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Real-Time Bus Route and Timing Information System using IoT

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Abstract

This system suggests a user-friendly online interface for accessing real-time routes and schedules of the bus. The system provides the most recent information about bus locations, routes, and anticipated arrival times by utilizing the Internet of Things (IoT) and Global Positioning System (GPS) capabilities. The technology continuously collects position data by installing GPS modules on buses and linking them to an IoT network. After that, the data is sent to a central server for processing and display. The web interface serves as the main point of contact for users, it displays the positions of buses in real-time on a map along with integrated route data. By seeing the real-time position and expected arrival time of approaching buses, passengers may easily plan their journeys by accessing the webpage from any device with an internet connection. In addition to reducing wait times, enhancing customer satisfaction levels, and facilitating better travel arrangements, this gives transportation authorities useful information for optimizing bus routes and schedules.

Keywords: Internet of Things, Global Positioning System, ESP32, Android Studio.

1. Introduction

An essential component of the urban infrastructure, public transportation provides a lifeline for commuters everywhere. Buses are among the most reliable options due to their wide coverage and reasonable prices. However, the enduring problem of unpredictable bus arrival times still frustrates users and hinders the effectiveness of public transportation networks. This

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unpredictability not only disrupts daily schedules but also diminishes the excitement of riders. It is now essential to address this issue, which has increased research and development in the field of precise bus arrival time forecasting. Because of their limitations, traditional scheduling-only solutions must evolve into more sophisticated prediction systems. These systems represent a paradigm shift in bus timing prediction by utilizing a wide range of data sources, including weather data integration, historical data analysis, real-time traffic information, and GPS integration. Through dynamic adaptation to real-world elements, including weather, traffic congestion, passenger load variations, and inefficient signal timing, these systems improve the predictability of public transportation by offering a more accurate and nuanced depiction of bus arrival times.

Implementing a robust real-time bus information system that combines Internet of Things (IoT) and Global Positioning System (GPS) technology is essential for achieving accurate bus arrival predictions. The system comprises three main components: a web interface, a central server, and an on-board bus unit. The On-Board Bus Unit, equipped with a microprocessor, GPS module, and communication module, serves as the central hub for data collection and transmission. It continuously gathers and transmits bus location data in real-time. The Central Server, functioning as the hub, aggregates, processes, and distributes data streams from every bus to provide a comprehensive and up-to-date overview of the bus network

The Web Interface provides an easy-to-use platform for accessing real-time bus information, including interactive maps, bus stop details, route information, and potential delays. This platform serves as the primary point of contact for passengers. The real-time bus information system enhances passenger experience by facilitating effective route planning. Additionally, it provides transportation authorities with valuable insights to optimize operational efficiency and improve public transportation management. The seamless integration of these components enables the system to achieve these goals.

1.1 Objective

To provide accurate and timely information, the system offers real-time locations of buses, enabling passengers to track its accurate arrival times. Real-time estimates of bus arrival times at various stops are delivered, thereby minimizing waiting times. Complete route maps and schedules are supplied to assist passengers in planning their journeys efficiently. The

system allows users to search for routes, stops, and bus numbers and enables the saving of frequently used information for quick access. Furthermore, the system tracks and analyzes bus performance to identify and address delays or disruptions. Utilizing real-time data, the system adjusts and optimizes bus routes and schedules based on actual usage and performance.

2. Related Work

This study examines a real-time bus arrival prediction system that uses smartphones to increase bus schedule accuracy [1]. With an emphasis on buses, this study offers a real-time management system for public transport that is based on GPS and WiFi [2]. The research enables a thorough analysis of the planning and execution of a real-time passenger information system [3]. This study describes how real-time bus monitoring and management can be achieved with cloud computing [4]. This research focuses on how bus scheduling systems in urban areas can be enhanced by using real-time data [5]. The use of sophisticated traffic monitoring systems to enhance bus routing in urban areas is covered in this research [6].

The study highlights a system that provides real-time bus tracking and passenger information using GPS and GSM technologies [7]. The potential of cloud computing to improve real-time bus arrival systems, especially in smart cities, is examined in this research [8]. This research explores the real-time prediction of bus delays using big data analytics [9]. To improve real-time tracking and scheduling, the research addresses the integration of IoT in urban bus transit systems [10]. An algorithm for enhancing the tracking and forecasting of bus arrival times is presented in this study [11]. This research focuses on developing a real-time bus information system for smart cities using machine learning techniques [12]. The integration of GTFS data into real-time transit applications is examined in this study [13]. A real-time monitoring system powered by GPS is presented in this research to enhance bus operations [14]. This research describes a hybrid method to improve real-time bus scheduling by utilizing both GPS and traffic data [15].

3. Existing System

This is the traditional method, where pre-published timetables are used to show the planned arrival and departure times for buses at each stop. These schedules are typically available at bus stops, online on the bus company's website, or through downloadable PDFs.

These systems provide real-time information at bus stops themselves. This can be achieved through electronic displays that show estimated arrival times for upcoming buses and automated announcements that inform passengers of approaching buses and potential delays.

4. Proposed Metho

The system allows a user to track their bus from the Android app. With the help of tracking system, the users can see how far the bus is. This allows the user to plan their route and travel plan accordingly. The app will also give the approximate time and distance of the bus. This will reduce the wait time and enhance customer satisfaction.

Utilizing high-speed processor-equipped GPS and GSM module integrated with IoT devices on buses is essential to access the real-time bus route and timing information system. This data is sent to a centralized web server, allowing passengers to plan their trips more efficiently.

The ESP8266 microcontroller, equipped with the built-in Wi-Fi module, serves as the central processing unit (Figure 1). It processes the data received from the GPS (global positioning system) module and forwards it to the cloud server. The GPS module conveys the live location of the bus, such as the longitude and latitude to ESP8266, which is then relayed to the cloud server for further processing and storage.

The data stored in the cloud server is forwarded to the mobile application developed using Android Studio. The admin panel grants access to the authorized users and manages and monitors the data stored in the cloud server, enabling the users to track the real-time bus locations and retrieve the information whenever it is needed. The web application ensures that the users can view real-time data and receive the route information of the bus and its current location, thus enabling a user-friendly interaction.

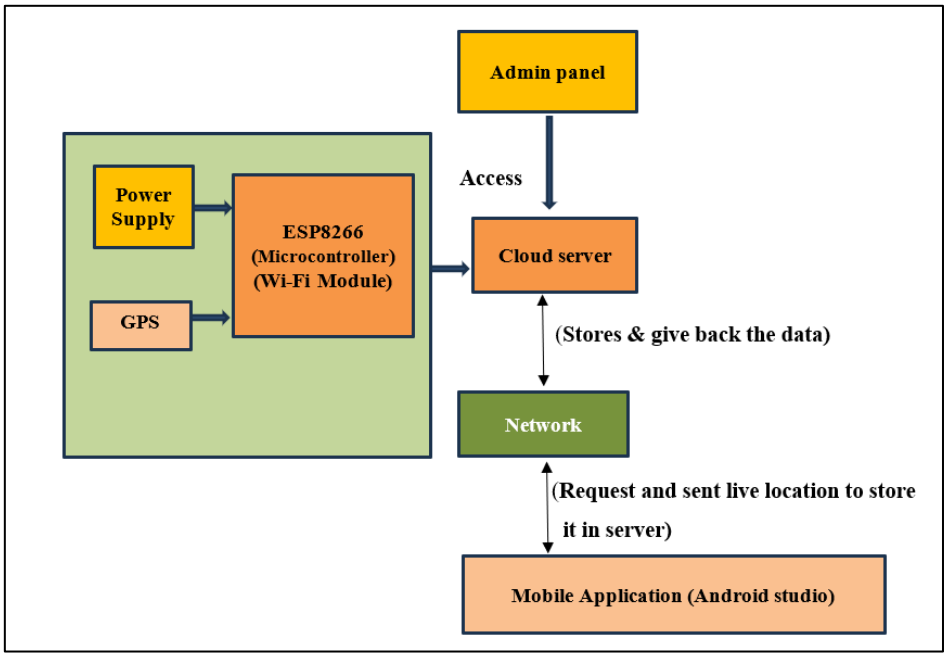

Figure 1. Block Diagram of the Bus Route and Time Tracker

4.1 Components Used

The proposed system for tracking the bus utilizes a standard GPS module (Neo -6M), to obtain the location data of the bus. It communicates with the ESP8266 through UART (serial communication), transmitting latitude, and longitude of the location. The ESP8266 is responsible for establishing the communication between the cloud server using MQTT (Messaging Queuing Telemetry Transport) protocols. The ESP8266 forwards the location data received, to the cloud server using the MQTT. The cloud server stores and forwards the data to the web application whenever it is requested by the authorized user.

Table 1. Hardware and Software Components Used

S.No	Hardware Components	Uses
1.	Esp8266 microcontroller	The ESP8266 microcontroller is used in bus monitoring systems to connect various peripherals to a web server and upload information to a database.
2.	GPS Module	It is used in bus monitoring systems to track the location of buses in real-time, which helps improve the quality of public transportation.

S.No	Software Components	Uses
1.	Language – Embedded C	The Embedded C programming language allows for precise control and optimization of system operations.
2.	Android Studio	Android Studio is the official integrated development environment (IDE) for Android application development.
3.	Arduino IDE	Arduino IDE provides a user-friendly platform for writing and uploading code to the board facilitating the integration of various components.

Table.1 illustrates the hardware and the software components used in developing the system.

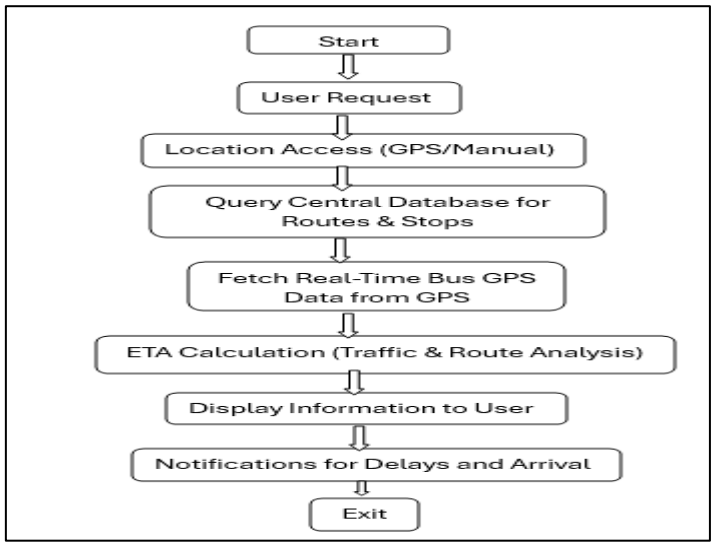

Figure 2. Flow Chart of the Bus Route and Schedule Tracking System

4.2 Workflow

The Flowchart in Figure 2 shows the workflow of the bus route and schedule tracking system

STEP 1: The user initiates a request to check the available public transport route and the estimated time of arrival (ETA) for a specific bus.

STEP 2: The system obtains the user's location through GPS or the manual input of the location given by the user.

STEP 3: Once the user's location is identified, the system queries the central database to fetch the available bus route and the nearby stops based on the user's location.

STEP 4: The central database fetches the real-time bus GPS data from the central hub fixed in the buses operating on the relevant routes, identifying the current position and status.

STEP 5: The estimated time of arrival is determined taking into consideration the current traffic conditions, bus position, delay factors, and the estimated time of arrival for the next buses at the selected stop.

STEP 6: Notifications on the estimated time of arrival, the delay in arrival, and the schedule changes are sent to the user.

STEP 7: Exit.

5. Implementation and Results

The ESP8266 will collect the real-time GPS data using NEO -6m and publish the data to an MQTT topic. The MQTT broker (Mosquitto) is installed on the central server to handle the MQTT communication. The broker is configured to allow incoming data from the ESP8266. The Android app subscribes to the MQTT broker to receive real-time bus data. The Paho MQTT library is used in the work to implement the MQTT client in Android Studio.

The Google Maps API used in the proposed system displays the bus routes and stops on a map. The Google Distance Matrix API integrated into the system determines the traffic-based estimated time of arrival by querying from the current bus location to the user's selected stop. The ETA is determined taking into consideration the bus's current speed from the GPS data, traffic conditions through the API, and the delay through the central hub. The Firebase cloud messaging sends real-time notifications to the user when the bus is delayed or there is a schedule change. Figures 3-8 depict the prototype developed and the mobile application developed.

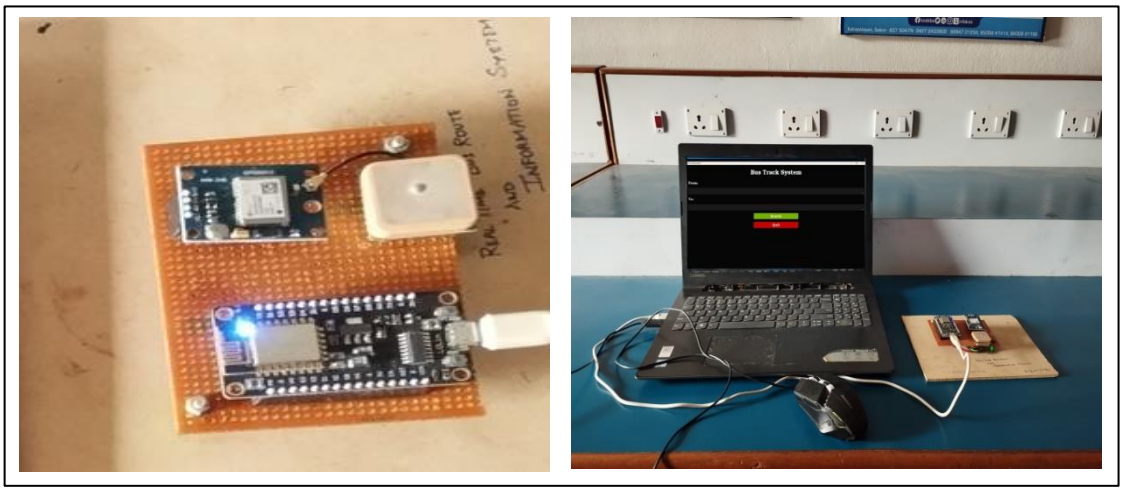

Figure 3. Prototype of Real-Time Bus Route and Information System

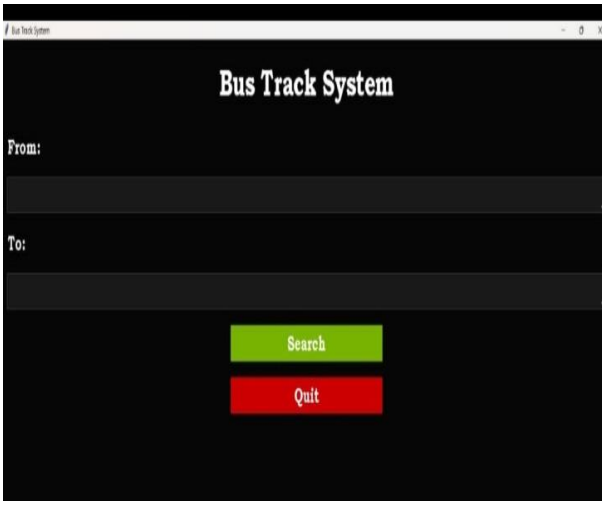

Figure 4. Initial Web Page Start Up

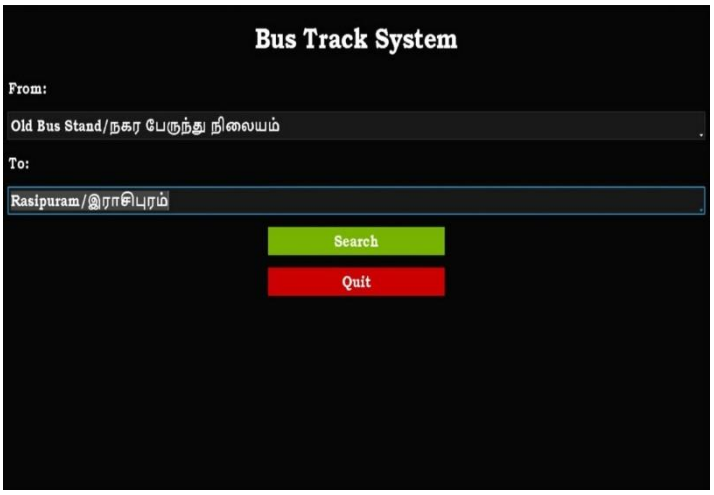

Figure 5. To and From Location

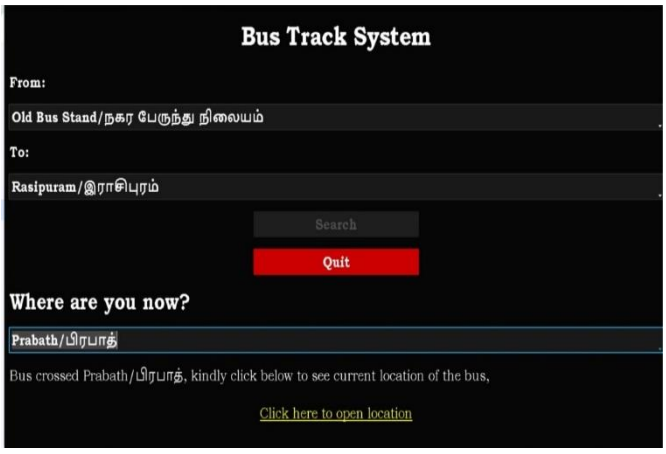

Figure 6. Path of a Bus Detected

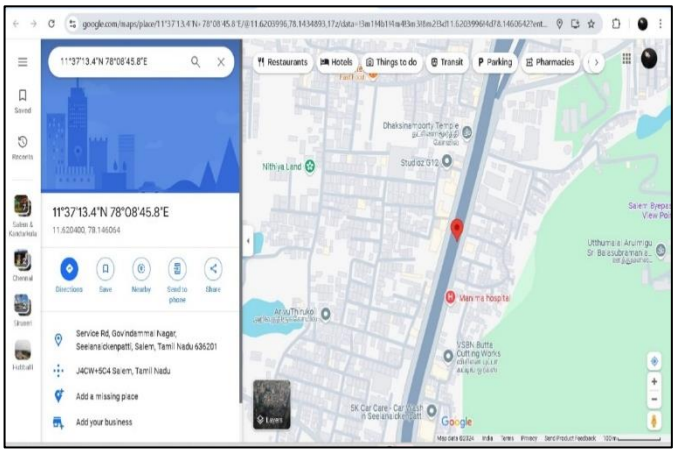

Figure 7. Location in Google Map

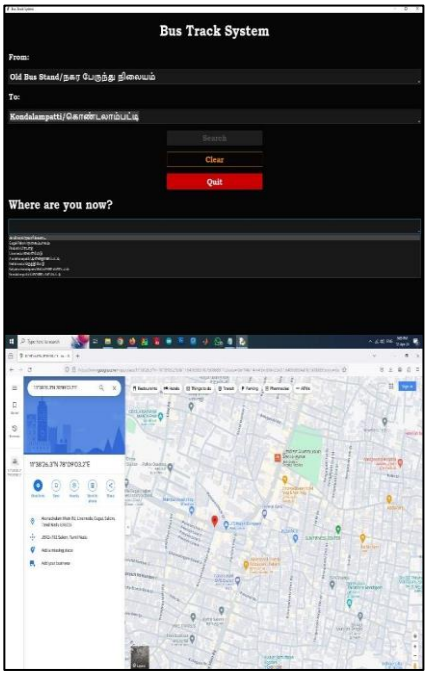

Figure 8. Enhanced Model for Detecting and Path Identifying

6. Conclusion

The user will get the current location of the bus through the application. In addition to receiving the bus's position, passengers may also estimate how long it will take for the bus to get to a particular location. The location data is obtained through the central hub fixed in the bus. By doing this, the bus's distinctiveness is preserved while its position is shown on the map. The client's request for bus information is retrieved from the cloud database through the web application. The location of that specific Bus ID will be received from the server and displayed on the map when the user picks it.

Furthermore, open data platforms could allow for seamless integration with other city services, providing a more comprehensive picture of urban mobility. By utilizing these advancements, real-time bus information systems can become a cornerstone of smart cities, promoting efficient public transportation and a more connected urban ecosystem.

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