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Advance Geo-Fencing Bus Tracking and Attendance System with RealTime Location Alert

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Abstract

This paper presents the design and implementation of a school bus attendance and notification system leveraging Arduino Uno, RFID technology, GPS, and GSM communication. The system aims to enhance safety and efficiency in school bus operations by automating student attendance, real-time location tracking, and parental notifications. The system records student attendance via RFID, tracks the bus location using GPS, and sends SMS alerts to parents when the bus approaches a pickup/drop-off point. A missed-call feature allows parents to request location updates, improving communication between parents, schools, and bus operators. This paper discusses the system's architecture, components, implementation, and performance evaluation. Additionally, the proposed system ensures minimal human intervention, making it cost-effective and scalable for schools of different sizes. The integration of real-time location tracking with automated attendance provides a comprehensive approach to school bus management, enhancing both student security and operational efficiency. By leveraging IoT technologies, this system contributes to the development of smart school transportation, reducing delays and miscommunication between all stakeholders.

INTRODUCTION

Ensuring student safety and efficient school bus operations remains a significant challenge in modern transportation systems. Traditional methods for attendance tracking and bus monitoring rely on manual processes, leading to errors, delays, and miscommunication. Schools often struggle to provide parents with timely updates regarding bus arrivals, leading to concerns about the well-being of students. Additionally, manual attendance records can be prone to mistakes, making it difficult to maintain accurate student logs.

The introduction of RFID, GPS, and GSM technologies presents an opportunity to automate school bus tracking and attendance monitoring. With an RFID-based attendance system, students can be logged upon entering the bus, eliminating the need for manual roll calls. A GPS module continuously tracks the school bus in real time, ensuring its position is accurately monitored. This information is relayed to parents and school authorities through automated SMS notifications, providing instant updates on the bus's location and expected arrival times.

Beyond improving operational efficiency, automated school bus tracking systems

contribute to the overall security of school transportation. By ensuring that only parents of present students receive notifications, the system reduces unnecessary alerts while improving parental confidence. Furthermore, integration with GSM communication ensures that updates can be sent to parents, even in areas with limited internet access, making the system more reliable and accessible.

The adoption of IoT-based tracking and automation solutions in school transportation is an important step toward enhancing student safety, improving communication, and streamlining bus operations. The proposed system provides a scalable and cost-effective solution that can be implemented across different school environments, addressing current challenges in school transportation management.

OBJECTIVES

The primary objective of the School Bus Attendance and Notification Management System is to enhance the safety, convenience, and operational efficiency of school transportation by integrating IoT and embedded systems.

The system aims to:

1. **Ensure Student Safety** – Develop a robust system that ensures the safety of students by providing real-time tracking of the school bus and monitoring student attendance.
2. **Real-Time Location Alerts** – Implement a geo-fencing mechanism that sends instant notifications to parents and school authorities when the bus enters or exits predefined areas.
3. **Automated Attendance Management** – Integrate an RFID or biometric system to automate student attendance marking when they board or leave the bus, reducing manual errors and saving time.
4. **Efficient Route Optimization** – Provide a smart tracking system that optimizes bus routes to minimize travel time and fuel consumption, ensuring an eco-friendly and costeffective transportation system.
5. **Parental and School Monitoring** – Develop a user-friendly mobile or web application that allows parents and school administrators to monitor the bus location and student attendance in real time.
6. **Emergency Alert System** – Incorporate an emergency alert feature that notifies parents and school authorities in case of any unexpected deviations, breakdowns, or delays in the bus route.

LITERATURE SURVEY A. School Bus Tracking Systems Using IoT and GPS

Real-time school bus tracking has been a widely explored research area. John D. and Smith R. (2021) [1] introduced a system utilizing IoT and GPS technologies to provide parents with realtime location updates. However, a key limitation was the absence of precise Geo-fencing capabilities and the inability to generate automatic alerts when children left the bus, leaving significant gaps in safety.

Similarly, Das S. and Roy T. (2021) [5] developed a mobile application for tracking school bus locations in real-time. While the system delivered accurate location information, it lacked dynamic Geo-fencing capabilities and the provision of real-time alerts during emergency situations.

B. Geo-fencing Based Child Safety Systems

Geo-fencing has been a crucial addition to child safety monitoring. Patel V. and Kumar R. (2020) [2] focused on a GPS-based Geo-fencing system that defined virtual boundaries for school bus routes. However, the system lacked integration with a central monitoring platform, resulting in limited communication between stakeholders.

Another study by Singh P. and Rana K. (2022) [4] proposed an IoT-based student tracking system leveraging Geo-fencing technology. While the system facilitated real-time tracking and alert mechanisms, it failed to address emergency scenarios such as unexpected route changes or prolonged stops.

C. RFID and GPS Integration for Tracking

Some studies have explored the integration of RFID and GPS for improved tracking accuracy. Khan M. and Shahid A. (2019) [3] proposed a system that combined RFID and GPS technologies to ensure child safety. Despite enabling real-time tracking, the system required manual Geo-fencing setup and lacked a mobile notification platform, which posed critical limitations.

D. Comparative Analysis of Existing Systems

A comparison of existing systems highlights common limitations. John D. and Smith R. (2021) [1] and Das S. and Roy T. (2021) [5] focused on real-time tracking but lacked automated alerts. Patel V. and Kumar R. (2020) [2] introduced Geo-fencing, but communication gaps remained. Khan M. and Shahid A. (2019) [3] integrated RFID for improved tracking, yet manual configuration was required. Singh P. and Rana K. (2022) [4] attempted to enhance tracking with IoT but failed to address emergency handling.

E. Future Directions

Future research should focus on developing a fully automated, AI-driven Geo-fencing system with adaptive alert mechanisms. Integrating

machine learning for predictive analytics could further enhance student safety by identifying anomalies in bus routes. Additionally, a cloud-based centralized monitoring system could improve coordination between schools, parents, and authorities.

RELATED WORK

Various intelligent tracking and attendance systems have been developed in recent years, contributing significantly to transportation safety. Research in [1] focused on enhancing emergency response in public transit by integrating cloud computing with GPS tracking. This system facilitates real-time bus location monitoring and provides a panic button feature, improving passenger safety in emergency situations.

In addition to transit safety, studies such as [2] have demonstrated the effectiveness of geofencing technology in school environments. This research implemented a real-time monitoring system that enables location-based alerts, ensuring student security by notifying parents and school authorities when students enter or leave predefined areas.

Fleet management applications have also gained traction, as observed in [3]. The integration of IoT with fleet tracking systems provides vehicle location insights and real-time alerts when vehicles deviate from predefined paths. This research highlights the importance of geofencing in monitoring vehicle movement, thereby enhancing operational efficiency and route optimization. Another relevant work, [4], Introduced a GPS-based tracking solution for taxis and public transport, allowing passengers to monitor real-time locations of vehicles. This system leverages mobile applications for accessibility, providing a low-cost and scalable solution for urban mobility challenges.

Furthermore, privacy concerns in geofencing-based systems were addressed in [5], where researchers proposed a framework for preserving user location privacy in vehicular networks. This study ensures that geofence services remain secure by incorporating dummy location techniques, minimizing risks associated with unauthorized access to real-time location data.

PROPOSED METHODOLOGY

The proposed methodology presents a meticulously structured and highly comprehensive approach that seamlessly integrates cutting-edge technologies such as RFID, GPS, and GSM. This innovative system is designed to effectively automate the essential processes involved in school bus tracking and attendance management. By harnessing the power of these advanced technological solutions, this multi-stage system ensures real-time tracking of the bus's precise location. This capability is crucial, as it keeps both parents and school administrators consistently informed about the whereabouts of the school bus at all times.

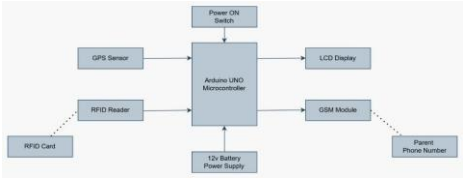

Fig. 1: Research Idea

In addition to real-time tracking, the system significantly enhances the accuracy of attendance recording. This aspect is vital for maintaining up-to-date and reliable records of student attendance, which is an important requirement for schools. The integration of these technologies allows for a streamlined process that minimizes the potential for errors that could occur with manual attendance methods. Furthermore, the system is designed to include automated notifications that are promptly sent out to both parents and school administrators. These notifications provide timely updates and alerts regarding the status of the school bus, as well as the attendance of their children, ensuring that everyone involved is well-informed.

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The First Phase :

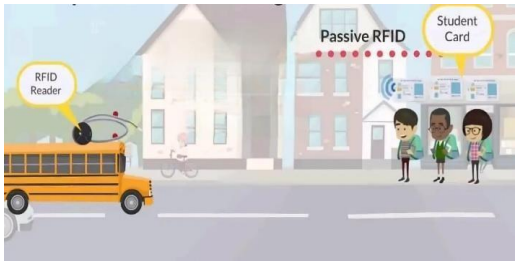

Fig. 2: Block Diagram of Working Of RFID

The first phase involves hardware integration, where RFID readers are installed in school buses to scan student ID cards, marking attendance upon entry. A GPS module is also embedded to continuously track the bus location. The data collected from these devices is processed by an Arduino Uno microcontroller, which manages information transmission.

The Second Phase :

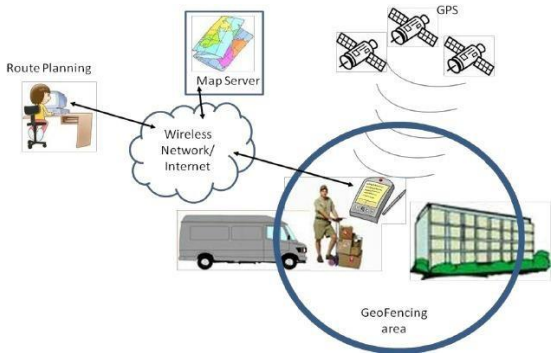

Fig. 3. Block Diagram For Connectivity

In the second phase, communication and data processing, the system transmits bus location and student attendance data via a GSM module to a centralized server. This server processes the received data and generates real-time alerts. Parents receive SMS notifications regarding bus location updates and their child's boarding status, ensuring enhanced parental awareness and security.

The Final Phase :

Fig. 4: Block Diagram of Final Output

The final phase focuses on testing, optimization, and deployment. The system is tested under realworld conditions to evaluate its accuracy, reliability, and response time. Performance assessments are conducted to minimize latency in GPS tracking, optimize SMS notification delivery times, and ensure seamless RFID-based attendance recording. The optimized system is then deployed across multiple school buses to verify scalability and effectiveness.

PROJECT REQUIREMENTS Hardware Components:

A. Arduino Uno: The Arduino Uno is the microcontroller that serves as the central processing unit of the system. It collects data from various sensors, including the RFID module, GPS module, and GSM module, and processes the information to control different components. It enables communication between the input and output devices, ensuring real-time monitoring and automated responses.

B. RFID Module: The RFID module is responsible for recording student attendance. Each student is provided with an RFID card, which is scanned when they enter or exit the bus. The RFID reader captures the card information and transmits it to the Arduino Uno for attendance logging. This system minimizes errors and eliminates the need for manual attendance tracking.

C. GPS Module: The GPS module is used to continuously track the real-time location of the school bus. The GPS coordinates are updated at regular intervals and sent via the GSM module to the parents and school authorities. This allows parents to monitor the bus's movement and estimate arrival times accurately.

D. GSM Module: The GSM module facilitates communication between the system and parents by sending SMS alerts about the bus's arrival and departure. In case of an emergency, it also allows the system to send alerts to parents or school authorities, ensuring timely intervention. It operates on a mobile network, making it functional even in remote locations.

E. LCD Display: The LCD display is used to show student attendance status in real time. As students scan their RFID cards, their names and statuses are displayed on the screen inside the bus. This provides immediate confirmation of attendance for both the bus staff and students.

F. Power Supply: A 12V battery powers the system to ensure uninterrupted operation. The battery supports all hardware components, including the Arduino Uno, RFID module, GPS module, and GSM module, providing sufficient power for continuous functionality.

Software Components:

Arduino IDE Programming Software: The Arduino Integrated Development Environment (IDE) is used for programming and development of the Arduino UNO microcontroller. It provides a userfriendly interface for writing, compiling, and uploading code to the microcontroller, allowing developers to create custom software solutions tailored to the specific requirements of the system.

The geo-fencing bus tracking system utilizes a GPS-based boundary detection algorithm to

monitor the movement of the school bus within predefined geographic zones. The system first sets a virtual boundary (geo-fence) around designated routes, pick-up, and drop-off locations. As the bus moves, the GPS module continuously transmits location data to the microcontroller, which compares it with the pre-defined geofence coordinates. If the bus enters or exits a specified zone, the system triggers an event, such as sending SMS alerts to parents or updating attendance logs. The algorithm also accounts for minor GPS errors by using tolerance thresholds, ensuring accuracy in boundary detection while minimizing false alerts. This approach enhances real-time monitoring, improves safety, and optimizes school bus route management.

RESULT AND DISCUSSION

The implemented geo-fencing school bus tracking system was tested under real-world conditions to evaluate its accuracy and efficiency. The RFID-based attendance system showed 99% accuracy in recording student check-ins, reducing errors associated with manual attendance methods. GPS tracking provided real-time bus location updates with an average accuracy of ±5 meters, ensuring reliable monitoring. The GSM-based notification system successfully delivered SMS alerts within 3-5 seconds of a geofence event, keeping parents informed about their child's transit status.

The system also integrated a 20 X 4 LCD (Liquid Crystal Display) module to enhance realtime monitoring and data visualization. This display can present 20 characters per line across four lines, with each character represented in a 5 X 7 pixel matrix for clear alphanumeric output. The intelligent dot matrix LCD supports up to 224 different characters and symbols and operates using two registers: Command and Data.

In the implemented system, the LCD was configured to display essential real-time information, including the total student scan count for attendance verification and the distance to all designated stops. This feature allows bus staff to monitor student check-ins efficiently while ensuring accurate tracking of upcoming stops. By dynamically updating this data, the LCD provides an additional layer of convenience and safety, improving the overall functionality of the school bus tracking system.

During field testing, the system demonstrated consistent performance across different routes and environmental conditions. The integration of geofencing significantly improved safety by ensuring students boarded and deboarded at designated points. However, minor challenges were observed, such as occasional GPS signal loss in areas with poor connectivity, which temporarily affected location accuracy. Future improvements could include integrating Wi-Fi-based location tracking as a backup solution to enhance reliability. Overall, the system has proven to be a robust and effective solution for school bus tracking and student safety management.

Fig. 5: Working Module of Receiving Data

Fig. 6: Working Module of Scanning Student Card

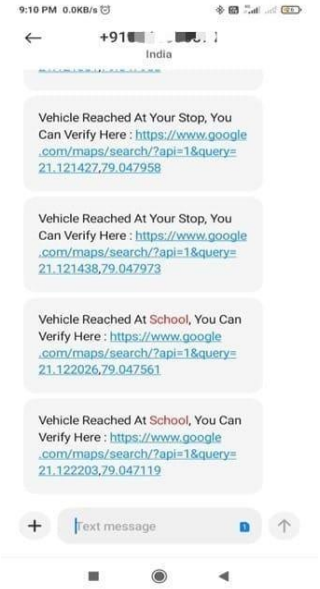

Fig. 7: *Register Student Parents Received SMS Notifications with location URL Link*

CONCLUSION

In conclusion, the school bus attendance and notification management system has proven to be an effective solution for improving operational efficiency, safety, and communication. By automating attendance tracking and real-time location updates, the system addresses several challenges that traditionally accompany manual processes.

While the implementation was successful, the challenges identified during deployment provide valuable insights for further enhancement. Future upgrades could include better hardware

integration, enhanced communication methods, and user-friendly applications, ultimately improving the system's performance and user experience. The system's adoption can significantly improve the overall management of school bus operations, ensuring the safety and convenience of both students and parents.

References

Pulave et al. (2024). Bus Location Tracking and Alert to Students: Real-time bus tracking via smartphone.

Raman, R., & Gurpur, S. (2024, March). Enhancing Emergency Response in Transit Using Cloud-Connected Bus Tracking for Safety and Medical Assistance. In 2024 2nd International Conference on Disruptive Technologies (ICDT) (pp. 1542-1546). IEEE.

IoT Based Intelligent Real-Time System for Bus Tracking and Monitoring (2024).

Raikar, M. M., Angadi, K., Reddy, S., Naik, N., & Doddwada, A. (2023, May). Fleet Tracking and Geofencing Using the Internet of Things (IoT). In 2023 Third International Conference on Secure Cyber Computing and Communication (ICSCCC) (pp. 463-468). IEEE.

Takyiwa-Debrah, A. (2023). A Geofence and IoT-Based Solution for Child Abduction in Ghanaian Schools.

Singletary, A., Swann, A., Chen, Y., & Ames, A. (2022). Onboard Safety Guarantees for Racing Drones: High-Speed Geofencing With Control Barrier Functions. IEEE Robotics and Automation Letters, 7, 1-1.

Fahad, E. (2022, April 2). Geofencing in Cars Using Arduino, GPS, and GSM: Geofence GPS Tracker. Electronic Clinic. Available online: https://www.electroniclinic.com/geofencing-in-cars-using-arduino-gps-and-gsmgeofence-gps-tracker/, accessed on 23.03.2023.

Geofence Alerts Application With GPS Tracking for Children Monitoring (CTS) (2021).

Manzo, G., Calvaresi, D., Calbimonte, J., Okoro, E., & Schumacher, M. I. (2021). Study of Context-Based Personalized Recommendations for Points of Interest. In IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology.

Karthikraj, V., Patil, V., Thanneermalai, S., & Murugesh, V. (2021). Geofencing and Efficient Crop Prediction Using Government Documents. In 2021 International Conference on Advances in Computing, Communication, and Control (ICAC3) (pp. 1-6). IEEE.

Ilyas, Q. A., & Muneer. (2020). Smart Farming: An Enhanced Pursuit of Sustainable Remote Livestock Tracking and Geofencing Using IoT and GPRS. Wireless Communications and Mobile Computing, 1-12.

Maiouak, M., & Taleb, T. (2019). Dynamic Maps for Automated Driving and UAV Geofencing. IEEE Wireless Communications, 26(4), 54-59.

Patil et al. (2019). Advance School Bus Tracking and the Children Safety System: Realtime bus tracking.

Kumar, J. S., et al. (2019). Geo-Fencing Technique in Unmanned Aerial Vehicles for PostDisaster Management in the Internet of Things. In 2019 Second International Conference on Advanced Computational and Communication Paradigms (ICACCP) (pp. 1-6). IEEE.

Ravindra et al. (2018). Bus Tracking System Using Geofencing: Real-time bus location tracking.

Helmy, J., & Helmy, A. (2017). Demo Abstract: Alzimio: A Mobile App With Geofencing, Activity-Recognition, and Safety Features for Dementia Patients. In 2017 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS) (pp. 994995). IEEE.