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IoT-Based Smart School Bus and Student Monitoring Systems

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Abstract: ***Student transportation safety is a critical concern for educational institutions, parents, and government authorities. Conventional school bus systems rely on manual attendance recording, fixed schedules, and verbal communication, which often leads to inefficiencies, delays, and safety risks. With the rapid advancement of Internet of Things (IoT) technology, smart transportation systems have emerged as reliable solutions for real-time monitoring and automated data management. This review paper presents a comprehensive analysis of IoT-based smart school bus and student monitoring systems, with a primary focus on the base research paper titled "IoT Based Smart School Bus and Student Monitoring System." The study reviews earlier approaches based on RFID, GPS, GSM, and IoT architectures, highlighting their advantages and limitations. The paper further explains the working principles, components, and benefits of the proposed IoT-based system using ESP32 microcontroller, GPS module, RFID reader, Real-Time Clock (RTC), LCD display, and cloud integration through Google Sheets. The review emphasizes improvements in safety, attendance accuracy, communication, and data transparency. The findings suggest that IoT-based school transportation systems offer scalable, cost-effective, and future-ready solutions for modern educational environments.***

Keywords: Smart School Bus, GPS Tracking, RFID, Student Monitoring System, Real-Time Tracking, Arduino, GSM Communication, Vehicle Tracking, Student Safety.

I. INTRODUCTION

School transportation is an essential service that directly affects the safety and well-being of students. Every day, school buses transport millions of students, making them one of the most widely used public transport services for children. Despite its importance, school transportation management has traditionally relied on manual processes, which are often inefficient and unreliable. Parents frequently face uncertainty regarding bus arrival times, student boarding status, and route delays.

In traditional systems, attendance is recorded manually by bus conductors or drivers using paper registers. Such methods are prone to human error and lack real-time verification. Additionally, schools often do not have live access to bus location data, making it difficult to respond quickly in emergency situations. These challenges highlight the need for an intelligent monitoring system that ensures transparency and accountability. The Internet of Things (IoT) has emerged as a transformative technology that enables real-time communication between physical devices and cloud platforms. IoT systems integrate sensors, microcontrollers, communication modules, and cloud storage to monitor and manage real-world processes. In transportation systems, IoT enables live vehicle tracking, automated passenger identification, and centralized data management.

Applying IoT to school bus systems allows continuous monitoring of bus location and student attendance. Parents can track their child's journey, while school administrators can analyze transportation data for better decision-making. The base paper proposes an IoT-based smart school bus and student monitoring system that combines GPS tracking, RFID-based attendance, RTC-based time synchronization, on-board display, and cloud-based data logging. This review paper critically examines this approach and places it in context with earlier research to assess its effectiveness and future relevance.

II. LITERATURE SURVEY

Raj, J. T., and Sankar, J. [1] proposed an IoT-based smart school bus monitoring and notification system to improve student safety during transportation. Their system uses RFID technology to identify students when they board or leave the bus and GPS to track the real-time location of the vehicle. Notifications are sent to parents to keep them informed about their child's travel status. Although the system improves communication and monitoring, it mainly focuses on notification delivery and does not provide centralized cloud-based data analysis.

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Sridevi, K. et al. [2] presented a smart bus tracking and management system using IoT technologies. The proposed system continuously tracks the bus location using GPS and provides route and timing information to users through an IoT platform. The system helps reduce uncertainty related to bus arrival times and improves transportation management. However, the study gives limited attention to automated student attendance and real-time data storage for long-term analysis.

Emad, B., Elhakim, A., Abdulhamid, A., and Zualkernan, I. A. [3] developed an IoT-based school bus tracking and monitoring system that integrates multiple sensors and communication modules. The system allows real-time tracking of school buses and enables parents to monitor their child's transportation status through a network-based platform. While the system improves monitoring accuracy, it requires subscription-based access, which may reduce ease of use for all parents.

Jisha, R. C., Jyothindranath, A., and Kumary, L. S. [4] proposed an IoT-based school bus tracking and arrival time prediction system using GPS, RFID, and GSM technologies. The system predicts the arrival time of the school bus and allows parents to monitor the bus route through a mobile application. Although the approach improves scheduling and tracking accuracy, it does not fully address student safety between the bus stop and home.

Huang, Z., Xu, X., Zhu, H., and Wang, C. [5] introduced a multimodal representation learning approach for recommendation systems in IoT environments. Their work focuses on combining multiple data sources to improve recommendation accuracy using advanced learning techniques. While this study is not directly related to school bus tracking, it highlights the importance of intelligent data analysis in IoT systems, which can be applied to transportation monitoring for predictive and decision-making purposes.

Gadade, B., Mulani, A. O., and Harale, A. D. [6] proposed an IoT-based smart school bus and student monitoring system that integrates ESP32, GPS, RFID, RTC, LCD display, and Google Sheets. The system provides real-time bus tracking, automated student attendance, and cloud-based data storage. This approach improves safety, reduces manual effort, and enhances communication between parents and school authorities. Compared to previous systems, this solution offers better scalability, simplicity, and real-time accessibility.

III. EXISTING SYSTEM

Traditional school bus systems depend heavily on manual supervision and fixed schedules. Attendance is usually taken verbally or recorded on paper, which is time-consuming and prone to mistakes. In some cases, students may forget to report their presence, leading to inaccurate records.

Another major limitation is the absence of real-time tracking. Parents often wait at bus stops without knowing the exact arrival time. During traffic congestion or route changes, there is no reliable way to track the bus location. This lack of transparency increases anxiety and reduces trust in the transportation system.

Data management in existing systems is fragmented. Attendance records, route details, and driver information are stored separately, often in physical files. Retrieving historical data during emergencies or audits becomes difficult. Communication between parents and school authorities is also limited to phone calls or messages, which may not be timely.

Even systems that use basic GPS tracking often lack integration with attendance data. Such systems provide partial solutions and fail to address student safety comprehensively. These limitations demonstrate the need for an integrated IoT-based monitoring system.

IV. PROPOSED SYSTEM

The proposed IoT-based smart school bus and student monitoring system introduces an integrated architecture that addresses the shortcomings of existing systems. The ESP32 microcontroller acts as the central unit, coordinating communication between all components and managing data flow.

The GPS module continuously captures the real-time location of the school bus. This information allows parents and administrators to track the bus and estimate arrival times accurately. RFID technology is used for automated student identification. Each student carries a unique RFID card, which is scanned when boarding or exiting the bus.

A Real-Time Clock module ensures accurate timekeeping. This is essential for recording attendance and location data with correct timestamps. Accurate time synchronization improves data reliability and accountability.

An LCD display installed inside the bus provides real-time information such as current time, bus location, and attendance status. This improves transparency and keeps students informed during travel.

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The system integrates with Google Sheets for cloud-based data storage. Attendance records and GPS data are automatically uploaded to a centralized spreadsheet. Authorized users can access this data in real-time without requiring specialized software or servers. This approach significantly reduces implementation and maintenance costs.

A. Comparative Analysis

Compared to RFID-only systems, the proposed solution offers real-time location tracking in addition to automated attendance. Compared to GPS-only systems, it provides student-level monitoring rather than just vehicle tracking. Unlike complex IoT systems that require mobile applications or subscription services, the use of Google Sheets ensures simplicity and accessibility.

The system balances technological capability with practical usability. It is suitable for schools with limited technical resources while still providing advanced monitoring features. Its modular design also allows future expansion without major changes.

V. RESULT

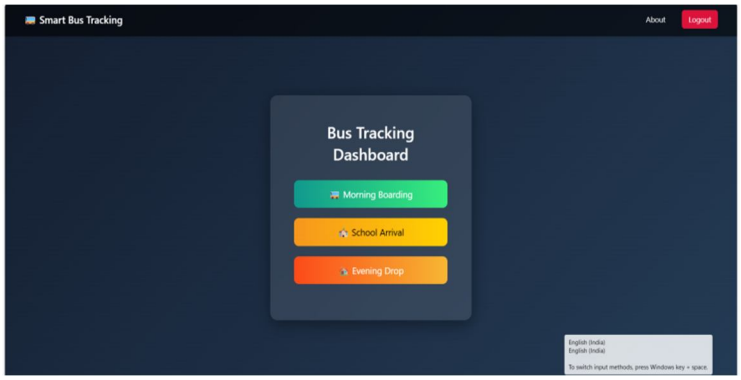


Fig. Dashboard



Fig.Regitration Dashboard

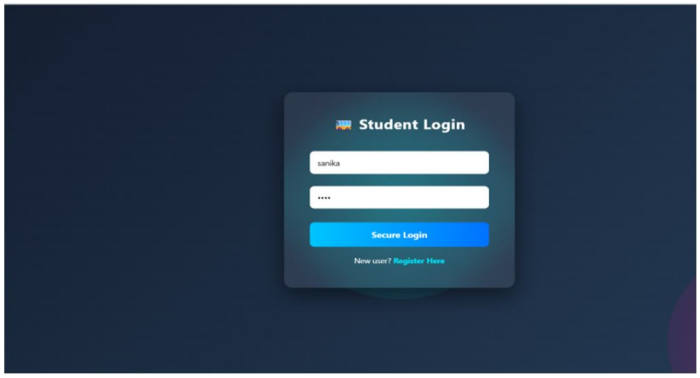


Fig.student Login

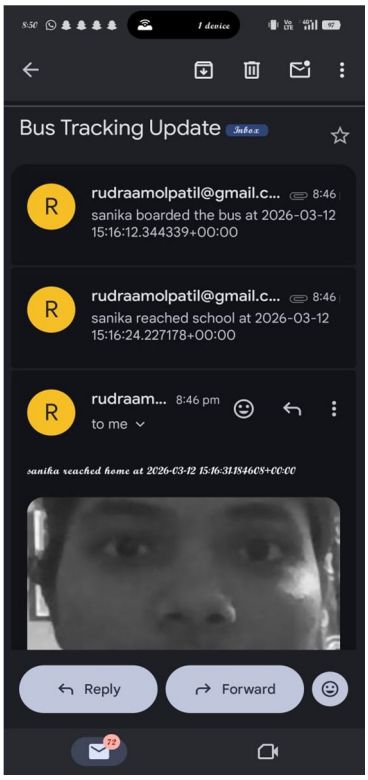


Fig. All notification to send Gmail id

VI. FUTURE SCOPE

Future enhancements of IoT-based school bus systems may include artificial intelligence for route optimization and delay prediction. Machine learning algorithms can analyze historical data to improve scheduling efficiency. Emergency alert systems can be enhanced to notify parents instantly during route deviations or delays.

Integration with school management systems can automate attendance synchronization across platforms. Energy-efficient components and solar-powered modules may also improve sustainability.

VII. CONCLUSION

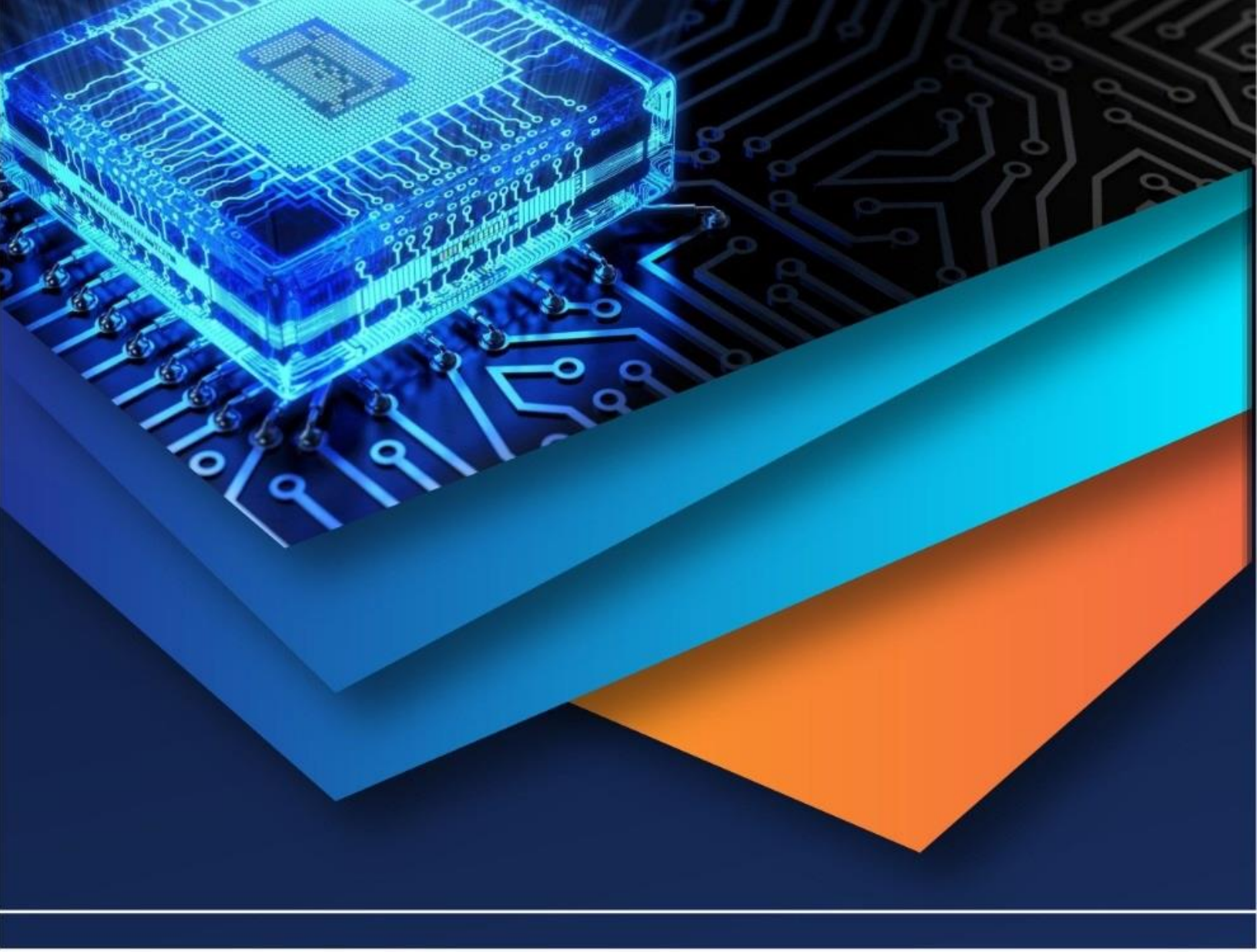
This review paper analysed IoT-based smart school bus and student monitoring systems with a focus on the proposed model presented in the base paper. The study highlights how traditional school transportation systems suffer from lack of real-time tracking, manual attendance, and poor communication. IoT-based solutions effectively address these challenges by integrating location tracking, automated attendance, and cloud-based data management.

The reviewed system demonstrates that combining ESP32, GPS, RFID, RTC, LCD display, and Google Sheets creates a reliable, efficient, and user-friendly transportation monitoring solution. Such systems significantly enhance student safety, improve operational efficiency, and strengthen communication between schools and parents. With future enhancements such as artificial intelligence and predictive analytics, IoT-based school transportation systems have strong potential to become standard solutions in modern education environments.

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