

An Overview of Real-Time Bus Tracking in Smart Bus Stop System

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Abstract: The “An Overview of Real-Time Bus Tracking in Smart Bus Stop System” aims to enhance public transport accessibility in areas with limited or no internet connectivity. The system employs GPS modules mounted on buses to continuously capture location coordinates. This data is transmitted to bus stops through a LoRa-based wireless communication network, ensuring reliable long-distance data transfer with minimal power consumption. An ESP32 microcontroller at each bus stop receives and interprets the transmitted information to calculate and display the bus’s estimated arrival time (ETA) on an LCD or LED display. By operating independently of cellular networks, the system provides a cost-effective, energy-efficient, and scalable solution for rural and remote transportation networks. The proposed system improves passenger convenience, reduces idle waiting times, and contributes to the modernization of rural mobility infrastructure.

Keywords: Smart Bus Stop, Real-Time Tracking, LoRa Communication, GPS Module, ESP32

I. INTRODUCTION

In educational institutions, buses serve as one of the most dependable and economical modes of transportation for students traveling from hostels, nearby towns, and remote villages. Despite their importance, students often experience uncertainty regarding bus arrival schedules, resulting in unnecessary waiting time, inconvenience, and reduced punctuality. Traditional bus-tracking systems depend heavily on mobile internet or cellular networks, which are frequently unreliable or unavailable in rural areas, limiting their effectiveness. To overcome these limitations, this paper presents An Overview of Real-Time Bus Tracking in Smart Bus Stop Systems. The proposed design integrates GPS modules on buses to capture their precise location and employs LoRa-based wireless communication to transmit this data to bus stops. At each stop, an ESP32 microcontroller processes the received information to estimate the bus’s arrival time (ETA), which is displayed on an LED or OLED screen for commuters. For enhanced security and access control, the system incorporates a QR code verification feature, allowing only registered students to board the bus. Each student is assigned a unique QR code to prevent unauthorized travel and improve the management of transportation services. Furthermore, the system’s low-cost, energy-efficient design and support for mesh networking make it suitable for large coverage areas, ensuring consistent performance even in off-grid or low-connectivity regions.

II. LITERATURE SURVEY

Malligeswari et al. (2023) proposed an IoT-based college bus tracking system utilizing GPS to provide students with real-time bus location updates. Their system aimed to reduce waiting time and improve safety. However, challenges such as data security, scalability, and performance optimization still require further research.

Navya Sree et al. (2022) developed an Integrated College Bus Tracking System that employed an Android application to display bus location using latitude and longitude. This approach enabled students to track buses accurately and avoid unnecessary delays. While effective in convenience, the system’s scope was mainly limited to location display, with potential improvements in features like Estimated Time of Arrival (ETA) prediction, interactive mapping, and stronger security mechanisms.



Totawar et al. (2021) presented an IoT-enabled Smart School Bus Monitoring System that used GPS for real-time tracking and generated alerts in case of route deviations. The system was also integrated with school management software to enhance safety and operational efficiency. Despite its advantages, the system could be further strengthened with predictive analytics, better data protection, and improved user-friendly interfaces for both parents and administrators.

Ahmed et al. (2019) proposed a secure kiosk-based school bus tracking solution, which allowed guardians to monitor student movement through authorized access. This method improved student safety but lacked mobility and real-time alerts, which could be addressed by mobile app integration.

Mohan Raj et al. (2019) introduced an Automated School Bus Tracking System that combined RFID for student attendance with GPS/GPRS tracking. The system generated SMS and email notifications along with administrative reports, ensuring better safety and management. However, real-time analytics and mobile app-based solutions could enhance its overall effectiveness.

Keerthi and Prashanth (2020) presented a Smart School Monitoring System integrated with Smart Bus features, where GPS-enabled tracking was linked with school monitoring functions to improve student safety and resource management. Nevertheless, enhancements in scalability, automation, and advanced safety mechanisms could make the system more robust.

Table 1:

Author	Year	Objective	Pros	Cons	Platform Used
Malligeswari et al.	2023	IoT-based college bus tracking system using GPS for real-time updates	Reduces waiting time, improves safety	Lacks security, scalability, and performance optimization	IoT + GPS
Navya Sree et al.	2022	Integrated college bus tracking system with Android app showing latitude & longitude	Accurate tracking, avoids delays	Limited to location display, lacks ETA & security	Android Application
Totawar et al.	2021	IoT-enabled smart school bus monitoring with GPS and alerts	Route deviation alerts, integrated with school management	Needs predictive analytics, better data protection, improved UI	IoT + GPS + School Management System
Ahmed et al.	2019	Kiosk-based secure school bus tracking for guardians	Authorized access, enhances student safety	No mobility, lacks real-time alerts	Kiosk System
Mohan Raj et al.	2019	Automated bus tracking with RFID attendance + GPS/GPRS tracking	SMS/email notifications, administrative reports, improved safety	No real-time analytics, lacks mobile app	RFID + GPS/GPRS
Keerthi & Prashanth	2020	Smart school monitoring system	Links school monitoring with bus tracking, ensures	Needs scalability, automation, advanced safety	GPS + Monitoring System



		integrated with GPS-enabled smart bus	safety		
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III. PROPOSED METHODOLOGY

The Bus Tracking System helps passengers know the real-time location of buses without using the internet. It has two parts the Bus Unit (Transmitter) and the Bus Stop Unit (Receiver).

In the Bus Unit, a GPS module collects the bus location and sends it with the Bus ID and Time to the ESP32 microcontroller. The ESP32 processes the data and transmits it through the LoRa module for long-range communication.

At the Bus Stop Unit, the LoRa module receives the data and sends it to a microcontroller, which displays the bus location and arrival details on a screen.

This system is low-cost, works without the internet, and helps passengers easily track buses in real-time.

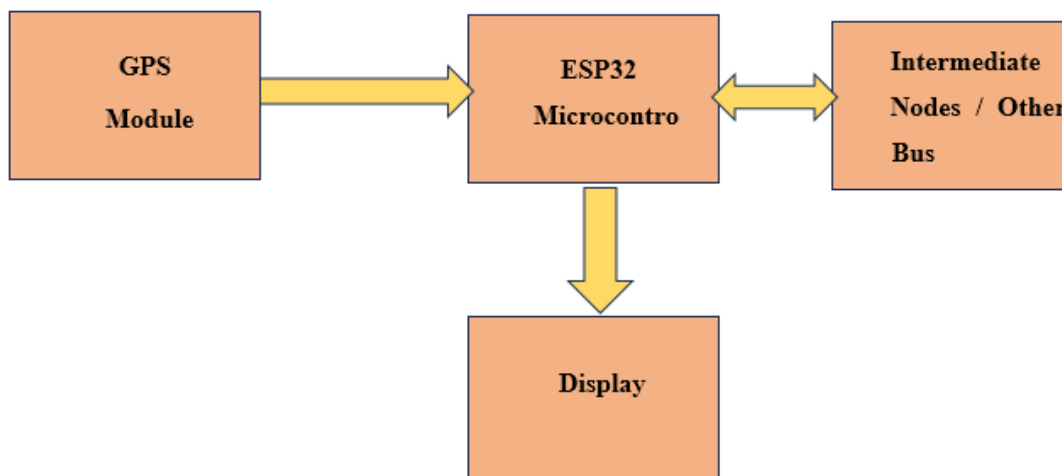


Figure 1: shows block diagram of proposed methodology

The Bus Tracking System using GPS NEO-6M and ESP32 is an IoT-based project developed to provide real-time tracking and monitoring of buses. The system helps passengers know the exact location and estimated arrival time of the bus, improving travel convenience and reducing waiting time. A GPS NEO-6M module is installed in the bus to continuously collect real-time location data, including latitude and longitude coordinates. This data, along with the Bus ID and Timestamp, is sent to the ESP32 microcontroller. The ESP32 processes the data and transmits it to a cloud server or mobile application through Wi-Fi. This allows the bus's live location to be tracked using any internet-connected device.

At the Bus Stop Unit, a display screen or web-based dashboard receives the data from the cloud and shows details such as the bus number, route, and estimated time of arrival. In large networks, intermediate nodes or other buses can be added to enhance system coverage and communication efficiency.

This system provides an efficient, low-cost, and scalable solution for smart transportation. It enhances passenger convenience, supports traffic management, and can be upgraded further with features like mobile app alerts, route prediction, and cloud-based analytics for improved city transport systems.

IV. RESULT AND DISCUSSION

The Smart Bus Stop System was evaluated both quantitatively and qualitatively to verify its performance in providing real-time bus location updates. The system was tested using actual bus routes, with GPS NEO-6M modules installed in buses and ESP32 microcontrollers handling data processing and transmission. On the testing setup, the system



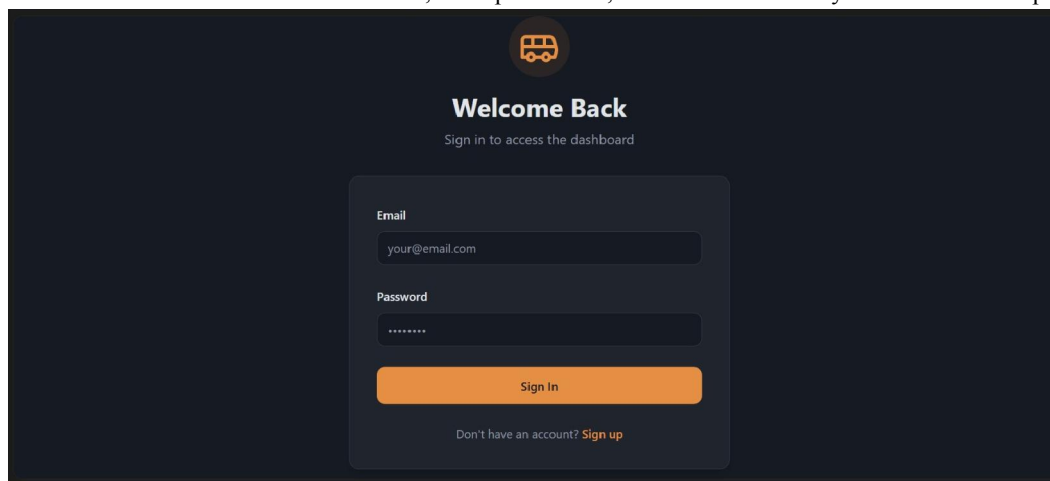
successfully tracked buses in real-time, with location data, bus ID, and timestamps being accurately processed and displayed on the bus stop display units.

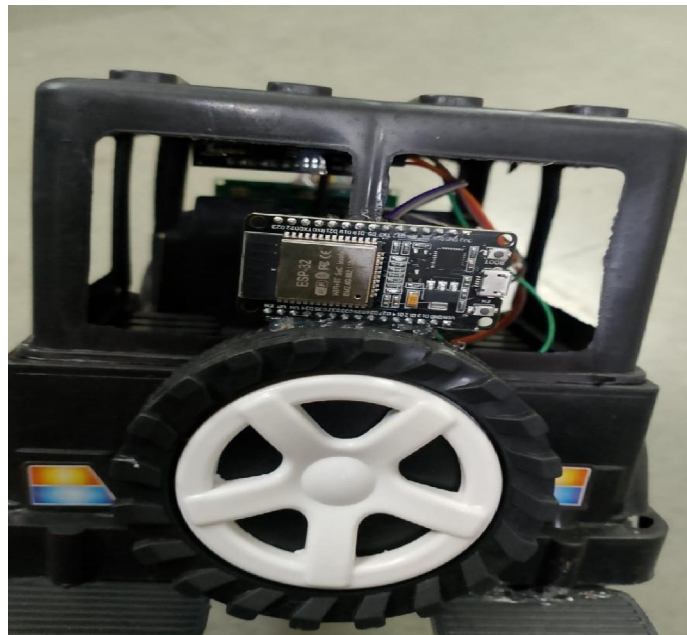
The results showed that the system could reliably display estimated arrival times and current bus locations with minimal delay. Passengers could easily identify approaching buses and plan their travel accordingly. For instance, the ESP32 correctly processed GPS data from multiple buses, updating the display continuously without significant latency. The system maintained accuracy even when tracking buses across different routes and during moderate variations in signal reception.

To demonstrate usability, the system was tested across different times of the day and varying traffic conditions. Buses equipped with the GPS module consistently transmitted location data, which was accurately displayed at the bus stops. Intermediate nodes or multiple bus updates were handled efficiently, ensuring smooth operation across a network of buses.

Another important finding was the scalability and adaptability of the system. The ESP32-based design allows additional buses or bus stops to be integrated without affecting overall performance. The Wi-Fi-based data transmission to the cloud server ensures that the system can be monitored remotely, providing real-time updates to passengers via mobile applications or display screens.

Overall, the evaluation highlights that the Smart Bus Stop System is a reliable, low-cost, and scalable solution for public transportation management. It improves passenger convenience, reduces waiting times, and offers potential for future enhancements such as mobile notifications, route predictions, and cloud-based analytics for urban transport.





V. CONCLUSION

The proposed Smart Bus Stop System with Real-Time Bus Tracking using the GPS 6M module and ESP32 microcontroller effectively addresses the common issues faced by students and commuters in areas with limited internet connectivity. By utilizing LoRa communication for data transfer, the system provides accurate and real-time bus location updates without relying on mobile networks. The integration of a QR code verification mechanism enhances passenger safety and ensures that only authorized users can access the service. This solution is cost-effective, power-efficient, and simple to deploy, making it especially suitable for educational institutions and rural transport systems. By displaying the estimated arrival time (ETA) on digital screens, the system reduces unnecessary waiting times and improves the overall reliability of public transportation. In the future, the system can be expanded with cloud integration and mobile applications to provide even greater accessibility and data analytics for transport management.

not use lora using gps neo 6m model

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