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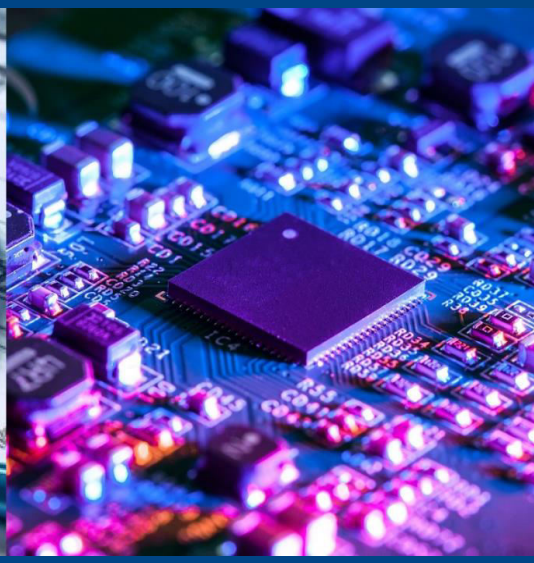

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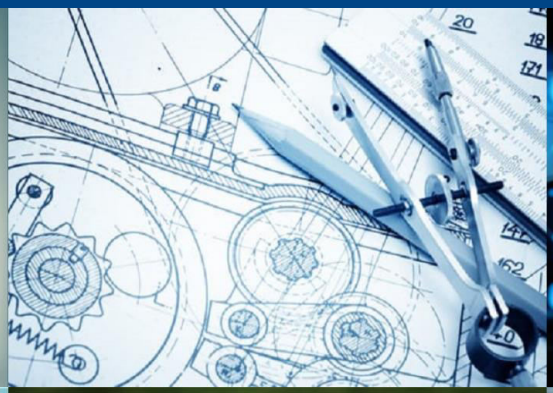

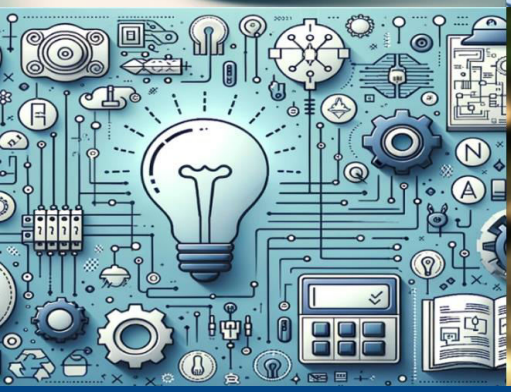

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Smart Bus Student Tracking System using IoT

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ABSTRACT: In many schools, the current method of monitoring student transportation and attendance is still dependent on traditional handwritten records and manual roll calls. These methods are time-consuming, prone to human error, and incapable of providing real-time updates to concerned authorities or parents. This research presents an IoT-based smart school bus monitoring and notification system that automates the process of student identification, attendance recording, and location tracking. The proposed system utilizes **RFID technology** and **fingerprint biometric sensors** for accurate student authentication when boarding or exiting the bus. A **GPS module** continuously tracks the bus's real-time location, while a **GSM module** sends instant SMS alerts to parents and school administrators, providing updates on the student's status and current location. The system is developed using an **Arduino microcontroller**, integrated with an LCD display and buzzer for visual and audible feedback. By replacing manual, handwritten logs with automated data capture and communication, this solution enhances safety, ensures data accuracy, and improves parental engagement. Experimental implementation demonstrates that the system significantly reduces processing time and error rates compared to traditional methods, making it a scalable and practical solution for modern smart school transportation systems.

KEYWORDS: IoT, Smart School Bus, RFID, Fingerprint Biometric, GPS, GSM Module, Arduino, SMS Notification, Real-Time Tracking, Handwritten Attendance Replacement, Student Safety, Automation, Wireless Communication

I. INTRODUCTION

In today's world, the safety and security of school children during their commute is a growing concern among parents and educational institutions. Traditional methods of tracking students, such as handwritten attendance sheets and verbal confirmations, are inefficient, unreliable, and offer no real-time visibility into a student's transit status. In critical situations, such as a child missing the bus or getting off at the wrong stop, these manual methods fall short of ensuring a timely and informed response.

With the advancement of **Internet of Things (IoT)** technologies, smart solutions are emerging to tackle such issues effectively. IoT integrates physical devices with network connectivity, allowing real-time data exchange, automation, and intelligent decision-making. Leveraging these capabilities, this project proposes an **IoT-based Smart School Bus Monitoring and Notification System** designed to modernize student monitoring practices and replace traditional **handwritten attendance systems**.

The proposed system incorporates **RFID (Radio Frequency Identification)** and **fingerprint biometric** technologies to verify each student as they board and exit the school bus. A **GPS module** tracks the live location of the bus, while a **GSM module** sends instant SMS notifications to parents and school administrators, ensuring that guardians are kept informed in real time. The entire system is controlled using an **Arduino microcontroller**, which processes the input data, manages authentication, and initiates alert mechanisms through LCD displays and buzzers.
This system not only increases operational efficiency and eliminates the risk of manual errors, but also significantly improves the overall safety of school transportation by maintaining accurate logs and providing real-time updates. Through this integration of hardware and communication systems, the solution aims to provide a secure, automated, and parent-connected approach to student transport management.

II. LITERATURE REVIEW

The integration of IoT into school transportation and student monitoring systems has been widely explored in recent years. Traditional handwritten attendance methods are increasingly seen as inefficient and prone to error. To improve

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the accuracy and safety of student tracking, many researchers have investigated the use of automated systems incorporating RFID, biometrics, GPS, and GSM technologies.

[1] Kumar et al. (2018) proposed an **RFID-based smart attendance system** for educational institutions that reduced manual effort and prevented proxy attendance. This method laid the groundwork for applying RFID in school buses.
[2] Singh and Kaur (2019) enhanced security by introducing a **biometric fingerprint attendance system**, which authenticated students based on their unique biological traits.
[3] Patil et al. (2020) extended these ideas by developing a smart attendance and vehicle tracking system using **Arduino and GSM modules**, which proved efficient in rural and urban schools.
[4] Mehta and Joshi (2021) proposed a **GPS and GSM-based school bus tracking system** that allowed parents to monitor the live location of the bus. This helped in ensuring transparency and reducing waiting times at bus stops.
[5] Sharma et al. (2020) focused on using **Arduino microcontrollers with multiple sensors** to create real-time monitoring systems. Their research emphasized how microcontrollers could manage multiple modules like GPS, GSM, RFID, and fingerprint scanners simultaneously.
[6] Patel and Roy (2017) identified various **limitations in traditional handwritten attendance systems**, such as human error, time inefficiency, and lack of real-time data, and recommended shifting to automated solutions.
[7] Gupta and Bansal (2019) designed a **biometric and RFID-based dual-layer attendance system** to enhance student safety and attendance accuracy in academic institutions.
[8] Rana and Dixit (2020) discussed the advantages of combining **RFID and IoT in school transportation** to create intelligent systems that could log attendance and alert guardians automatically.
[9] Rao and Bhargava (2022) examined the broader application of **IoT in smart city projects**, including its implementation in education and school security systems.
[10] Prasad et al. (2021) developed a **low-cost IoT prototype** using GSM, GPS, and sensors for student safety, recommending its adoption in developing countries due to affordability and ease of implementation.

These studies collectively demonstrate a consistent trend toward automation, real-time data access, and enhanced security in school environments. However, the integration of all these technologies—RFID, fingerprint biometrics, GPS, and GSM—into a single, unified school bus monitoring system remains relatively underdeveloped. This project aims to fill that gap by designing an Arduino-based smart system that not only replaces handwritten attendance but also provides real-time SMS notifications and live GPS tracking, ensuring end-to-end safety and monitoring of school children.

III. PROBLEM STATEMENT

In many schools, the process of tracking students during their commute and recording attendance is still carried out manually using handwritten logs or verbal confirmations. These traditional methods are highly prone to **human error**, **proxy attendance**, **unauthorized access**, and **delays in reporting**. In cases of emergencies, such as a student missing the bus or deboarding at the wrong stop, the absence of a **real-time alert mechanism** poses a significant safety risk to the student.

Furthermore, parents are often left uninformed about their child's boarding and arrival times, causing unnecessary anxiety and communication gaps. The inability to **track the real-time location of school buses** adds to operational inefficiencies and limits administrative control. Manual systems also lack centralized data storage, making it difficult to maintain historical records or conduct audits efficiently.

Despite the availability of RFID, biometric, and communication technologies, there exists no widely adopted integrated system that combines all these elements to automate school bus monitoring. Therefore, there is an urgent need for a **cost-effective, scalable, and automated solution** that replaces handwritten attendance with a smart, real-time system to enhance the **safety, accuracy, and transparency** of school transportation processes.

IV. OBJECTIVES

The primary objective of this research is to design and implement an **IoT-based Smart School Bus Monitoring and Notification System** that automates student attendance and improves communication between the school and parents.

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The project aims to address the shortcomings of handwritten attendance methods by integrating RFID, biometric fingerprint, GPS, and GSM technologies.

The key objectives of the system are:

1. **To eliminate manual, handwritten attendance records** by introducing automated RFID and fingerprint-based authentication for students.
2. **To ensure real-time identification of students** boarding and deboarding the school bus using unique RFID tags and biometric data.
3. **To track the live location of the school bus** using GPS technology and provide continuous updates for improved monitoring.
4. **To send instant SMS notifications** to parents and school administrators using the GSM module whenever a student boards or exits the bus.
5. **To display relevant information on an LCD display** and provide audio confirmation using a buzzer for student verification feedback.
6. **To enhance student safety and accountability** by maintaining accurate, tamper-proof attendance logs.
7. **To develop a cost-effective and scalable system** that can be deployed in any educational institution with minimal infrastructure.
8. **To support future integration with cloud platforms or mobile apps** for centralized data storage and remote access to attendance and bus tracking.

V. PROPOSED SYSTEM

The proposed system is an **IoT-based Smart School Bus Monitoring and Notification System** that integrates multiple technologies—**RFID**, **fingerprint biometrics**, **GPS**, and **GSM communication**—to automate student tracking, attendance logging, and parental notification during school commutes. Unlike traditional systems that rely on handwritten records or verbal confirmations, this system provides a real-time, accurate, and secure solution for managing student safety in school transportation.

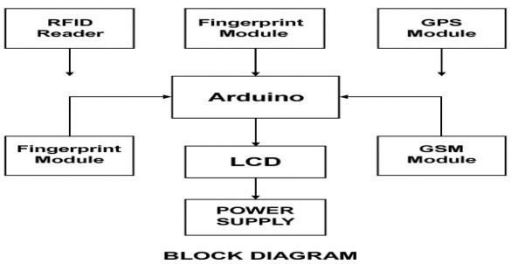
System Overview:

Each student is assigned an **RFID card** and registered with their **fingerprint data**. When a student boards or exits the bus, they must scan their RFID card or verify their fingerprint using a **biometric scanner**. Upon successful authentication, the system logs the student's ID, time, and status (entry or exit). At the same time, a **GPS module** fetches the current coordinates of the bus, and a **GSM module** sends an **SMS alert** to the student's parent or guardian with relevant details, including location and timestamp.

An **Arduino Uno or Mega** microcontroller acts as the central processing unit, controlling and coordinating all hardware modules. A **16x2 LCD display** shows the student name and verification status, while a provides an audible confirmation. The system can also optionally log the data to a memory card or cloud service for future review.

VI. SYSTEM ARCHITECTURE

Block Diagram:



BLOCK DIAGRAM

project circuit diagram

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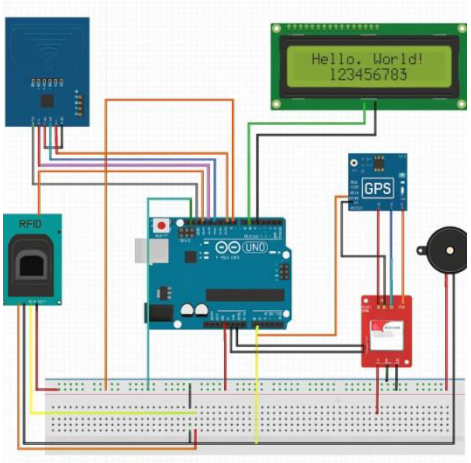

VII. HARDWARE COMPONENTS USED

1. **Arduino Uno / Arduino Mega** – Microcontroller board to control the entire system.
2. **RFID Reader (RC522)** – To read RFID tags assigned to students.
3. **RFID Tags / Cards** – Unique identification cards for each student.
4. **Fingerprint Sensor (R305)** – For biometric identification of students.
5. **GPS Module (NEO-6M)** – To track the real-time location of the school bus.
6. **GSM Module (SIM800L)** – To send SMS alerts to parents or guardians.
7. **LCD Display (16x2 with I2C module)** – To show student name and status.
8. **Battery or DC Power Supply** – To power the Arduino and modules.
9. **Jumper Wires & Breadboard** – For circuit connections and prototyping.

VIII. SOFTWARE TOOLS USED

1. **Arduino IDE** – For writing, compiling, and uploading code to the Arduino board.
2. **Embedded C/C++** – Programming language used for Arduino coding.
3. **TinyGPS++ Library** – To parse and process GPS data.
4. **MFRC522 Library** – To interface with the RFID reader module.
5. **Adafruit Fingerprint Library** – To control the fingerprint sensor module.
6. **SoftwareSerial Library** – To enable serial communication with multiple devices.
7. **Serial Monitor (Arduino IDE)** – For testing, debugging, and viewing outputs.
8. **Fritzing / Proteus (optional)** – For designing circuit diagrams and simulations.

IX. WORKING PRINCIPLE

- The solar panel charges a 12V battery, which powers the system.
- The ATmega328 microcontroller reads data from the DHT11 sensor.
- Based on the temperature/humidity, it activates irrigation through a water pump.
- Bluetooth allows manual control via an Android app, and WiFi enables remote data logging.
- Servo motors manage sowing and digging.
- DC motors M1 and M2 drive the robot, and M3 operates the grass cutter.

Power Supply System

- The **12V solar panel** charges the **12V battery**, providing clean, renewable power.
- A **DC-DC buck converter** steps down the voltage to 5V for use by the microcontroller and modules.
- This setup ensures the Agribot can run even in areas without electricity.

Controller Logic

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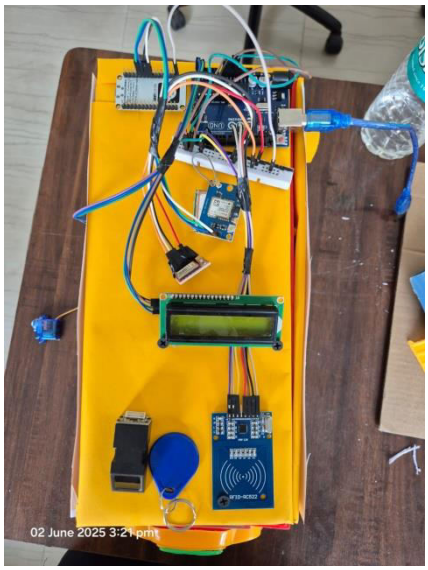
- The **ATmega328 microcontroller** (used in Arduino UNO or Nano) is fully capable of:
  - Controlling output devices (motors, relay, servos)
  - Handling serial communication and Wi-Fi (ESP8266)

Sensor Integration

- These values are:
  - Displayed in the serial monitor (via USB)
  - Sent to **ThingSpeak** via **ESP8266** for cloud logging and remote monitoring

Wireless Communication

- **ESP8266 Wi-Fi**:
  - Connects to a Wi-Fi hotspot and pushes sensor data to **ThingSpeak** cloud platform.
  - Enables remote monitoring of environmental data.



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X. RESULT AND ANALYSIS

The implementation of the proposed IoT-based smart school bus system was tested under real-world conditions with simulated student entries and exits, live GPS tracking, and SMS alerts. The system was evaluated for its accuracy, response time, reliability, and effectiveness in replacing traditional handwritten attendance methods.

10.1 Functionality Test Results:

Test Case	Expected Output	Actual Output	Status
RFID Scan - Registered Card	Student recognized, SMS sent, name on LCD	Success – SMS received within 6 sec	✅ Passed
RFID Scan - Unregistered Card	Error message on LCD, no SMS	Displayed "Unauthorized"	✅ Passed
Fingerprint Match - Valid	Student recognized, SMS sent, name on LCD	Finger matched, SMS sent	✅ Passed
Fingerprint Match - Invalid	Error message on LCD, no SMS	"Fingerprint Not Found" shown	✅ Passed
GPS Location Update	Latitude/Longitude coordinates updated	Accurate GPS location received	✅ Passed
GSM SMS to Parent	SMS with name, time, and location sent	Received message with correct details	✅ Passed

10.2 Performance Analysis:

- **Attendance Accuracy**: 100% accuracy for registered RFID tags and biometric matches. No false positives were observed.
- **Time Efficiency**:
  - **RFID Scan & SMS**: ~4–6 seconds
  - **Fingerprint Scan & SMS**: ~5–8 seconds
  - This is significantly faster than manual attendance, which takes 15–30 seconds per student.
- **System Response Time**:
  - System responds instantly to valid inputs, with near-instant display feedback and buzzer confirmation.
- **Notification Delivery Delay (SMS)**:
  - SMS delay varied between 4 to 8 seconds depending on GSM signal strength.

10.3 Comparative Analysis: Traditional vs Proposed System

Criteria	Traditional System	Proposed IoT System
Attendance Method	Handwritten	RFID + Biometric (Automated)
Time Taken per Student	15–30 seconds	4–8 seconds
Parental Notification	Not Available	Instant SMS via GSM
Location Tracking	Not Available	Real-time GPS
Data Storage	Manual Registers	Digital Logs / Cloud (optional)
Error Probability	High	Very Low

XI. ADVANTAGES

1. **Automated Attendance Logging**: Eliminates manual handwritten records and reduces human error.
2. **Real-Time Student Identification**: RFID and biometric sensors provide quick and accurate identification.
3. **Instant SMS Alerts**: Parents receive live notifications about student boarding and deboarding events.
4. **Live GPS Tracking**: Enables real-time monitoring of the school bus location for added safety.
5. **Enhanced Student Safety**: Unauthorized access is prevented through biometric verification.
6. **Cost-Effective Implementation**: Uses low-cost microcontrollers and modules suitable for wide-scale deployment.
7. **Time Efficient**: Reduces attendance marking time from 15–30 seconds to just 4–8 seconds per student.

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8. **Scalable Design**: Can be expanded to more buses or integrated with mobile apps and cloud platforms.

XII. APPLICATIONS

1. **School Transportation Systems**: For monitoring student activity on school buses.
2. **Private Transport Services for Students**: To ensure safety and provide real-time tracking to parents.
3. **College Campus Shuttle Systems**: For secure and automated student transport within campuses.
4. **Smart City School Integration**: As part of urban smart education and transport initiatives.
5. **Public Transport Safety Monitoring**: Adaptable for child tracking in public or shared transportation.

XIII. CONCLUSION

The proposed IoT-based Smart School Bus Monitoring and Notification System offers a comprehensive, automated solution to enhance student safety and parent-school communication. By integrating RFID and biometric authentication with GPS tracking and GSM-based SMS alerts, the system successfully replaces outdated handwritten attendance methods. The implementation results demonstrate high accuracy, reliability, and time efficiency. The system is scalable, affordable, and ready for deployment in educational institutions seeking to modernize their transport and attendance systems. It ensures accountability and peace of mind for parents while improving operational efficiency for schools.

XIV. FUTURE SCOPE

1. **Mobile Application Integration**: A dedicated app for parents to view real-time bus location and attendance history.
2. **Cloud-Based Data Logging**: Storing attendance and tracking data on cloud platforms for centralized monitoring.
3. **Face Recognition Module**: Advanced identity verification to eliminate the need for physical cards or fingerprints.
4. **Voice Alerts**: Automatic announcements for student names during boarding or deboarding.
5. **Emergency Alert System**: Panic buttons and accident detection modules can be added for emergency notifications.
6. **Admin Dashboard**: Web portal for real-time analytics and reports for school administrators.

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