoring and tracking of bus transportation. Here's a summary of the main features:

1. Personalized Visualization of Bus Routes: The system employs Google Maps to showcase bus routes, enabling users to effortlessly trace the path of each bus operating in Erbil city. The map effectively distinguishes between different bus lines, enabling users to focus on their preferred routes. This tailored approach enhances user satisfaction and provides a clear graphical representation of bus routes.

2. Real-Time Bus Location and Time Estimations: The online platform furnishes users with live updates on bus locations. Utilizing Google's live location sharing, bus drivers can accurately share their real-time whereabouts. Users accessing the online platform can easily track buses on the map. Moreover, the system calculates the anticipated time for a bus to reach its destination, giving users real-time data to plan their trips effectively.

3. Development of the Online Platform: The web-based application is created using JavaScript, a widely utilized programming language for web development. JavaScript facilitates the development of an interactive and user-centric interface. Users can conveniently access the application online to view bus routes. Additionally, the application provides information about bus drivers, including their contact details, bus IDs, and journey durations.

4. Use of Barcodes and QR Codes: Barcodes are graphical symbols affixed to objects that can be scanned using a barcode scanner. Barcodes have been in existence since the early 1970s and are now extensively employed for object recognition across diverse industries. They gained widespread adoption with the introduction of automated checkout systems in retail outlets. Barcodes are easily implementable and offer a simple method for identifying and tracking objects.

D. Smart Environment

In our modern automated society, there is a strong emphasis on creating intelligent environments. This involves seamlessly integrating computers, smartphones, and the internet into our day-to-day activities. The Internet of Things (IoT) facilitates the realization of such smart environments by interconnecting various devices and systems. Although "Smart City" typically pertains to urban development and infrastructure, within the IoT context, it represents the comprehensive automation of an entire city through internet

connectivity [15]. This entails the management of traffic signals, monitoring pollution levels, and the implementation of diverse applications [16]. Sensors play a pivotal role in deploying IoT within a smart city, underpinning the automation systems that serve as the city's economic backbone. These systems encompass a range of functions such as vehicle parking tracking, building vibration monitoring, traffic management, disaster recovery, waste management, and supply chain oversight [15]. A smart city comprises a multitude of automation systems that significantly enhance efficiency and the overall quality of life for its inhabitants [14].

IV. Result and Discussion

In this research, we employed web development methodologies to create a bus tracking system, incorporating Google Maps integration to showcase the routes taken by each bus and enable real-time sharing of bus positions. The primary objective of the system was to enhance public transportation services by delivering instantaneous information to users, thereby improving overall efficiency and convenience. Furthermore, the system highlights the routes taken by individual buses, aiding users in choosing the appropriate buses to reach their desired destinations.

Our implementation followed a layered architecture, encompassing a backend system, a frontend interface, database management, and integration with customized Google Maps. These elements collaboratively established a comprehensive bus tracking system.

A. Development of the Backend

The backend system is accountable for storing and managing bus-related data, including routes, schedules, and live location updates. Java programming language and its associated frameworks were utilized for this purpose. A web-based interface was devised to streamline communication between the frontend and backend systems.

B. Development of the Frontend

The frontend interface was crafted to provide an intuitive user experience for bus tracking. HTML and CSS were employed to construct interactive components, enabling users to search for buses, select routes, and track bus locations in real-time. The integration of Google Maps seamlessly presented the map interface and allowed for the visualization of bus routes. The details are depicted in Table 1 and Table 2 below.

Table 1: Bus Timetable for Gulan Street in Erbil City.

Stations	S1	S2	S3	S4	S5	S6	S7
No.1	4:00	4:02	4:04	4:06	4:08	4:10	4:12
No. 2	4:12	4:14	4:16	4:18	4:20	4:22	4:24
No. 3	4:24	4:26	4:28	4:30	4:32	4:34	4:36
No. 4	4:36	4:38	4:40	4:42	4:44	4:46	4:48
No. 5	4:48	4:50	4:52	4:54	4:56	4:58	5:00
No. 6	5:00	5:02	5:04	5:06	5:08	5:10	5:12
The duration for each trip taken by every bus is 12 minutes to complete the journey.							

Table 1: Details Regarding Bus Driver

Name	Contact	Bus Identification
Murat	06603339999	44-A 9090
Kenan	06603338888	44-A 9191
Mustafa	06603337777	44-A-9092
Vedat	06603336666	44-A-9391
Karem	06603335555	44-A-9292
Tahir	06609993967	44-A-9595

C. Incorporating Google Maps Integration

Google Maps integration was a fundamental component of our system. It empowered users to emphasize the routes taken by each bus by employing polylines on the map. This functionality enabled users to have a visual representation of the routes and gain insights into the bus paths. Additionally, the markers of the buses on the map were constantly refreshed with real-time location data, providing users with the ability to track the buses in real-time. Figure 3 illustrates the highlighted routes in blue, denoting the path taken by the 40-meter bus during its full circuit.

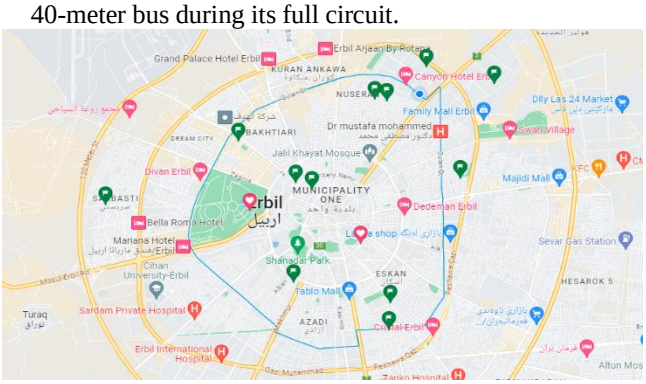

Figure (3): Highlighted Bus Routes During their Journey

V. Conclusion

In summary, this study has successfully created an expansive web-based system, significantly elevating the bus tracking experience for users in Erbil City. Through the integration with Google Maps and the highlighting of each bus's route during its journey, students now have effortless access to crucial route and schedule details. This study's distinctive contributions are rooted in its comprehensive and user-centric approach to bus tracking. While prior studies may have focused on rudimentary tracking features, our web-based system offers a more integrated and extensive solution. The amalgamation of bus tracking data with Google Maps provides users with an intuitive experience, enabling them to visualize the paths taken by each bus. This

integration with a widely adopted mapping service amplifies the system's accessibility and adaptability for users. Real-time updates on the bus's live location ensure users are well-informed throughout their travel. Beyond basic tracking, the system furnishes additional information about bus drivers, including their names, phone numbers, bus IDs, and shift timings. Users can effortlessly access all pertinent information from any location with an internet connection, be it at home, work, or college. This grants users the convenience of efficient journey planning and staying updated on bus statuses and schedules. Overall, this study underscores the significance of implementing a web-based bus tracking system seamlessly integrated with Google Maps. The system offers a user-friendly interface, ensuring users have comprehensive and essential information at their fingertips. By enhancing route visibility, real-time tracking, and access to driver details, this system enriches the overall bus travel experience for students and other users. Future endeavors should explore enhancements and expansions to optimize the system's functionality and cater to the evolving needs of public transportation users.

VI. ACKNOWLEDGEMENT

I extend my sincere gratitude to God for providing the strength and wisdom during my academic journey. A special thanks to my parents for their unwavering support and belief in me. I am also appreciative of my mentors, educators, and colleagues who have contributed to my growth. Additionally, I acknowledge the reviewers and editors for enhancing the quality of my published article.

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