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Smart Student Travel Management System With Rfid And Gsm Integration

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Abstract
This project presents an intelligent safety and real-time monitoring system for school transportation that combines RFID (Radio Frequency Identification) technology with GSM (Global System for Mobile Communications) for instant alerts. The system automatically notifies parents and school authorities whenever a student boards or alights from the school bus and upon safe arrival at the school premises. Traditional school transport systems often suffer from significant limitations, including delayed information, manual tracking processes, and lack of reliable confirmation about a child's whereabouts. These gaps create anxiety for parents and pose challenges for school administrators in ensuring student safety. The proposed solution integrates an RFID reader, a GSM module, and an Arduino-based microcontroller to create a seamless, automated tracking mechanism. Each student is issued a unique RFID tag. As the student boards or exits the bus, the RFID reader instantly detects the tag, and the system triggers an immediate SMS notification to registered parents and school authorities. The same process is repeated upon arrival at school, providing end-to-end visibility of the student's journey. By merging contactless local identification (RFID) with wide-area cellular communication (GSM), the system delivers a cost-effective, scalable, reliable, and user-friendly solution. It significantly enhances transparency, reduces uncertainty regarding student safety, and enables prompt response in case of any irregularity. This embedded system represents a practical and efficient step toward modernizing school transportation safety through technology, ensuring peace of mind for parents while strengthening accountability within school transport operations.

Keywords: *Arduino Microcontroller, Arduino IDE, GSM Module, RFID module, Wireless Communication.*

1. Introduction

In recent years, the safety and security of school children during daily transportation have emerged as a pressing concern for parents, educational institutions, and transport authorities worldwide. With the increasing number of students commuting by school buses, ensuring their well-being from the moment they board the bus until they reach school (and vice versa) has become a critical responsibility. Unfortunately, traditional school transportation systems still largely depend on manual attendance registers and verbal confirmations by bus staff. These methods are not only time-consuming but also highly susceptible to human error, oversight, and delays. Instances of children being inadvertently left behind in buses, especially during extreme weather conditions, have led to tragic outcomes, including cases of suffocation and severe health complications. Such incidents highlight the urgent need for an automated, reliable, and real-time monitoring mechanism that can provide immediate visibility into a child's transportation status.

The rapid advancement in embedded systems, wireless communication, and identification technologies has opened new possibilities for addressing these challenges. Among the most promising solutions is the integration of Radio Frequency Identification (RFID) and Global System for Mobile Communications (GSM) technologies. This project presents an intelligent RFID and GSM Based School Children Transportation System designed to provide automated tracking and instant notification capabilities, thereby significantly enhancing the safety and accountability of school transportation.

The Need for an Automated Solution

Conventional school bus systems suffer from several inherent limitations. Manual roll calls are often conducted hurriedly, leading to inaccuracies, especially when managing large groups of students. There is frequently a lack of real-time

communication between the bus driver, school authorities, and parents. In many cases, parents remain unaware of their child's boarding or alighting status until the child physically reaches home or school. This information gap creates anxiety among parents and reduces the ability of schools to respond promptly in case of any irregularity or emergency.

Furthermore, the growing number of working parents and nuclear families has increased reliance on school transportation services. Parents expect greater transparency and assurance regarding their child's safety during transit. An effective system must therefore provide accurate, timely, and automated updates without requiring constant manual intervention. The proposed system addresses these concerns by leveraging the strengths of two mature technologies: RFID for precise, contactless identification and GSM for reliable, long-distance communication.

Overview of the Proposed System

The core of the system revolves around an **Arduino-**based microcontroller that acts as the central processing unit. Each student is issued a unique RFID tag, which can be embedded in their school ID card or worn as a wristband. RFID readers installed inside the school bus automatically detect these tags when students board or alight from the vehicle. Upon successful tag detection, the microcontroller processes the information and instructs the connected GSM module to send structured SMS alerts to the registered mobile numbers of parents and school authorities.

Technical Foundation

Radio Frequency Identification (RFID) is a wireless technology that allows automatic identification and tracking of objects or individuals using radio waves. It eliminates the need for line-of-sight scanning, making it far more efficient than traditional barcode systems. In this project, a High-Frequency (HF) RFID reader is used for its reliable performance in close-range applications typical of a school bus environment.

Global System for Mobile Communications (GSM) is a widely used digital cellular network standard known for its robust SMS capabilities and extensive coverage. The GSM module enables the system to deliver instant text messages even in areas with limited internet connectivity, ensuring high reliability across urban and semi-urban regions.

The combination of these two technologies creates a low-cost, scalable, and dependable solution. The Arduino Uno microcontroller serves as an ideal platform due to its sufficient I/O capabilities, ease of programming, and compatibility with both RFID and GSM modules.

Significance of the Project

This project represents a meaningful application of embedded systems technology toward solving a real-world societal issue. By automating student tracking and providing instant notifications, the system significantly reduces parental anxiety and strengthens the overall safety framework of school transportation. It also helps schools maintain better accountability, improve operational efficiency, and respond more effectively during emergencies.

The proposed solution is particularly relevant in the Indian context, where millions of children rely on school buses daily. It offers a practical, affordable, and easily deployable system that can be adopted by both private and government educational institutions. Furthermore, the modular design allows for future enhancements such as GPS integration for live location tracking, mobile applications for parents, and data logging for transport analysis.

The RFID and GSM Based School Children Transportation System transforms conventional school bus operations into a smart, responsive, and secure ecosystem. It not only addresses current safety gaps but also sets a foundation for the future of intelligent school transportation management.

2. Project Description

AIM

The primary aim of this project is to enhance the safety, security, and traceability of school transportation by developing an automated system that detects student boarding and alighting events in real time and instantly notifies parents and school authorities through gsm-based sms alerts.

PURPOSE

The system is designed to overcome the limitations of traditional manual attendance and monitoring methods by providing reliable, automated, and timely information about a child's movement. Its specific purposes are:

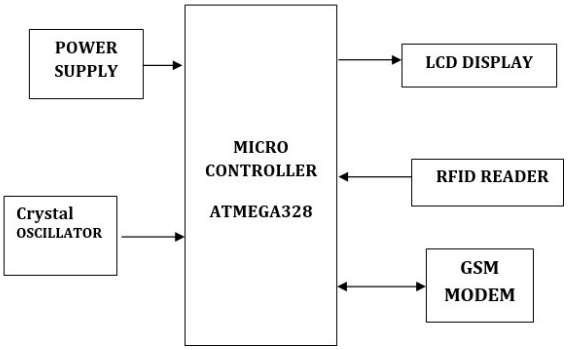
To automatically capture student boarding and alighting events using rfid readers installed inside the school bus.

To process the rfid tag data using an arduino-based microcontroller that acts as the central control unit.

To transmit structured, real-time sms notifications to parents and school authorities via a gsm module whenever a student boards, exits the bus, or arrives at school.

To optionally integrate with school gate systems for automatic confirmation of student entry or exit from the school campus, thereby ensuring complete end-to-end tracking.

Block Diagram:



3. RELATED WORK

The safety and real-time monitoring of school children during transportation have become critical concerns for parents, schools, and transport authorities. Traditional manual attendance systems are prone to human error, delays, and lack of transparency. To address these challenges, researchers and engineers have increasingly explored the integration of Radio Frequency Identification (RFID) and Global System for Mobile Communications (GSM) technologies in embedded systems for automated student tracking.

3.1 This chapter reviews existing literature on RFID-based identification, GSM-based notification systems, and their combined application in school transportation safety. It highlights the evolution of these technologies, key findings from previous studies, identified gaps, and the relevance of the current project.

RFID Technology in Transportation and Tracking

RFID is a wireless technology that uses electromagnetic fields to automatically identify and track tags attached to objects or individuals. Several studies have demonstrated its effectiveness in transportation systems.

Al-Ghobari et al. (2018) developed an RFID-based student attendance and bus tracking system. Their work showed that RFID provides fast, contactless, and accurate identification compared to manual methods. The system successfully reduced time wasted during roll calls and improved accountability. However, they noted limitations in real-time parent notification due to the absence of GSM integration.

Similarly, Sutar et al. (2016) proposed an RFID-based school bus monitoring system that tracks students boarding and alighting. Their findings indicated high accuracy in tag detection but highlighted the need for a wider communication network to inform parents instantly.

GSM Technology for Real-Time Alerts

GSM modules enable reliable long-distance communication through SMS, making them ideal for notification systems.

Kumar and Raj (2017) implemented a GSM-based vehicle tracking system for public transport. Their study concluded that GSM provides cost-effective, real-time alerts with good coverage even in semi-urban areas. However, they observed occasional network delays during peak hours, suggesting the need for backup mechanisms.

Sharma et al. (2019) developed a GSM-based child safety system for school buses. Parents received SMS notifications when the child boarded or left the bus. The system was appreciated for its simplicity and reliability, though it lacked automatic student identification, relying instead on manual input.

4. Arduino

Overview:

The Arduino Uno is a microcontroller board subject to the ATmega328 (datasheet). It has 14 motorized data/yield pins (of which 6 can be utilized as PWM yields), 6 essential wellsprings of information, a 16 MHz artistic resonator, a USB alliance, a power jack, an ICSP header, and a reset catch. It contains everything expected to help the microcontroller; just interface it to a PC with a USB association or power it with an AC-to-DC connector or battery to begin.

The Uno contrasts from every first board in that it doesn't utilize the FTDI USB-to-back to back driver chip. Or on the other hand possibly, it joins the Atmega16U2 (Atmega8U2 up to change R2) adjusted as a USB-to-successive converter.

The Uno board has a resistor dismantling the 8U2 HWB line to ground, making it less mind boggling to put into DFU mode.

The board has the going with new highlights:

pinout: included SDA and SCL pins that are close to the AREF stick and two other new sticks set close to the RESET stick, the IOREF that engage the shields to adapt to the voltage gave from the board. In future,

shields will be extraordinary with both the board that uses the AVR, which works with 5V and with the Arduino Due that works with 3.3V. The resulting one is a not related stick, that is set something aside for future purposes.

Gsm
(Global System For Mobile Communication)

GSM (GLOBAL SYSTEM FOR MOBILE COMMUNICATION) is the most popular standard for mobile telephony systems in the world. The GSM Association, its promoting industry trade organization of mobile phone carriers and manufacturers, estimates that 80% of the global mobile market uses the standard. GSM is used by over 1.5 billion people across more than 212 countries and territories. This ubiquity means that subscribers can use their phones throughout the world, enabled by international roaming arrangements between mobile network operators. GSM differs from its predecessor technologies in that both signaling and speech channels are digital, and thus GSM is considered a second generation (2G) mobile phone system. This also facilitates the wide-spread implementation of data communication applications into the system.

The GSM standard has been an advantage to both consumers, who may benefit from the ability to roam and switch carriers without replacing phones, and also to network operators, who can choose equipment from many GSM equipment vendors. GSM also pioneered low-cost implementation of the short message service (SMS), also called text messaging, which has since been supported on other mobile phone standards as well. The standard includes a worldwide emergency telephone number feature (112).

Newer versions of the standard were backward-compatible with the original GSM system. For example, Release '97 of the standard added packet data capabilities by means of General Packet Radio Service (GPRS). Release '99 introduced higher speed data transmission using Enhanced Data Rates for GSM Evolution (EDGE).

5. Rfid

RFID (Radio Frequency Identification) technology has been around for many years. Prior to the year 2000, common uses for RF-ID in the USA included tollway passes, access ID cards and the tiny ID chips that are inserted in animals for identification. The recent introduction of RFID in the supply chain as well as several mandates has added to the awareness and value of this technology.

RFID tags operate at several different frequencies. The majority of RFID tags operate at either 13 MHZ or 900 MHZ. Think of these two frequencies as the AM and FM bands on your radio. Each one has its advantages. For example, one works better when surrounded by metal while the other will work better over long distances.

13 MHZ (HF) tags are generally better at penetrating liquids and are usually used for access control such as in security cards and wristbands. The read range at this frequency is about 3 feet or 1 meter.

900 MHZ (UHF) tags operate better when reading multiple tags simultaneously, and thus are generally the tag type of choice for inventory purposes. The read range at this frequency is about 3-10 feet or more depending on what type of reader, interrogator or access point is used.

Most RFID tags do not contain any data in them after they are manufactured; they are similar to a blank label waiting for information to be printed on them. To place information in the tag, an encoder must be used. One of the most popular methods of encoding is with an RFID Capable Label Printer that has a built-in encoder and RFID Capable Barcode Label Software.

There are basically three types (called classes) of tags:

Class 0 - these tags are like a license plate in that they are read only and are encoded with data when they are manufactured.

Class 1 - these tags allow you to write the data in the tag and are usually one time programmable (OTP). These are available in either HF or UHF versions and are known as GEN1.

Class 1 GEN2 EPC (GEN2) - these tags are the latest type of UHF tag and are the types of tags most referred to in this document. They are also the tags required for mandates by various suppliers such as Wal-Mart and the US Department of Defense (DOD). In the industry, we refer to these tags simply as GEN2. These tags are 96 bits or larger and contain advanced features such as lock after write and CRC read verification.

The following components are required to write data (encode) to class 1 tags:

Software Application à Encoder Software à Tag Encoder à RFID Tag

The following components are required to read data from the tag:

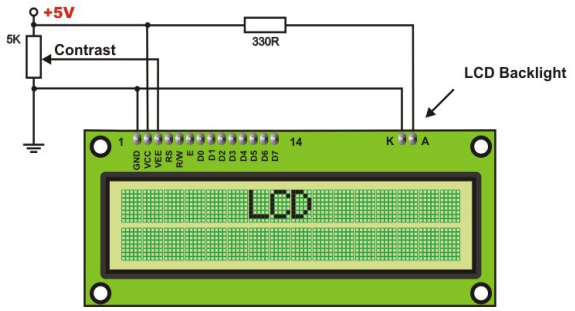
RFID Tag, Reader, Interrogator or Access Point à Decoding Software à Software Application

IDAutomation.com provides some components of this system including Software Applications, Encoder Software and Tag Writers.

6. Liquid Crystal Display

LCD screen:

LCD screen consists of two lines with 16 characters each. Each character consists of 5x7 dot matrix. Contrast on display depends on the power supply voltage and whether messages are displayed in one or two lines. For that reason, variable voltage 0-Vdd is applied on pin marked as Vee. Trimmer potentiometer is usually used for that purpose. Some versions of displays have built in backlight (blue or green diodes). When used during operating, a resistor for current limitation should be used (like with any LE diode).



7. Software Description

Arduino IDE compiler:

Arduino is an open-deliver electronics platform based mostly on smooth-to-use hardware and software utility. Arduino boards can observe inputs - slight on a sensor, a finger on a button, or a Twitter message - and flip it into an output - activating a motor, turning on an LED, publishing a few components online. You could tell your board what to do by sending a hard and fast of commands to the microcontroller at the board. To do so that you use the Arduino programming language (based totally mostly on Wiring), and the Arduino software (IDE), based on Processing.

Over the years Arduino has been the brain of lots of obligations, from regular gadgets to complex medical gadgets. A worldwide community of makers - college students, hobbyists, artists, programmers, and specialists - has collected spherical this open-deliver platform, their contributions have brought as much as a terrific amount of available know-how that can be of terrific assist to novices and experts alike.

Arduino has become born on the Ivrea interaction format Institute as a clean tool for instant prototyping, geared towards university college students without a historic past in electronics and programming. As quickly as it reached a miles wider community, the Arduino board started converting to conform to new dreams and traumatic situations, differentiating its provide from smooth eight-bit boards to merchandise for IoT

Programs, wearable, three-d printing, and embedded environments. All Arduino boards are without a doubt open-deliver, empowering clients to assemble them independently and ultimately adapt them to their unique dreams. The software program, too, is open-supply, and its miles growing thru the contributions of customers globally.

8. Conclusion

In recent years, the safety and security of school children during transportation have become a major concern due to increasing incidents of children being inadvertently left behind in buses, sometimes leading to tragic outcomes such as suffocation. The integration of **RFID and GSM technologies** offers a reliable, automated solution to address these challenges.

This project successfully develops a **Bus Safety System for School Children** that provides real-time monitoring and instant notifications. Using RFID tags for automatic student identification and a GSM module for SMS alerts, the system informs parents, bus drivers, and school authorities whenever a student boards, alights from the bus, or arrives at school.

The proposed system enhances accountability, reduces response time during emergencies, and brings greater peace of mind to parents. It is cost-effective, scalable, easy to deploy, and represents a meaningful application of embedded systems technology toward improving the safety of school transportation.

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