INTELLIGENT ROUTING SYSTEM FOR STUDENT'S SAFETY IN COLLEGE BUS USING GPS AND GIS TRACKING

Project Reference No.: *49S_BE_1341*

College : S G Balekundri Institute of Technology, Belagavi.
Branch : Department of Civil engineering
Guide(s) : Dr. Santosh B Chikkabagewadi
Prof. Sujay Gejji
Student(s) : Ms. B Jhanu
Ms. Padmashree Sheetal Shetti
Ms. Pooja Sadanand Alaj
Mr. Ajit Doddamani

Keywords:
GPS Tracking, GIS Mapping, Real-Time Monitoring, Route Optimization, Student Safety, Smart Bus System, Android Application

Introduction:

The increasing demand for safety, transparency, and efficient transport management in educational institutions has highlighted the need for reliable real-time bus tracking systems. This project presents the design and development of an Intelligent Bus Routing System for SGBIT College, utilizing GPS, GSM, and cloud-based technologies to provide accurate location monitoring. The hardware implementation integrates an ESP32 microcontroller with a NEO-6M GPS module for position acquisition and a SIM900A GSM module for wireless data transmission. The collected coordinates are uploaded to the Firebase Realtime Database and visualized through a mobile application using Google Maps API, enabling continuous tracking of the bus on an interactive interface. The system architecture ensures stable communication between hardware, cloud, and user interface, allowing real-time updates with minimal latency. GIS-based route representation enhances monitoring capability and supports better route understanding and management. Pilot testing confirmed successful data acquisition, reliable transmission, and accurate map visualization, demonstrating the system's effectiveness in a practical environment. The proposed model offers a cost-effective and scalable solution that improves student safety, reduces waiting time, and enhances transport transparency. The system shows strong potential for future expansion, including multi-bus tracking, historical data analysis, and intelligent route optimization.

Objectives:

1. To design a GPS- and GIS-based intelligent routing system for SGBIT College buses.
2. To enhance the safety and security of students through real-time tracking and monitoring.
3. To offer live updates on travel progress through developing a smart application.

Methodology:

1. Requirement Analysis: Requirement analysis was carried out to understand the existing transportation issues and system needs. A student survey was conducted to collect feedback on punctuality, safety, and tracking requirements. The responses helped identify major problems such as delays and lack of real-time updates. This stage ensured that the system is designed based on actual user needs. It forms the foundation for developing an effective and user-oriented solution.

2. Data Collection: Preliminary route data was collected to understand the current bus network. Information such as bus stops, geographic coordinates, pickup timings, and student boarding details were recorded. This data was organized systematically for further processing and analysis. It provided a clear understanding of route coverage and transport patterns. This step is essential for accurate mapping and system development.

3. GIS Route Mapping: The collected data was used in QGIS software to create digital maps of bus routes. Each bus stop was plotted using its coordinates to visualize the complete route. This helped in analyzing route coverage, stop distribution, and overlapping areas. GIS mapping improves understanding of spatial data and transport efficiency. It also supports better planning and monitoring of routes.

4. Hardware Integration: The system hardware was developed by integrating ESP32 microcontroller with GPS and GSM modules. The ESP32 acts as the central processing unit of the system. The GPS module is used for location tracking, while the GSM module handles communication. All components are connected to ensure smooth data flow. This integration forms the core of the real-time tracking system.

5. GPS Data Acquisition: The GPS module continuously receives signals from satellites to determine the bus location. It calculates real-time latitude and longitude coordinates with high accuracy. The data is generated in a standard format and sent to the microcontroller. This ensures continuous tracking of the moving vehicle. Accurate data acquisition is essential for reliable system performance.

6. Data Processing: The ESP32 microcontroller processes the raw GPS data received from the module. It filters and extracts important information such as coordinates. The data is converted into a readable and usable format. Error checking is also performed to ensure accuracy. This step prepares the data for transmission and further use.

7. Data Transmission: The processed data is transmitted using the GSM module through GPRS communication. It sends location information to the cloud database at regular intervals. The system ensures continuous connectivity using a SIM card. In case of network issues, data is stored temporarily and retransmitted. This ensures reliable real-time data communication.

8. Cloud Integration: Firebase is used as the cloud platform to store and manage real-time data. The transmitted GPS data is continuously updated in the database. It allows multiple

users to access live information simultaneously. The cloud ensures data availability and scalability. This enables efficient data handling and synchronization.

9. Mobile Application Development: A mobile application is developed using Visual Studio for user interaction. The app provides an interface for students and administrators to access bus information. It connects to the cloud database to retrieve real-time data. The design focuses on simplicity and usability. This makes the system accessible and user-friendly.

10. System Synchronization: All system components including hardware, cloud, and mobile app are interconnected. Continuous communication is maintained between these components. This ensures real-time data updates without delay. Proper synchronization improves system performance. It enables smooth and reliable operation.

11. System Testing: The system was tested to verify its performance and accuracy. GPS data, transmission reliability, and app functionality were evaluated. The results confirmed accurate tracking and minimal delay. Screenshots and outputs were recorded for validation. Testing ensures system reliability in real conditions.

12. Final Implementation: The complete system was implemented successfully for real-time bus tracking. It provides accurate location updates and improves transport efficiency. The system enhances student safety and reduces waiting time. It ensures better communication between users and transport authorities. Overall, it delivers a smart and effective transportation solution.

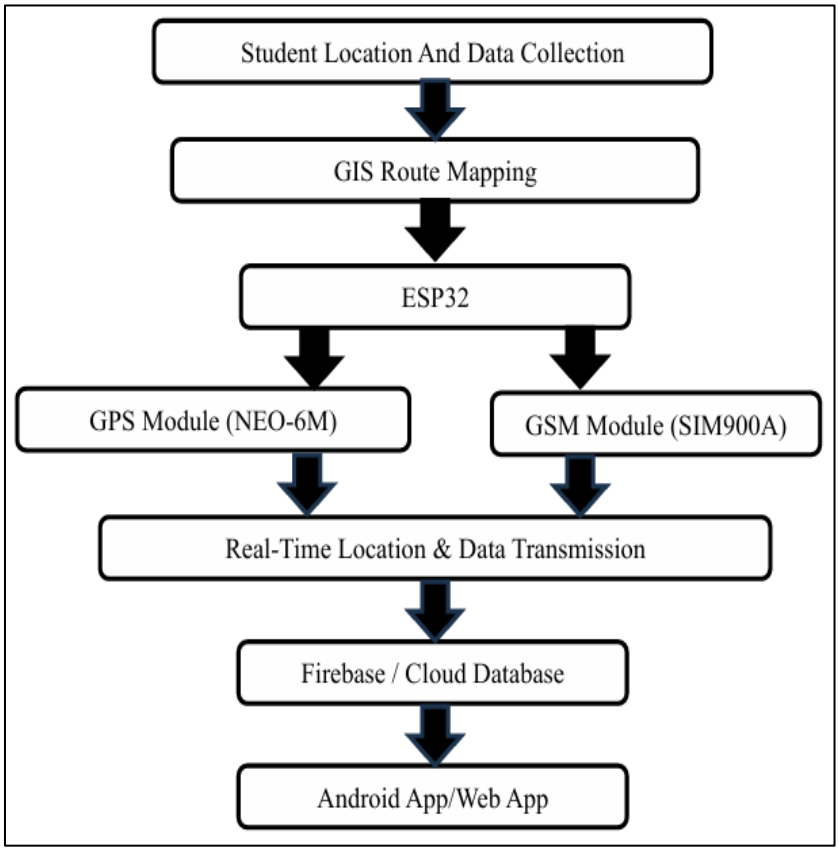

Figure 1: Methodology sequence in form of flow chart

Result and Conclusion

1. Hardware Implementation:

The hardware system was successfully implemented using ESP32, GPS (NEO-6M), and GSM (SIM900A) modules. The integrated setup enabled real-time acquisition and transmission of location data. All components functioned effectively under test conditions, ensuring stable communication. The system demonstrated reliable performance for continuous tracking. This forms the core of the intelligent bus tracking system.

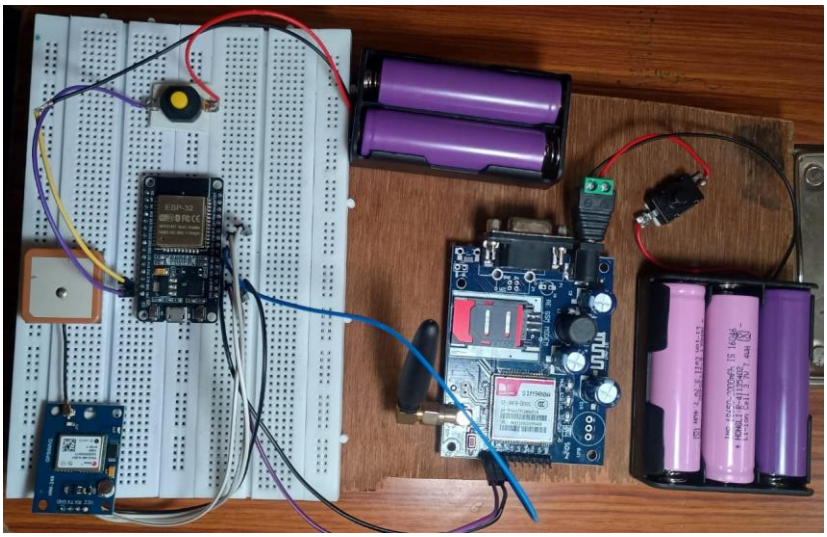

Figure. 2: Hardware Implementation of Bus Tracking System

2. Circuit Diagram

The circuit diagram was designed to establish proper connections between the microcontroller, GPS, and GSM modules. It ensured efficient data flow from the GPS module to the ESP32 for processing and further transmission via GSM. The design was tested for accuracy and reliability. Proper interfacing of components enabled smooth system operation. This confirms correct hardware integration.

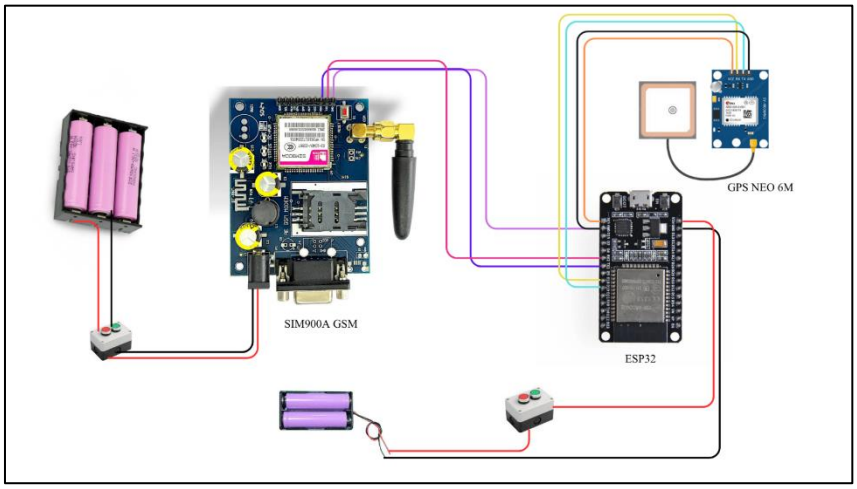

Figure. 3: Circuit Diagram of Integrated Tracking System

3. GIS-Based Route Visualization of Bus Network

GIS-based mapping was carried out using QGIS to visualize bus routes and stops. All bus routes were mapped; however, one representative route was included in the report for clarity. The visualization clearly showed route alignment, stop locations, and spatial coverage. It enabled better understanding and monitoring of the transportation network. This supports efficient route management and planning.

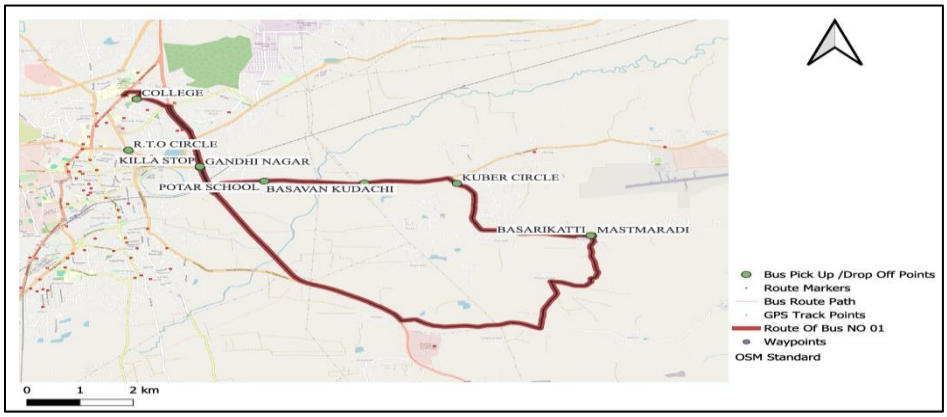

Figure 4. GIS-Based Route Visualization for Bus Route No: 01 (MASTMARDI)

4. Mobile Application Interface

The developed mobile application successfully displayed real-time bus location using Google Maps API. The interface was designed to be user-friendly and easy to navigate. It provided accurate tracking information with minimal delay. Students could conveniently monitor bus movement through the application. This enhanced accessibility and overall user experience.

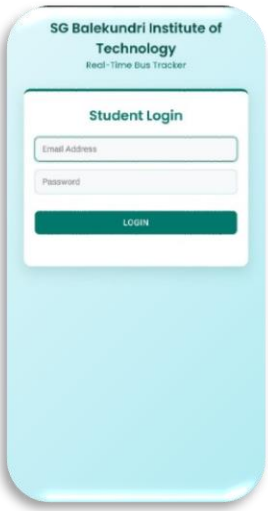

Figure 5. User Authentication Interface
Secure login system for students and administrators

Figure 6.. Bus Selection Dashboard
Displays available routes and allows users to choose a bus for detailed information.

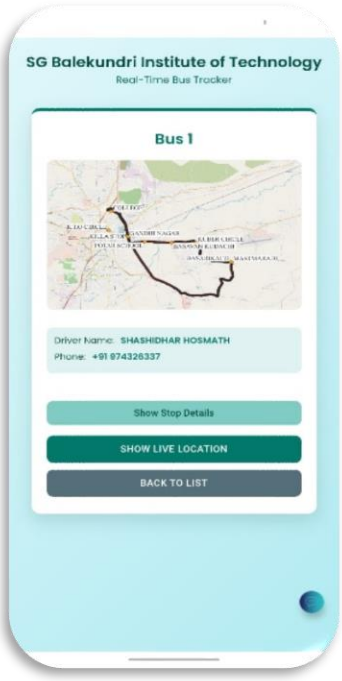

Figure 7. Route Information & Stop Overview Shows route map, driver details, and complete stop list for the selected bus

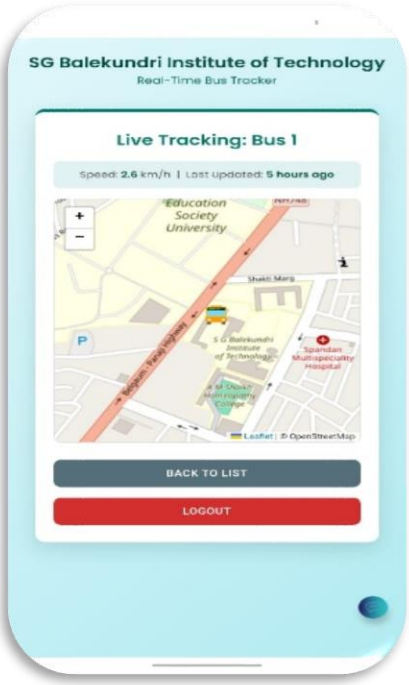

Figure 8. Real-Time Bus Location Tracking

5. System Testing and Real-Time Data Output

System testing was conducted to evaluate the performance of GPS data acquisition and transmission. The results showed accurate location tracking with minimal delay. The communication between hardware, cloud database, and mobile application was stable and reliable. Real-time updates were successfully reflected in the application. This confirms the efficiency and reliability of the system.

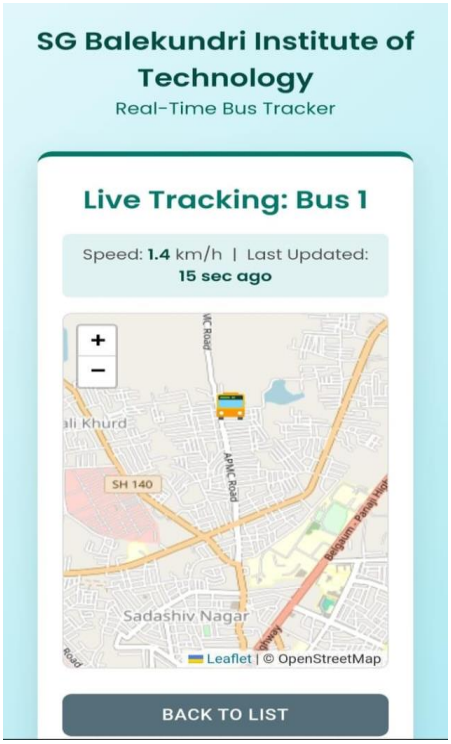

Figure 9. Real-Time Bus Location Displayed in the Developed Mobile Application -

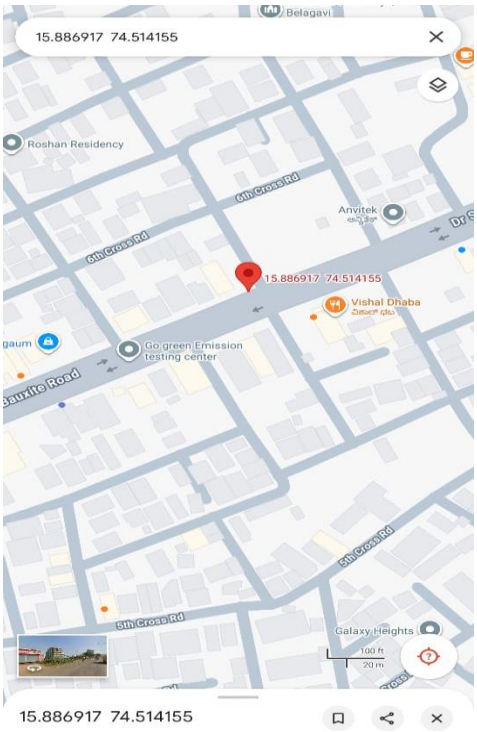

Figure 10. Corresponding Bus Location Verified Using Google Maps

6. Student Feedback Analysis

After pilot testing of the Intelligent Bus Routing System, a student survey was conducted to evaluate its effectiveness and user satisfaction. The results showed that although buses were generally punctual, issues like overcrowding and waiting time still existed. A majority of students preferred features such as live tracking and route visibility through a mobile application. The feedback confirmed that real-time tracking improved confidence, reduced uncertainty, and enhanced safety. Overall, the results validate the system's usefulness and its potential for wider implementation.

Conclusion

The development of the Intelligent Bus Routing System for Student Safety in SGBIT College successfully achieved its primary objectives of providing real-time bus tracking and enhancing transparency in the transportation system. The integration of the ESP32 microcontroller, NEO-6M GPS module, and SIM900A GSM module enabled accurate acquisition and transmission of location data, while the Firebase backend ensured reliable storage and continuous synchronization. The mobile application interface effectively displayed live bus positions on the map, allowing users to monitor movement in a simple and user-friendly manner. The pilot testing phase demonstrated stable system performance, consistent data updates, and smooth communication between the hardware, cloud database, and application. These results validate the functionality and reliability of the proposed model in practical usage scenarios. The system has shown significant potential to improve safety, reduce uncertainty in travel time, and support better route management within the college transport network. Overall, the project establishes a strong foundation for implementing intelligent transportation solutions in educational institutions. With further enhancements such as multi-bus tracking, historical data analysis, and automated notifications, the system can be expanded into a more comprehensive transport management platform in the future.

References:

1. ([1] S. Pardakhe and P. Padile, "Smart GPS tracker using Arduino UNO," *International Journal of Scientific Development and Research*, vol. 10, no. 4, 2025.
2. [2] M. A. Shaikh and R. Patel, "Bus Tracking System Using GPS and GSM," *International Journal of Advanced Research in Computer and Communication Engineering*, vol. 7, no. 6, 2024.
3. [3] D. M. Bilana *et al.*, "College Bus Live Tracking System Using GSM and GPS," *International Research Journal of Modernization in Engineering, Technology and Science*, vol. 6, no. 5, 2024.
4. [4] C. Alakesan *et al.*, "Enhancing road safety for school children through smart school buses," *International Journal of Engineering Research & Technology*, vol. 12, no. 3, 2024.
5. [5] S. M. Sandhya and M. Reddy, "Design and implementation of vehicle tracking system using ESP32," *International Journal of Innovative Research in Technology*, vol. 11, no. 4, 2024.

6. [6] K. Myint and N. Oo, “Real-time vehicle tracking system using Arduino, GPS, GSM and web-based technologies,” *International Journal of Novel Research and Development*, vol. 3, no. 2, 2024.
7. [7] N. P. Patil *et al.*, “Android App for Bus Tracking Using GPS,” *International Research Journal of Modernization in Engineering, Technology and Science*, vol. 5, no. 2, 2023.
8. [8] F. Al-Hilali, R. D. Luhar, and M. M. Jamaal, “GPS and GSM-based smart vehicle tracking system,” in *Proc. Middle East College Student Research Conference*, 2023.
9. [9] A. Kumar and R. Singh, “Real-time object tracking system using Arduino with Spot-it mobile application,” *International Journal of Advanced Research in Computer and Communication Engineering*, vol. 12, no. 3, 2023.
10. [10] S. Gupta and A. Kumar, “Smart bus tracking system,” *International Journal of Creative Research Thoughts*, vol. 11, no. 5, 2023.
11. [11] B. G. T. L. Aberathne *et al.*, “Application of school bus routing problem in GIS to organize school buses in Kandy City, Sri Lanka,” *Journal of Geospatial Surveying*, vol. 3, no. 2, 2023.
12. [12] I. Ahmed and S. Bhatia, “GIS-based route optimization for effective traffic management: A case study of Srinagar City,” *International Journal of Innovative Research in Computer Science & Technology*, vol. 10, no. 3, 2022.
13. [13] M. J. A. Baig *et al.*, “Design and implementation of an open-source IoT and blockchain-based peer-to-peer energy trading platform using ESP32-S2, Node-Red and MQTT protocol,” *Energy Reports*, 2021.
14. [14] R. Kumar and S. Prabhu, “Smart GPS tracker using Arduino,” *International Journal of Research Publication and Reviews*, vol. 2, no. 7, 2021.
15. [15] F. Mien, “Arduino-based tracking system using GPS and GSM,” *International Journal of Innovative Science and Research Technology*, vol. 5, no. 3, 2020.

Future Scope

The future scope of this project includes

1. AI-based route optimization can be implemented to suggest faster and more efficient routes based on traffic and road conditions.
2. Introducing student-focused features like ETA notifications and bus arrival alerts can enhance user convenience.
3. Integration of RFID or QR-based attendance can automate boarding verification and improve safety.