

REAL-TIME SCHOOL BUS MONITORING SYSTEM FOR ENHANCED STUDENT SAFETY USING RFID AND GPS TECHNOLOGIES

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Abstract: The safety of students during their commute to and from school is a critical concern for parents and school administrations. To address this, a low-cost, real-time school bus monitoring system is proposed, integrating RFID and GPS technologies with an ESP8266 microcontroller. The system provides real-time data on the bus's location, speed, route, and passenger list, ensuring that each student's safety is individually monitored. RFID tags identify students as they board or alight the bus, with notifications sent to parents via a mobile application. This system allows school administrations to manage their bus fleets effectively, reduce potential mishaps, and enhance communication with drivers and parents. The Ublox 6M GPS module tracks the bus's geographic coordinates and speed, while the ESP8266 uploads the data to a remote server for real-time access through a mobile app. By offering a reliable and affordable solution, this system addresses the shortcomings of existing GPS tracking devices, which may lack real-time capabilities or be prohibitively expensive. With growing advocacy from educational boards for school bus monitoring systems, this solution meets the urgent need for improved student safety during school commutes.

Keywords: Real-time School Bus Monitoring, RFID and GPS Integration, Student Safety Tracking, ESP8266 Microcontroller.

1. Introduction

Ensuring the safety of children during their daily commute to and from school has become an increasingly significant concern for parents, school administrations, and society as a whole. As urban areas expand and traffic congestion intensifies, the risks associated with school transportation have grown, making the development of reliable and efficient child-tracking systems a priority. Several studies and innovations have been proposed to enhance the safety of school children, addressing various aspects of their commute. Despite these advancements, existing solutions often have limitations that hinder their effectiveness or practicality.

The security of school-going youngsters during their transport processes and the observing of their participation have been proposed in [1]. Anyhow, prior to carrying out such frameworks in true situations, it is pivotal to think about their adaptability and cost-viability, while additionally guaranteeing consistence with information protection and security guidelines. The work introduced in [2] recommends a technique to upgrade the security and proficiency of public transportation in metropolitan regions through constant area following and course improvement for transports [3]. This framework use GPS, GSM, and general parcel radio help (GPRS) advances to screen transport areas progressively, using an eager sending calculation to improve transport courses in view of ongoing traffic information [4].

A RFID innovation based wise transportation framework has been proposed to work on the security and proficiency of school transport transportation [5]. RFID innovation likewise offers a savvy answer for following understudy participation on transports [6]. IoT innovation works with ongoing correspondence between different gadgets, permitting information assortment and examination from various sources, including GPS, traffic sensors, and traveller request [7]. AI calculations can then dissect this information to decide the ideal transport courses. The creators of [8] introduced a technique for concurrent restriction and speed estimation of portable vehicles utilizing radio recurrence electronic tag (RF-ELP) innovation. The proposed framework utilizes RF-ELP and GPS collectors to decide the area and speed of vehicles progressively precisely.

Checking vehicle speed is fundamental for street security, traffic the executives, and proficient driving [9]. In addition, speed checking can improve eco-friendliness, lessen emanations, and advance harmless to the ecosystem driving practices [10]. It can likewise decidedly impact driver conduct by giving constant input on speed, empowering protected and dependable driving [11]. RFID innovation has been broadly taken on in wise transportation frameworks because of its flexibility and various advantages [12]. Research shows that data combination is basic across different applications as it empowers better direction and further developed execution. Detached RFID labels, fuelled by the energy from RF signals sent by the user, answer by sending their novel recognizable proof numbers [13]. In school transport global positioning frameworks, uninvolved RFID labels can be implanted in understudies' ID cards, with RFID checks introduced on transports.

A few cloud stages are accessible for school transport checking, offering simple admittance to area and participation information from anyplace with a web association. Amazon Web Administrations (AWS) IoT, Sky blue IoT, and research Cloud offer types of assistance for interfacing, observing, and overseeing gadgets, including school transports [14], [15]. These stages can gather information from GPS gadgets, RFID users, and different sensors, store and interaction it, and examine the information to give continuous area and participation following [16]. ThingSpeak is an open-source IoT stage that works with ongoing information assortment, stockpiling, and examination from associated gadgets [17]. It upholds different gadgets and conventions, offering cloud-based information capacity, examination, and perception.

The remote sensor organization (WSN)- based Wise Transportation Frameworks examined in are essentially focused on street transport in military regions, which require elevated degrees of safety and unwavering quality while gathering information from conveyed sensor hubs. Considering that vehicle following is a limitation issue, a few examinations have zeroed in on confinement inside WSNs. The GPRS, RFID, and WSNs-based global positioning frameworks across a few boundaries, like expense, power utilization, precision, network availability, stockpiling, and wellbeing. GPRS-based following uses portable organizations to follow gadgets, giving high exactness, continuous following, and huge stockpiling limit [17]. Be that as it may, it has significant expenses, power utilization, and requires ordinary upkeep. RFID-based following purposes radio recurrence ID to follow objects, offering a financially savvy arrangement with low power utilization and insignificant support necessities [5]. Nonetheless, it has restricted reach and ongoing following capacities. WSN-based following purposes sensors to follow gadgets remotely, offering continuous following, low power

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utilization, and versatility [6]. Be that as it may, it has restricted reach and capacity limit and can be costly to set up.

The proposed work presents a school transport checking framework that adjusts cost-viability, simple incorporation, continuous vehicle following, and improved wellbeing and security. The framework utilizes aloof RFID innovation and GPRS correspondence for ongoing vehicle following and checking. GPRS as a correspondence convention offers a WAN association, making it more straightforward to track and screen vehicles in regions without Wi-Fi network. Then again, latent RFID gives ongoing ID and following without power utilization, making it energy-proficient and financially savvy. The framework's alarm highlight improves security by advising the proprietor or overseer of any unpredictable action, like robbery. The ongoing information created by the framework can be utilized for proficient armada the board, smoothed out correspondence, further developed record-keeping, and expanded wellbeing and security. This framework can assist schools and transport administrators with following administrative necessities and give a more secure, safer climate for youngsters.

2. Basic Building Blocks Hardware Description

The image illustrates the core components of the system using an Arduino microcontroller. This system leverages IoT technology to enhance the safety and monitoring of students during their daily commute. In Figure 1, each component is described in detail, along with its significance in the overall system.

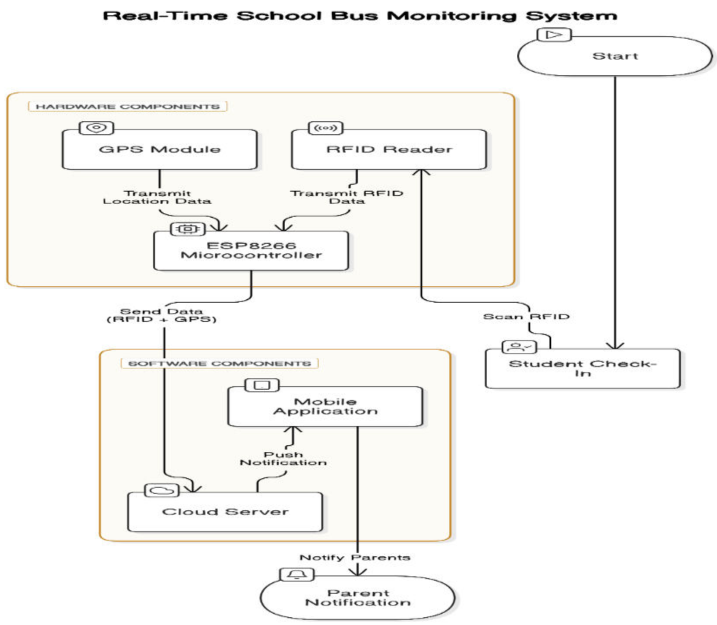

Figure 1: Circuit Diagram for IoT Based Smart Home
Security Cum
Automation System with GSM Module

a) **Arduino Uno**:

- **Function**: The central processing unit of the system.

- **Importance**: The Arduino Uno is a microcontroller that serves as the brain of the system. It integrates data from various sensors and modules (such as RFID, GPS, WiFi) and processes it to execute necessary actions like updating the LCD, triggering the buzzer, and communicating with the mobile app. The ease of programming, abundant libraries, and community support make Arduino Uno an ideal choice for this project.

b) **Power Supply**:
- **Function**: Provides the necessary electrical power to all components.
- **Importance**: A reliable power supply is crucial for the consistent operation of the Arduino and all connected peripherals. Without a stable power source, the system could fail to function, potentially compromising the safety and monitoring capabilities of the bus.

c) **LCD (Liquid Crystal Display)**:
- **Function**: Displays information such as the current status of the system, student entries and exits, and other alerts.
- **Importance**: The LCD is the visual output device that provides real-time feedback to the bus driver or operator. It can display critical information like the number of students on board, unauthorized entry alerts, and more. This helps the driver stay informed and take immediate action if needed.

d) **GPS Module**:
- **Function**: Tracks the geographic location and speed of the school bus.
- **Importance**: The GPS module is essential for real-time tracking of the bus's location. This information is crucial for both parents and school administrators, as it allows them to monitor the bus's route, ensure that it adheres to the schedule, and respond quickly in case of any deviations or delays. The GPS data is also used to estimate arrival times, reducing the anxiety of parents waiting for their children.

e) **WiFi Module**:
- **Function**: Enables communication between the Arduino system and a remote server or mobile app.
- **Importance**: The WiFi module facilitates the transfer of data collected by the Arduino (e.g., GPS coordinates, RFID readings) to a cloud server. This data is then accessible via a mobile app, allowing parents and school officials to monitor the bus remotely. The WiFi module ensures that the system is connected to the internet, enabling real-time updates and notifications.

f) **RFID Reader**:
- **Function**: Scans RFID tags carried by students to log their entry and exit from the bus.
- **Importance**: The RFID reader is a crucial component for tracking individual students. Each student carries an RFID tag, and when they board or leave the bus, the RFID reader scans the tag and logs the event. This data is then used to update parents and the school administration about the student's status, ensuring that no child is left behind or gets off at the wrong stop.

g) **Buzzer**:
- **Function**: Alerts the bus driver and others in case of unauthorized access or other significant events.
- **Importance**: The buzzer provides an auditory alert, which is critical in situations where immediate attention is required. For instance, if an unauthorized person tries to board the bus or if a student has an issue, the buzzer can sound an alarm to notify the driver, allowing for quick intervention.

h) **Mobile App**:
- **Function**: Interface for parents and school administrators to monitor the bus and receive notifications.
- **Importance**: The mobile app is the user interface of the system, providing real-time updates on the bus's location, student entries/exits, and any alerts. Parents can track the bus's route, get notified when their child boards or leaves the bus, and even communicate with the bus driver if needed. For school administrators, the app provides an overview of all buses in operation, ensuring efficient fleet management.

3. Methodology

The proposed framework includes four key components: a GPS device, an RFID system, a microcontroller, and a GSM module. The GPS device tracks the school vehicle's movement by communicating with GPS satellites. The RFID system, consisting of a reader and passive tags, identifies children as they board the vehicle. The microcontroller (Arduino UNO) handles backend processing, coordinating data flow and system operations. The GSM module is activated when a child presses a distress button, sending an alert SMS to pre-saved contacts for immediate assistance. Additionally, the GSM module uses GPRS to transmit RFID and GPS data to the ThingSpeak cloud for further analysis and visualization.

The framework operates through two systems. First system manages GPS data, where the GPS device sends location data to the Arduino UNO, which processes it and transmits it to the cloud via GPRS. Parents can track the vehicle's location in real-time, and in case of an emergency, the student's location is sent to a registered phone number. Secong system tracks individual students using RFID technology. When the RFID reader identifies a tag, it triggers an LED and a buzzer. If conditions are met, the tag's unique identifier is sent to the cloud, providing parents with real-time access via mobile devices.

GPRS and TCP are integral to the framework's communication system, ensuring reliable and wide-reaching data transmission. The GPRS module connects to the network, and once a TCP connection is established, it securely transmits data, offering a robust solution for mobile and remote applications. The following provides a simplified algorithm for the implemented code for the Smart School Bus Monitoring System project:

1. System Initialization (Setup):
   - Initialize the LCD display with a welcome message and "USING IOT".
   - Set the motor, buzzer, LED, and sensor pins as inputs/outputs.

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- Establish communication with the Arduino board and ESP-01 module (if connected).
- (Optional) Initialize the DHT sensor (commented out in the code).

2. Main Loop (loop):
   - Read RFID Tag:
   - Check for data on the serial port (connected to the RFID reader).
   - Read the received data character by character and store it in a string.
   - Compare the received RFID tag with authorized student IDs.
   - Authorized: * Increase a counter (count6) to track entry/exit events.
   - Display "Student Entry" or "Student Exit" on the LCD based on the counter (1 for entry, 2 for exit). * Send a confirmation message ("Student Entry\r" or "Student Exit\r") to a server (optional).
   - Reset the counter to 0 after displaying the exit message.
   - Unauthorized: Display "UNAUTHORISED CARD" on the LCD.
   - Turn on the LED and buzzer for a specific duration to alert.
   - Send a confirmation message ("Unauthorised Entry\r") to a server (optional). Clear the temporary data storage after processing the RFID tag.
   - ESP-01 Communication
     Check for data on the communication port connected to the ESP-01 module. Read the data and convert it to a string. Process the received message based on keywords: "HELLO": Respond with a confirmation message ("Wifi says: Hello\r") (optional). "LED ON" (commented out): Extract a number from the message (if valid) and potentially control LEDs based on the received instruction.
3. Delay:
   - Introduce a delay to prevent overwhelming the system with rapid data processing.
4. Repeat:
   - The loop function continuously executes, repeating the steps mentioned above (RFID tag reading, ESP-01 communication, delay) to monitor the system.

The code comments out functionalities related to sensor readings and sending analog data These might be implemented in the complete program to monitor additional parameters like temperature or humidity. The code focuses on the core functionalities of student identification and basic communication with the Wi-Fi Module. In a complete system, data would likely be transmitted securely to a cloud platform for further processing and analysis. Figure 2 depicts the Algorithm of the implemented code. Figure 3 depicts the actual implemented project.

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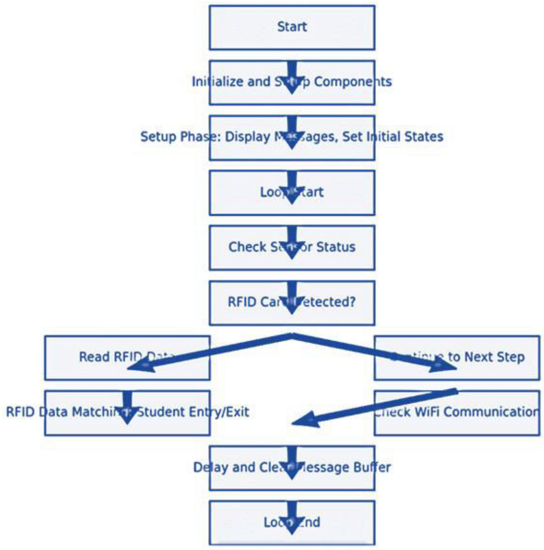

Figure 2: Flowchart of the operation of the Project

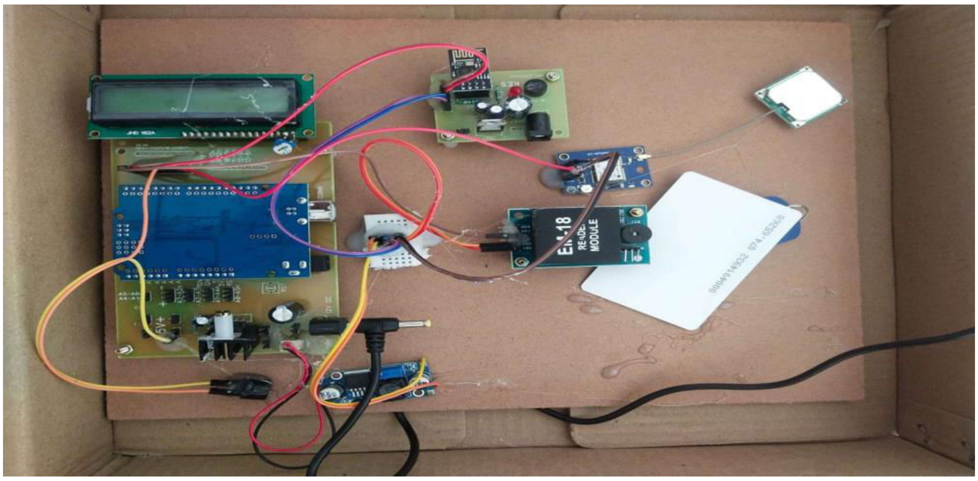

Figure 3: Actual Implemented Project

4. Conclusion

The project Smart School Bus Monitoring System using IoT is a comprehensive solution that enhances the safety and efficiency of school bus operations. By integrating components such as the Arduino Uno, RFID reader, GPS, and Wi-Fi modules, the system provides real-time tracking, monitoring, and alerts, ensuring that students are safe during their daily commute. The inclusion of a mobile app makes the system accessible to parents and school administrators, allowing them to stay informed and take prompt action when necessary. Overall, this system represents a significant advancement in student safety and transportation management, leveraging modern IoT technologies to create a safer and more reliable school bus experience.

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