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IOT Based Smart School Bus and Student Monitoring System

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Abstract: In the ever-evolving landscape of education and technology, ensuring the safety and efficient management of school transportation has become a paramount concern. This project presents an innovative solution, an IoT-based Smart School Bus and Student Tracking System, leveraging the power of ESP32 microcontroller, GPS module, RFID reader, RTC module, LCD display, and Google Sheets integration. The proposed system aims to enhance the safety and accountability of students during their transportation to and from school by providing real-time monitoring and tracking capabilities. The ESP32 microcontroller serves as the central processing unit, orchestrating communication and data exchange between the various components of the system. The GPS module enables accurate and continuous tracking of the school bus's location, allowing parents, school administrators, and relevant authorities to monitor its real-time position. Additionally, the system utilizes RFID technology to uniquely identify and track students as they board and disembark the bus. Each student is assigned a RFID card that communicates with the RFID reader, providing a seamless and automated attendance tracking mechanism. To ensure reliable timekeeping, a Real-Time Clock (RTC) module is incorporated, synchronizing the system time and enabling precise logging of events. The system also includes an LCD display, which serves as a local interface, providing real-time information such as bus location, current time, and any relevant announcements. Furthermore, the integration with Google Sheets facilitates the creation of a centralized database for storing and analysing student and bus data. The system automatically updates Google Sheets with information such as student attendance, bus location, and timestamps, providing a comprehensive and accessible record for school administrators and parents. The proposed Smart School Bus and Student Tracking System offer benefits such as improved safety, enhanced efficiency in attendance tracking, and streamlined communication between school authorities and parents. The use of modern IoT technologies ensures a scalable and adaptable solution that can be customized to suit the specific needs of different educational institutions. This system represents a step forward in leveraging technology to create a safer and more efficient school transportation environment.

Keywords: IOT, ESP32, GPS, RFID, RTC Module, LCD Display, Google Sheets, Student Tracking, School Bus, Real-Time Monitoring, Attendance Management, Safety, Communication, Technological Innovation.

1. Introduction

In recent years, the integration of Internet of Things (IoT) technologies has revolutionized various aspects of daily life, and the education sector is no exception. Ensuring the safety and efficient management of student transportation is a paramount concern for educational institutions. To address this challenge, we propose an innovative IoT-based Smart School Bus and Student Tracking System that leverages cutting-edge technologies such as the ESP32 microcontroller, GPS module, RFID reader, RTC module, LCD display, and seamless integration with Google Sheets. The primary objective of this system is to provide real-time monitoring of both school bus location and student attendance, offering a comprehensive solution to enhance safety, streamline operations, and facilitate communication between school authorities, parents, and students. The utilization of the

ESP32 microcontroller as the central processing unit ensures efficient communication and coordination among the various components of the system.
The GPS module serves as a critical component for accurate and real-time tracking of the school bus, allowing school administrators and parents to monitor the bus's location in real-time. The RFID reader is employed for student identification and attendance management, automating the boarding and disembarking processes and ensuring a secure and efficient workflow.
To maintain synchronization and accuracy in the collected data, a Real-Time Clock (RTC) module is integrated, providing precise timekeeping for the system. An LCD display is implemented on the school bus to provide real-time information such as the current location, time, and student attendance status, fostering transparency and communication within the bus.
Furthermore, the system adopts cloud-based technology through Google Sheets integration. This feature enables the seamless logging and monitoring of student attendance records and bus location data. Authorized personnel can access this information in real-time, facilitating efficient decision-making and comprehensive analysis of the school bus operation.
This paper explores the architecture, components, and functionalities of the proposed Smart School Bus and Student Tracking System. By embracing IoT technologies, the system aims to enhance safety measures, optimize transportation logistics, and strengthen communication channels in the dynamic environment of student transportation.

1.1 Problem Statement:

Student transportation is a critical aspect of educational institutions, and ensuring the safety and efficient management of school bus fleets can be a challenging task. Traditional methods of tracking school buses and monitoring student attendance often lack real-time capabilities, leading to concerns about student safety and operational inefficiencies. The absence of a comprehensive system for tracking school buses and students can result in:

1. **Safety Concerns:**
- Lack of real-time tracking makes it difficult for parents and school authorities to know the exact location of school buses, raising concerns about student safety during transit.
- Manual attendance processes may lead to errors or delays, compromising the safety of students on board.

2. **Operational Inefficiencies:**
- Inefficient and time-consuming manual processes for taking attendance and managing student boarding and disembarking contribute to operational delays.
- Limited communication channels between the school, parents, and students can result in miscommunication and challenges in coordinating transportation logistics.

3. **Data Accuracy and Accessibility:**
- Absence of a centralized system for tracking bus locations and student attendance can lead to data inaccuracies and difficulties in maintaining accurate records.
- Lack of a real-time monitoring system hinders the ability to quickly respond to emergencies or unexpected events during transit.

4. **Communication Gaps:**
- Insufficient communication tools on school buses limit the dissemination of important information to students, such as current location, time, and emergency notifications.
- Inadequate channels for parents and school authorities to communicate with each other in real-time regarding the whereabouts of the school bus and the status of students on board.

In light of these challenges, there is a pressing need for an integrated IoT-based Smart School Bus and Student Tracking System that utilizes technologies such as ESP32, GPS, RFID, RTC, LCD display, and Google Sheets to address the identified issues. This system aims to provide real-time tracking of school buses, automate student attendance management, improve communication between stakeholders, and ensure data accuracy through cloud-based integration. The proposed solution seeks to enhance the safety, efficiency, and overall effectiveness of student transportation in educational institutions.

Objectives

1. **Real-Time Location Tracking:**
- Utilize GPS technology to provide accurate real-time tracking of the school bus's location.
- Enable parents and school authorities to monitor the bus's position and expected arrival times.

2. **Automated Student Attendance Management:**
- Implement RFID technology for secure and automated student identification and attendance tracking.
- Streamline boarding and disembarking processes, ensuring accurate attendance records.

3. **On-Board Information Display:**
- Integrate an LCD display to provide on-board information, including current location, time, and student attendance status.
- Enhance communication within the bus and keep students informed about their journey.

4. **Real-Time Clock Synchronization:**
- Incorporate a Real-Time Clock (RTC) module to maintain accurate timekeeping on the system.
- Ensure synchronization of data with real-world events, enhancing the reliability of time-sensitive information.

5. **Cloud-Based Data Logging and Monitoring:**
- Integrate Google Sheets for cloud-based storage of student and bus data.
- Enable authorized personnel to monitor and analyze real-time and historical data for efficient decision-making.

6. **Enhanced Safety Measures:**
- Provide an immediate alert system for parents and school authorities in case of emergencies or deviations from the planned route.
- Enhance the overall safety of students during transportation.

7. **User-Friendly Interface:**
- Develop a user-friendly interface for parents, students, and school administrators to access relevant information easily.
- Ensure seamless communication channels between stakeholders.

8. **Scalability and Adaptability:**
- Design the system to be scalable, allowing for easy expansion to accommodate a growing number of buses and students.
- Ensure adaptability to the specific requirements of different educational institutions.

9. **Cost-Effective and Sustainable Solution:**
- Strive for a cost-effective implementation that maximizes the benefits of IoT technologies.
- Consider sustainable practices in terms of energy efficiency and environmental impact.

10. **Compliance with Regulations:**
- Ensure compliance with relevant regulations and standards governing student transportation.
- Guarantee data privacy and security measures are in place to protect sensitive information.

Scope

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2. Literature Survey

Raja et al. developed a RFID-based system to track children in buses, but the system's information could not provide information on dangerous situations. They combined RFID and GPS technology to identify students and alert parents via SMS, but the system's automatic notifications may be challenging due to the increasing number of notifications.

The study presents a system that provides real-time information about bus numbers, route details, and location using GPS attached to the bus. The system uses UNO for programming and can be accessed through an Android application. However, it is only suitable for children who can use the generated information.

Emad et al. proposed an IoT-based school bus tracking system, which uses modules like On-Board Diagnosis-II, RFID, DHT22, and a smartphone as a mobile hotspot. The system uses a publish/subscribe mechanism, which requires parents to subscribe for access, which may be a limitation for some parents and not user-friendly.

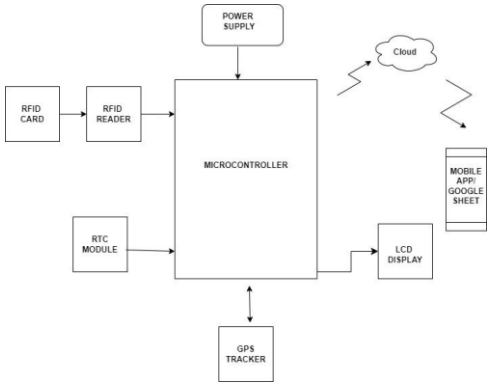
Jisha et al. developed a school bus monitoring system using RFID/GPS/GSM and GPRS technologies to track students and predict arrival times. Parents can monitor the bus route through an Android application, but the system did not consider student safety between the bus and home.

Raj and Sankar proposed a system that provides real-time information about vehicle parameters like location, route, speed, passenger list, and driver adherence. The system uses RFID and GPS technologies and an ESP8266 microcontroller to connect to a remote server over Wi-Fi. Parents can be notified when their ward alights or boards the bus.

Zhenhua et al. developed a multimodal representation learning-based model (MRLM) using global and multimodal feature representation learning. The model improved recommendation effectiveness in IoT by calculating users' preferences through cosine similarity, as demonstrated in real-world dataset experiments.

Son N. et al. have developed Device Profile for Web Simulation (DPWSim), a toolkit for developing service-oriented IoT applications on secure devices. It enables developers to prototype, develop, and test applications without physical devices, and facilitates collaboration among manufacturers, developers, and designers during product development.

3. Methodology



3.1 Block diagram
Fig 1. Block diagram of system

Working
The IoT-based Smart School Bus and Student Tracking System utilizes a combination of hardware components and software integration to provide a comprehensive solution for monitoring the school bus and tracking student activities. Here's a breakdown of how the system works:

1. **ESP32 Microcontroller:**
- The ESP32 serves as the central processing unit and controls the overall functionality of the system.
- It manages the communication between different components, processes data, and controls the flow of information.

2. **GPS Module:**
- The GPS module is connected to the ESP32 to continuously track the real-time location of the school bus.
- The GPS data includes latitude and longitude coordinates, providing accurate location information.

3. **RFID Reader:**
- RFID cards/tags are assigned to each student, and the RFID reader is installed near the entrance of the school bus.
- As students board or disembark, they scan their RFID cards, and the reader records the unique ID associated with each student.

4. **RTC Module:**
- The Real-Time Clock (RTC) module ensures accurate timekeeping within the system.
- It synchronizes the time data to maintain consistency between various events and recorded data.

5. **LCD Display:**
- An LCD display is integrated into the school bus to provide real-time information.
- The display shows details such as the current location of the bus, time, and student attendance status.

6. **Google Sheets Integration:**
- The ESP32 is programmed to send data to Google Sheets in real-time.
- Student attendance records, GPS coordinates, and other relevant information are logged into a Google Sheets document.

7. **Working Process:**
- The system starts when the school bus is in operation.
- The GPS module continuously updates the bus's location, sending this data to the ESP32.

- As students board or leave the bus, they scan their RFID cards, and the RFID reader records the corresponding information.
- The ESP32 processes this information, updates the LCD display with the current status, and logs the data into Google Sheets.
- Authorized personnel can access the Google Sheets document to monitor student attendance and the real-time location of the school bus.

8. Alerts and Notifications:

- The system can be enhanced with features such as alerts for parents when their child boards or disembarks.
- Alerts can also be triggered for school authorities if there are deviations from the planned route or delays.

3.3 Delopeevment

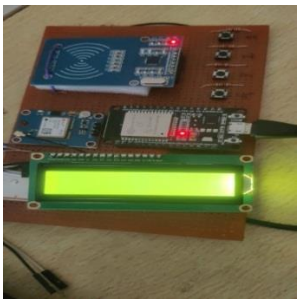


Fig 2.Developement diagram of Project

4. Conclusion

In conclusion, the IoT-based Smart School Bus and Student Tracking System presented in this project harnesses the capabilities of ESP32, GPS, RFID reader, RTC module, LCD display, and Google Sheets integration to create a comprehensive and efficient solution for enhancing student transportation and safety. This system not only addresses the traditional challenges associated with school bus operations but also leverages modern technologies to provide real-time monitoring and data management.

Future Scope

1. Harnessing the Power of Data:

- Data-Driven Decision Making: The system's ability to collect and analyze student attendance, bus location, and usage patterns empowers schools to make informed decisions regarding route optimization, resource allocation, and safety measures. This data-driven approach can lead to reduced transportation costs, enhanced efficiency, and improved student experiences.

2. Creating a Connected Ecosystem:

- Integration with School Management Systems: The integration of the tracking system with existing school management software can streamline attendance records, automate parent notifications, and provide a comprehensive view of student transportation within the broader context of school operations. This integration fosters a cohesive and efficient information flow.
- Incorporating Artificial Intelligence: The integration of AI algorithms can further enhance the system's capabilities by:
- Predicting delays or potential route disruptions based on traffic patterns and historical data.
- Identifying anomalies in student behavior or bus operations, signaling potential safety concerns or operational issues.
- Personalizing communication and notifications to parents based on individual preferences and needs.

5. REFERENCE

1. Raj JT, Sankar J “IoT based smart school bus monitoring and notification system,” in 2017 IEEE Region 10 Humanitarian Technology Conference (R10-HTC), Dhaka, (2017)

2. Sridevi K, et.al ,“Smart Bus Tracking and Management System Using IoT,”Asian Journal of Applied Science and Technology (AJAST), p.3, (2017)
3. Emad B, Elhakim A, Abdulhamid A, Zualkernan IA, “AN IOT BASED SCHOOL BUS TRACKING AND MONITORING SYSTEM “, ” in International Conference on Education and New Learning Technologies, (2016) Jisha RC, Jyothindranath A, Kumary LS “Iot based school bus tracking and arrival time prediction,” in International Conference on Advances in Computing, Communications and Informatics (ICACCI), Udupi, 2017
4. Huang Z, Xu X, Zhu H and Wang C “Multimodal Representatin Learning for Recommendation in Internet of Things,” IEEE Internet of Things, Vols. 6, no 6, pp. 10675–10685, Dec(2019)
5. Han SN et al “DPWSim: A simulation toolkit for IoT application using devices profile for web services,” in IEEE World Forum on Internet of Things (WF-IoT), Seoul, (2014)
6. utrackafrica, “SCHOOL BUS TRACKING & MANAGEMENT, ” 4 June 2020. [Online]. Available:https://www.utrackafrica.com/fleet-fuel-management/school-bus-tracking-management
7. Mutimura D “School Buses Could Solve Transport Problems,” 23 August [Online]. Available: https://en.igihe.com/people/school-buses-could-solve-transport-problems(2011)
8. Rafi R, Torner J and Westerberg P (SMART CITY SMART CITY RWANDAMASTERPLAN, Kigali, (2017)
9. Sarda, M., Deshpande, B., Deo, S., & Pathak, M. A. (2018). INTELLECTUAL PROPERTY AND MECHANICAL ENGINEERING-A STUDY EMPHASIZING THE IMPORTANCE OF KNOWLEDGE OF INTELLECTUAL PROPERTY RIGHTS AMONGST MECHANICAL ENGINEERS. International Journal of Social Science and Economic Research, 3(12), 6591-6596.
10. Deo, S. S. (2016). Protection of good samaritans: A study in the light of supreme court's decision in save life foundation case. Int J Law, 6, 12-3.
11. Takale, S., & Mulani, A. (2022). DWT-PCA Based Video Watermarking. Journal of Electronics, Computer Networking and Applied Mathematics (JECNAM) ISSN: 2799-1156, 2(06), 1-7.
12. Takale, S., & Mulani, D. A. Video Watermarking System. International Journal for Research in Applied Science & Engineering Technology (IJRASET), 10.
13. Sarda, M., Deshpande, B., Deo, S., & Karanjkar, R. (2018). A comparative study on Maslow’s theory and Indian Ashrama system.”. International Journal of Innovative Technology and Exploring Engineering, 8(2), 48-50.
14. Deo, S., & Deo, S. (2019). Cybersquatting: Threat to domain name. International Journal of Innovative Technology and Exploring Engineering, 8(6), 1432-1434.
15. Deo, S., & Deo, D. S. (2019). Domain name and its protection in India. International Journal of Recent Technology and Engineering.
16. Mulani, A. O., & Mane, P. B. (2017). Watermarking and cryptography based image authentication on reconfigurable platform. Bulletin of Electrical Engineering and Informatics, 6(2), 181-187.
17. Pol, R. S., Deshmukh, A. B., Jadhav, M. M., Liyakat, K. K. S., & Mulani, A. O. (2022). iButton Based Physical access Authorization and security system. Journal of Algebraic Statistics, 13(3), 3822-3829.
18. Patale, J. P., Jagadale, A. B., Mulani, A. O., & Pise, A. (2022). Python Algorithm to Estimate Range of Electrical Vehicle. Telematique, 7046-7059.
19. Shinde, R., & Mulani, A. O. (2015). Analysis of Biomedical Image‖. International Journal on Recent & Innovative trend in technology (IJRITT).
20. Maske, Y., Jagadale, M. A., Mulani, A. O., & Pise, M. A. (2022). Implementation of BIOBOT System for COVID Patient and Caretakers Assistant Using IOT. International Journal of Information Technology & Computer Engineering (IJITC) ISSN: 2455-5290, 2(01), 30-43.
21. Boxey, A., Jadhav, A., Gade, P., Ghanti, P., & Mulani, A. O. (2022). Face Recognition using Raspberry Pi. Journal of Image Processing and Intelligent Remote Sensing (JIPIRS) ISSN 2815-0953, 2(04), 15-23.
22. Ghodake, R. G., & Mulani, A. O. (2018). Microcontroller Based Automatic Drip Irrigation System. In Techno-Societal 2016: Proceedings of the International Conference on Advanced Technologies for Societal Applications (pp. 109-115). Springer International Publishing.
23. Mandwale, A., & Mulani, A. O. (2016). Implementation of High Speed Viterbi Decoder using FPGA. International Journal of Engineering Research & Technology (IJERT).
24. Kolekar, S. D., Walekar, V. B., Patil, P. S., Mulani, A. O., & Harale, A. D. (2022). Password Based Door Lock System. Int. J. of Aquatic Science, 13(1), 494-501.

25. Seth, M. M.M.Jadhav and A.O.Mulani (2022). Painless Machine learning approach to estimate blood glucose level of Non-Invasive device. Artificial Intelligence, Internet of Things (IoT) and Smart Materials for Energy Applications.
26. Mulani, A. O., Patil, R. M., & Liyakat, K. K. S.(2023) DISCRIMINATIVE APPEARANCE MODEL FOR ROBUST ONLINE MULTIPLE TARGET TRACKING., Telematique
27. Utpat, V. B., Karande, D. K., & Mulani, D. A. Grading of Pomegranate Using Quality Analysis. International Journal for Research in Applied Science & Engineering Technology (IJRASET), 10.
28. Mulani, A. O., & Mane, P. B. (2017). Watermarking and cryptography based image authentication on reconfigurable platform. Bulletin of Electrical Engineering and Informatics, 6(2), 181-187.
29. Deshpande, H. S., Karande, K. J., & Mulani, A. O. (2014, April). Efficient implementation of AES algorithm on FPGA. In 2014 International Conference on Communication and Signal Processing (pp. 1895-1899). IEEE.
30. Swami, S. S., & Mulani, A. O. (2017, August). An efficient FPGA implementation of discrete wavelet transform for image compression. In 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS) (pp. 3385-3389). IEEE.
31. Kulkarni, P. R., Mulani, A. O., & Mane, P. B. (2017). Robust invisible watermarking for image authentication. In Emerging Trends in Electrical, Communications and Information Technologies: Proceedings of ICECIT-2015 (pp. 193-200). Springer Singapore.
32. Mulani, A. O., & Mane, P. B. (2016). Area efficient high speed FPGA based invisible watermarking for image authentication. Indian journal of Science and Technology.
33. Mane, P. B., & Mulani, A. O. (2018). High speed area efficient FPGA implementation of AES algorithm. International Journal of Reconfigurable and Embedded Systems, 7(3), 157-165.
34. Kashid, M. M., Karande, K. J., & Mulani, A. O. (2022, November). IoT-based environmental parameter monitoring using machine learning approach. In Proceedings of the International Conference on Cognitive and Intelligent Computing: ICCIC 2021, Volume 1 (pp. 43-51). Singapore: Springer Nature Singapore.
35. Mane, D. P., & Mulani, A. O. (2019). High throughput and area efficient FPGA implementation of AES algorithm. International Journal of Engineering and Advanced Technology, 8(4).
36. Deshpande, H. S., Karande, K. J., & Mulani, A. O. (2015, April). Area optimized implementation of AES algorithm on FPGA. In 2015 International Conference on Communications and Signal Processing (ICCSP) (pp. 0010-0014). IEEE.
37. Mulani, A. O., & Mane, D. P. (2018). Secure and area efficient implementation of digital image watermarking on reconfigurable platform. International Journal of Innovative Technology and Exploring Engineering, 8(2), 56-61.
38. Mulani, A. O., & Mane, P. B. (2019). High-Speed area-efficient implementation of AES algorithm on reconfigurable platform. Computer and Network Security, 119.
39. Mulani, A. O., & Mane, P. B. (2014, October). Area optimization of cryptographic algorithm on less dense reconfigurable platform. In 2014 International Conference on Smart Structures and Systems (ICSSS) (pp. 86-89). IEEE.
40. Mandwale, A., & Mulani, A. O. (2015, January). Different Approaches For Implementation of Viterbi decoder. In IEEE International Conference on Pervasive Computing (ICPC).
41. Jadhav, H. M., Mulani, A., & Jadhav, M. M. (2022). Design and development of chatbot based on reinforcement learning. Machine Learning Algorithms for Signal and Image Processing, 219-229.
42. Mulani, A. O., Jadhav, M. M., & Seth, M. (2022). Painless Non‐invasive blood glucose concentration level estimation using PCA and machine learning. the CRC Book entitled Artificial Intelligence, Internet of Things (IoT) and Smart Materials for Energy Applications. Internet of Things (IoT) and Smart Materials for Energy Applications.
43. Mulani, A. O., Birajadar, G., Ivković, N., Salah, B., & Darlis, A. R. (2023). Deep learning based detection of dermatological diseases using convolutional neural networks and decision trees. Traitement du Signal, 40(6), 2819-2825.
44. Vikram A. Kolhe, Suyash Y. Pawar, Soheil Gohari, Altaf Osman Mulani, M. S. Sivagama Sundari, Giriraj Kiradoo, M. Sivaprakash & J. Sunil (2024) Computational and experimental analyses of pressure drop in curved tube structural sections of Coriolis mass flow metre for laminar flow region, Ships and Offshore Structures, DOI: 10.1080/17445302.2024.2317651.