Pioneering Transportation with Next-Gen Safety and Tracking Innovations

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***Abstract*—School buses are the best means of transport for the students across the global. School bus provide the utmost safety and facilities for the students for the transportation toand fro school and home. There has always been a concern to the parents about the missing of their children's. Many times, the students have to wait for a much longer duration for their schoolbus to arrive and the parents also has to wait for a longer duration looking for their children's bus to arrive so that they can pick them. The uncertainty among the students and parents that whether their school bus is yet to arrive for pickup or has already passed away before they could arrive has also beena major issue. The transport management doesn't always has complete information about the utilization of the school buses during every day of the week. This research work proposes the solutions to address these challenges, by real-time tracking, automatic vehicle location and control (AVLC) technologies. It provides a user-friendly interface for students, parents, and school/college management, enabling them to access relevant information and enhance the overall bus transportation experience. The cutting-edge technologies like global positioning system (GPS) and radio frequency indication (RFID) are used to track the live locationof the school bus and also update the pickup/drop of timingof the students. This intern motivates the people to admit their children to the school buses instead of using their own vehicle thereby reducing the traffic and air pollution.**

Keywords: Real-time tracking, Automatic Vehicle Location and Control (AVLC), Global positioning system (GPS) and Radio frequency Indication (RFID).

I. INTRODUCTION

In the era of technological advancements, ensuring the safety and convenience of students during their daily school commute is very significance [1]. Recognizing this need an innovative and comprehensive solution is designed to transform the traditional school bus management system. The smart bus tracking system leverages real-time GPS tracking technology to provide a reliable and user-friendly interface for monitoringand predicting the arrival times of school buses to the school administrators, parents, and students accordingly. The primarygoal of smart bus tracking system is to enhance the overall safety and efficiency of school transportation. Through school bus live location sharing, parents and school management gain good visibility into the real-time whereabouts of the school bus, fostering a sense of security and trust. The user- friendly interface ensures accessibility for allowing parentsand students to effortlessly track the bus's movement andpredict its arrival at their respective locations. Additionally, the application facilitates seamless communication between bus drivers and students by providing the former with real-time information on student locations, ensuring efficient pickups and drop-offs. This research work provides beyond individual benefitsof addressing broader societal concerns. By encouraging the use of school buses over personal vehicles, the project aimsto reduce traffic congestion in the vicinity of schools, con- tributing to a more sustainable and environmentally friendly transportation landscape. As we embark on this endeavour to redefine school bus management, smart bus tracking system aspires to provide a holistic solution so that schools and parents can collectively contribute to a safer, more efficient, and environmentally conscious school transportation system.

II. LITERATURE REVIEW

The literature surveys provide insights into the development and implementation of various college bus tracking and monitoring systems. They discuss the integration of technologies such as GPS, GSM, IoT, and web-based applications to enhance student safety, optimize bus operations, and improve communication among stakeholders. Current Systems: Systems use GSM/GPRS for data transfer, RFID for student data, and GPS for bus position. RFID is used to track people gettingon and off the bus. GPS tracks bus location and student pick- up/drop-off locations by providing position and timing information. Data transfer via the GSM network is made possible by GPRS[2]. Prior Ideas: Concerns about school bus tracking are addressed in part by a number of suggested solutions, some of which may not have been fully implemented. Monitoring loading and unloading operations, notifying absent students viaSMS, tracking the whereabouts of buses, and issuing alerts forspeeding and route deviations are just a few of the proposed functions[3]. A Few Selected Studies According to some research, children's identity cards contain QR codes that can be used to track the times of

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boarding and disembarkation via SMS-based applications [4]. Others concentrate on notifying students and calculating the arrival time. A vibration sensor is incorporated into one system to identify bus accidents. Present Research: The creation of a highly automated system thatmeets the needs of authorities and parents is described in the study. Both a tracking server unit and an on-board tracking device are part of the system [5]. RFID card numbers, current GPS location, and the status of boarding and disembarking are all recorded by the on-board tracking equipment. After being submitted to the tracking server and authenticated, the data is kept in the database. The system's objectives are to send alerts, track bus location, guarantee proper boarding, and deliver real-time information.

III. MOTIVATION AND BACKGROUND

A. Previous Solutions and Limitations:

The literature review reveals that various school bus tracking solutions have been proposed or implemented in the past[6][7][8]. However, many of these solutions have limitations, such as partial imple- mentation, lack of comprehensive features, or being confined to a controlled laboratory environment. Evolution of Tech- nologies:The integration of GPS, RFID, GSM, and mobile communication technologies has evolved over time[9][10]. The literature review highlights the use of these technologies in existing systems, showcasing their potential in addressing specific concerns related to school bus tracking.

B. Existing Challenges:

Challenges such as route deviations, speeding, and communication gaps during loading and unloading activities have been identified in previous research[10][11-15]. These challenges underscore the need for a holistic and fully implemented solution to address the multifaceted aspects of school bus tracking. Scope for Improvement :The gaps and limitations in existing systems provide an opportunity for further research and innovation. By building upon the foundations laid by previous studies, there is a scope to develop a comprehensive and user-friendly School Bus Tracking System that meets the needs of both parents and educational institutions.

C. Child Safety Concerns:

The primary motivation for re- searching and implementing a School Bus Tracking System stems from the paramount concern for child safety. Parents and educational institutions share a collective responsibility to ensure the well-being of students during their commute to and from school.

D. Communication Gap:

The lack of real-time information about the whereabouts of students during their bus journey poses a significant challenge. Parents often find it difficult to track their child's location, leading to concerns and potential anxiety. Bridging this communication gap is crucial for enhancing the overall safety and security of students.

Efficiency in School Management: Educational institutions face challenges in efficiently managing school bus routes, attendance records, and ensuring timely arrivals and departures. Implementing a robust tracking system not only addresses parental concerns but also streamlines the operational aspects of school bus management. Technological Advancements: The rapid advancements in technology, particularly in GPS, RFID, and mobile applications, present an opportune moment to leverage these tools for enhancing school bus safety. The integration of technologies like Google Maps API and Firebase database offers a comprehensive and efficient solution.

IV. ARCHITECTURE

The architecture for the School Bus Tracking System con- sists of three linked parts working together to enable efficient monitoring, management, and safety of students during theirbus commute. These parts are:

A. Management Domain

Web Interface: The management domain is accessible via a web interface that permits administrators to add, update, and handle student and bus data in real-time. Changes by the admininstantly update the database. Real-time Tracking:The man- agement domain connects directly to the database, allowing real-time updates and tracking across the system. The web interface gives administrators a centralized control point to monitor and manage the school bus tracking system.

B. Service Domain

IoT Technologies: The service domain includes IoT technologies within school buses, improving safety and authentication. RFID and Fingerprint tech are used for dual authenti- cation, greatly enhancing security during student boarding and leaving. RFID for Attendance: RFID technology enables secure student login and logout, facilitating real-time attendance data. Students use RFID cards to authenticate when boarding and leaving the bus.

C. GPS for Real-time Tracking:

GPS technology allows real-time bus tracking and navigation. This enables the system to alert parents even before the bus gets to its stop.

D. User Domain

a) Android Application: The user domain uses an Android app for parents. The app provides parents real-time notifications on their child's status during the bus commute.

b) Real-timeNavigation:

Parents can use the app to track the real-time bus location on a map, so they know where their child is Attendance Activity, The Android app has an attendance screento let parents see their child's login and logout times using RFID.

V. OVERALL SYSTEM INTERACTION:

Data Flow:The managementdomain updates the database via the web interface. The servicedomain uses IoT tech like

RFID for attendance and real- time tracking. The user domain and Android app get real-time notifications, bus navigation, and attendance details. Security Measures: Dual authentication with Fingerprint and RFID en- sures secure boarding and leaving. The management domain oversees and monitors the whole system, improving security and reliability.

VI. METHODOLOGY

The Arduino UNO is a versatile microcontroller board designed for a range of applications. It provides a platform for interfacing with various libraries, offering pre-built functions and drivers for diverse devices and processes. This feature minimizes the user's workload and simplifies the developmentprocess. The Arduino Uno is equipped with a sufficient number of digital and analog input/output pins, allowing usersto connect and control a variety of electronic components. Additionally, it supports communication interfaces like I2C, SPI, and UART, facilitating seamless connectivity with other devices.

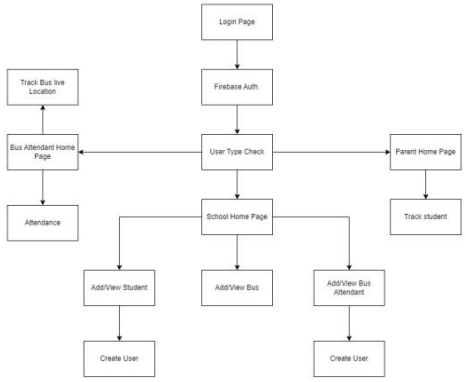

Fig. 1: System Architecture

Its flexibility enables the Arduino Uno to effectively link and regulate a wide array of actuators, sensors, and other electronic components, making it a valuable tool forboth beginners and experienced developers in the realm of embedded systems and electronics.

GSM, or Global System for Mobile Communications, isa widely used standard for mobile communication. In the context of sending SMS and notifications, GSM enables the transmission of short text messages over cellular networks. It allows devices, like GSM modules or mobile phones, to send SMS messages and notifications to recipients. Functioning on the principle of text-based communication, GSM facilitates the quick and reliable exchange of information. Devices integratedwith GSM modules can be programmed to trigger notifications or send SMS alerts, making it a vital technology for applica- tions ranging from remote monitoring to automated messagingsystems.

GPS, or Global Positioning System, is a satellite-based nav-igation system enabling precise location determination world- wide. A network of orbiting satellites continuously transmits signals to GPS receivers on Earth. By calculating the time it takes for signals to travel from multiple satellites, the GPS receiver triangulates its precise location, including latitude, longitude, and altitude. This data allows users to navigate accurately, making GPS integral for various applications such as navigation in vehicles, outdoor activities, and location- based services. The system's reliability and global coverage make GPS a fundamental technology in modern positioning, tracking, and mapping applications.

RFID, or Radio-Frequency Identification, is a technology that uses radio waves for the wireless identification and tracking of objects or people. RFID systems consist of tags, which contain electronic information, and readers, which use radio waves to communicate with the tags. When an RFIDtag enters the range of a reader, it receives energy from the reader's signal and transmits its stored information back to thereader. This information can include unique identifiers or data about the tagged object.

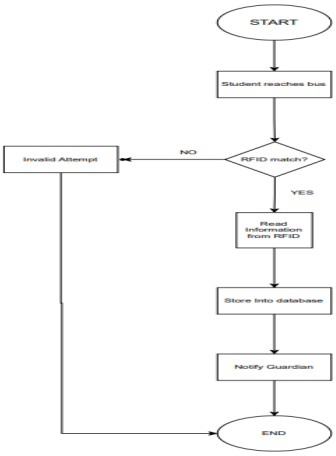

Fig. 2: Flow Chart of Authentication System

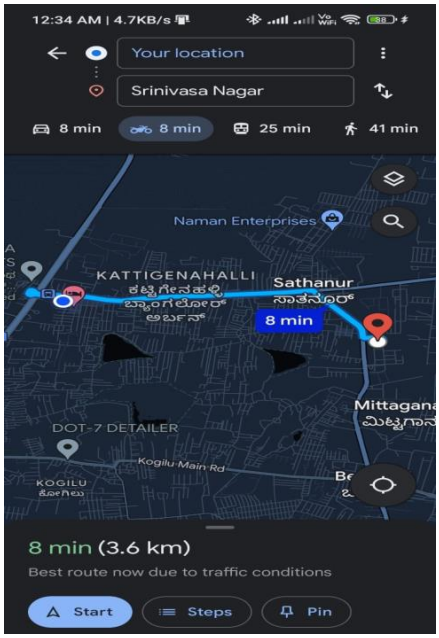

Fig. 3: Optimal Assignment

VII. Results and Discussion

A. Integration of RFID and GPS in School Bus Tracking System

The combination of Radio-Frequency Identification (RFID)and Global Positioning System (GPS) technologies plays a crucial role in building a comprehensive system for tracking the live location of a school bus and managing the pickup and drop timings of students.

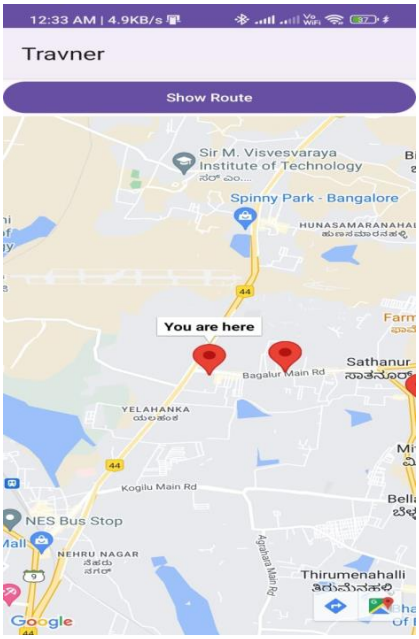

Fig. 4: Students Locations for Pickup

Fig. 5: The Admin control

B. GPS for Real-Time Location Tracking:

GPS technology is utilized to provide accurate and real-time location data of theschool bus. A GPS receiver installed on the bus communicateswith satellites, determining the precise geographical coordi- nates of the bus at any given moment. This information is then transmitted to a central server, enabling authorized users such as school administrators, parents, and the bus driver to track the bus's live location using a dedicated application or web interface as in Table I.

TABLE I. System Working Model

Scenario	Technology used	Technology used	Technology used
Situation	RFID	GPS	GSM
boarding	Scan the card	Location track	Update
travelling	No need	Live location	Update
departing	Scan the card	Location track	Update

C. RFID for Student Identification:

RFID tags are assigned to each student, typically embedded in their school ID cards. These RFID tags contain unique identification numbers associ-ated with individual students. As students board or disembark from the bus, RFID readers installed at the bus entrance and exit points automatically detect and log the presence of the RFID tags.

D. Automated Attendance System:

The integration of RFID technology enables the creation of an automated attendance system. When a student boards the bus, the RFID reader registers the student's presence, and this data is transmitted to the central server in real time. This process is repeated when the student disembarks. Consequently, parents and school administrators can access accurate and up-to-date attendance records for each bus journey.

E. Pickup and Drop Timings Recording:

By combining GPS and RFID technologies, the system can record the pickupand drop timings for each student. As the bus reaches each designated stop, the GPS system logs the time and location. Simultaneously, the RFID reader identifies students boarding or alighting, associating their actions with specific timings. This data is then compiled and made available through the tracking application, allowing parents and school authorities tomonitor when a particular student was picked up or dropped off.

F. Working of the system

When the school bus starts its journey, the GPS system begins transmitting the live location data to the central server. As the bus approaches a designated pickup point, the RFID reader scans the student IDs, marking their presence and recording the time. The GPS system simultaneously logs the bus's location andtime. This process repeats at each stop, creating a comprehensive record of student attendance, pickup, and drop timings. Parents and school administrators can access this information through a secure and user-friendly interface, providing real-time visibility into the school bus's location and the statusof each student on board. The integration of RFID and GPS technologies not only ensures accurate tracking of the school bus but also enhances the safety and efficiency of the entire school

transportation. system by automating attendance and pickup/drop timings for students.

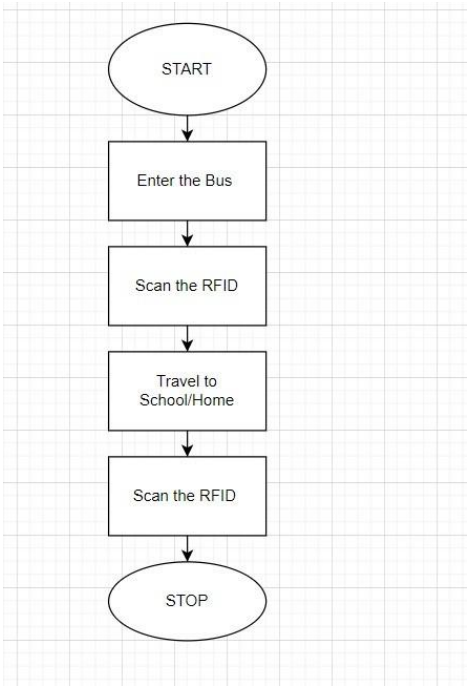

Fig. 6: Sequence Diagram of the user

VIII. CONCLUSION

Ensuring a systematic tracking system for students boardingand deboarding school buses necessitates real-time access to the bus's location. Opting for cost-effective yet robust sensors is imperative for efficiency. The incorporation of RFID technology in school ID cards enables seamless notificationto parents upon their child's entry and exit from the bus.Simultaneously, the GPS system provides live updates on the bus's whereabouts, enhancing parental awareness. The project employs a design that segregates the RFID and GPS sensors, eliminating calibration and maintenance inconveniences. Ad- dressing previous limitations, the program accepts GPS data with a precision of up to six digits, ensuring accurate location coordinates. The synergy of GPS and GSM modules ensures consistent, reliable performance with a compact design and cost-effectiveness.

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