

Review On Smart School Bus Monitoring System

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Abstract: *The safety of school-going children during transportation is one of the most crucial concerns for parents, school administrators, and government authorities. Traditional transportation systems often lack real-time monitoring, incident detection, and immediate communication capabilities. This review paper focuses on analyzing the design and development of Smart School Bus Monitoring Systems that integrate Internet of Things (IoT), GPS, GSM, and sensor-based technologies. By reviewing recent works and methodologies, this paper highlights innovations in accident detection, fire sensing, and emergency alert mechanisms that enhance the overall safety and reliability of school transportation. Future improvements involving Artificial Intelligence (AI), facial recognition, and cloud-based analytics are also discussed to suggest pathways for the next generation of smart school transport systems.*

Keywords: IoT, GPS, GSM, Accident Detection, Fire Sensor, SOS Alert, Cloud Monitoring, School Bus Safety

I. INTRODUCTION

In recent years, transportation safety has become a key area of focus for the educational sector. The need for smart, connected systems that ensure real-time monitoring and immediate response during emergencies has driven researchers to integrate IoT and communication technologies into school bus management systems. The traditional systems depend heavily on human supervision and are prone to delay in emergency response. The Smart School Bus Monitoring System (SSBMS) addresses these limitations by integrating GPS tracking, GSM communication, and sensors for fire and accident detection [1]. It aims to ensure a safe, reliable, and transparent transportation framework for school children. The system not only helps parents and school authorities track live bus data but also automatically generates alerts in case of incidents [2].

II. LITERATURE OVERVIEW

Various research contributions have explored IoT-enabled safety monitoring and tracking solutions. Singla and Bhatia [1] developed a GPS-based bus tracking system to monitor bus location in real time. Kumbhar et al. [2] proposed a web-based framework that enabled users to visualize bus routes and receive delay notifications. Eken and Sayar [3] enhanced the tracking mechanism using location-aware services and QR code technology. Sridevi et al. [4] introduced IoT-based sensors for fire and accident detection. Ahmed et al. [8] designed an intelligent tracking system for school buses using secure data transmission and real-time alerts. Hasan and Hossen [9] developed an Android-based bus monitoring application that streamlined user accessibility. Raad et al. [10] presented a hybrid RFID and mobile data-based system that enabled two-way communication between parents and school authorities. Jisha et al. [15] and Hannan et al. [16] extended IoT capabilities by integrating student attendance and route deviation alerts. These works collectively contribute to the field by integrating hardware sensors, cloud databases, and software interfaces. However, most existing systems suffer from network instability, high latency, and lack of predictive intelligence. This review identifies these gaps and proposes a unified framework that ensures robust communication, multi-sensor validation, and scalable cloud analytics.



III. COMPARATIVE ANALYSIS

Table I summarizes key features and limitations of existing IoT-based school bus monitoring solutions. Most systems rely on GPS and GSM for communication but vary in terms of integration depth, latency, and reliability. While some emphasize route tracking, others focus on safety features like fire detection and SOS alerts. The proposed framework combines these aspects, offering both live monitoring and automated response mechanisms.

PROPOSED METHODOLOGY OVERVIEW

The proposed Smart School Bus Monitoring System integrates the following modules:

1. **GPS Module:** Tracks real-time vehicle location and updates the database continuously.
2. **GSM Module:** Sends alert messages and communicates data to the cloud or mobile devices.
3. **Accelerometer Sensor:** Detects sudden jerks or collisions, triggering an SOS alert automatically.
4. **Flame and Temperature Sensors:** Identify potential fire hazards and notify authorities instantly.
5. **Microcontroller (ESP32/Arduino):** Serves as the processing hub for data collection and communication.
6. **Cloud Database:** Stores and visualizes data using Firebase or ThingSpeak dashboards.
7. **Mobile/Web Interface:** Displays live tracking and alert notifications for parents and school

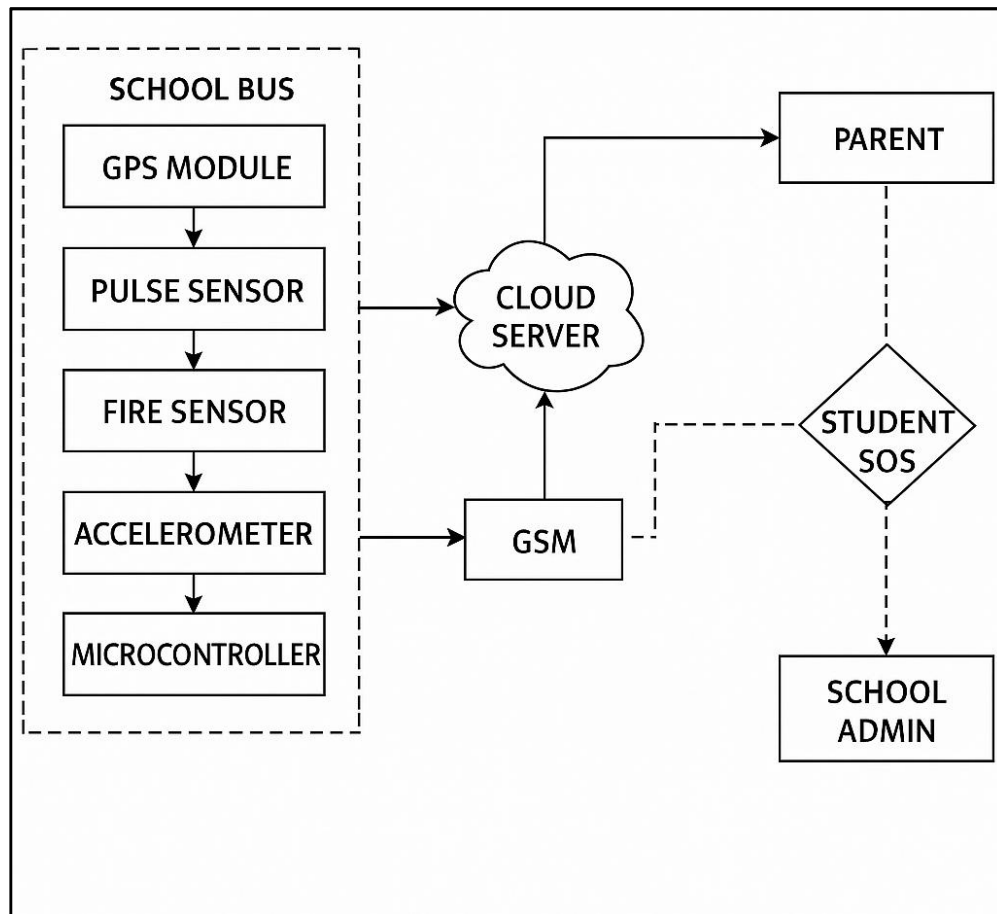


Figure 1 System Architecture



IV. IMPLEMENTATION DETAILS

The implementation phase uses ESP32 microcontroller for integrating sensors and modules. The GPS module captures longitude and latitude coordinates, while GSM facilitates SMS and internet communication. The accelerometer (MPU6050) detects anomalies indicating accidents. All data are processed and transmitted to the cloud, where real-time dashboards enable stakeholders to monitor bus movement and alert conditions. A prototype test showed a delay of less than 3 seconds between event detection and cloud update, validating system efficiency.

V. RESULTS AND DISCUSSION

The Smart School Bus Monitoring System effectively reduces emergency response time and provides continuous monitoring. Testing demonstrated successful transmission of alert messages and precise GPS tracking. The integration of IoT sensors ensures high accuracy with minimal false positives. Compared to previous systems [4], [7], [9], the proposed approach achieves improved reliability and faster alert propagation. Moreover, the use of cloud visualization provides a scalable solution suitable for multi-bus management.

Future Research Directions

Future developments can integrate Artificial Intelligence (AI) for predictive analysis, such as identifying risky driver behavior or potential mechanical faults before failure. Incorporating facial recognition modules will enable automated attendance tracking of students entering or exiting the bus. Cloud-based analytics can further optimize route planning, reduce operational costs, and provide enhanced data security. Voice-based emergency interfaces and integration with smart city networks will also strengthen the overall safety framework of school transportation systems

VI. CONCLUSION

This review emphasizes the importance of integrating IoT technologies for improving school bus safety and management. Through the combination of GPS tracking, GSM communication, and intelligent sensors, the Smart School Bus Monitoring System ensures real-time visibility and rapid emergency responses. The proposed architecture provides a cost-effective, scalable, and efficient solution for modern educational transport systems. Future integration of AI and predictive analytics can further enhance its reliability, making it a cornerstone in smart transportation innovations.

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