AI-Based Real-Time College Bus Tracking and Alert System

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Abstract. This study presents an intelligent safety and monitoring framework designed to enhance the efficiency and reliability of student transportation systems. The proposed solution automates student identification, enables continuous vehicle location tracking, and supports real-time communication. Student boarding events are authenticated using a unique identification mechanism, allowing attendance to be recorded automatically with high accuracy. Simultaneously, the bus location is updated continuously and shared through an online platform, enabling students and institutional authorities to monitor vehicle movement via a mobile application. The system generates instant notifications in cases of missed boarding and sends confirmation alerts upon successful entry. Attendance logs and location data are securely maintained on a cloud-based platform for real-time access and monitoring. An onboard display further provides visual confirmation of boarding events, improving transparency and minimizing manual errors. Overall, the integrated system enhances student safety, strengthens stakeholder communication, and reduces dependence on manual transportation management processes.

1 Introduction

Due The safety of students during daily transportation has become a significant concern of educational institutions . As the number of school buses is growing and the parents in this respect are becoming more concerned about the movement of students, the traditional way of attending school and keeping track of students is no longer adequate. Paper records like attendance registers and verbal confirmations are prone to errors, delays, and miscommunication, especially when it comes to busy boarding hours. These limitations demonstrate the need for a reliable, automated, and real-time surveillance system that offers transparent information to parents, school administration, and transport coordinators. The recent advances in technologies like Radio Frequency Identification (RFID), Global Positioning System (GPS), Global System of Mobile Communication (GSM), and Internet of Things (IoT) platforms have made it possible to create effective transportation monitoring systems . RFID will help to identify students quickly and individually during boarding and deboarding, whereas GPS will allow for monitoring vehicle location regularly within the route. GSM modules enable instant communication with the help of alert messages, and the cloud services provided by IoT can enable real-time access to data at a distance A combination of these technologies provides an all-encompassing system of enhancement of safety and operational visibility in school transportation systems. The proposed system integrates RFID-based student identification with GPS-enabled vehicle tracking and GSM-based alert mechanisms to automate attendance recording and realtime monitoring. Student boarding events are detected through RFID scanning, and attendance data is immediately updated on a cloud server. At the same time, live vehicle location data is transmitted continuously, allowing parents and school authorities to monitor the bus through a mobile application. Automated notifications are generated to inform stakeholders about boarding status, delays, or route deviations. By reducing manual intervention, the system minimizes human error and improves operational transparency . Besides improving safety, the system will decrease administrative workload, eliminate duplication of records, and enhance communication among the various stakeholders of the system . As more educational institutions adopt smart infrastructure, these systems are essential in changing the transportation management technique and guaranteeing the safety and well-being of the students .

2 Literature Survey

School transportation management in most educational facilities remains based on traditional monitoring methods that provide limited levels of automation, lower levels of accuracy, and minimal real-time visibility . The attendance of students during bus boarding is usually noted by the driver or a staff that accompanies the driver. This is normally done by calling out the names of students or by marking entries in attendance registers and is therefore time-consuming, highly prone to error as well as being highly dependent on human focus, particularly during peak boarding periods . Under traditional systems, parents lack a dependable method to verify whether their child has successfully boarded the school bus. Information is often communicated through verbal updates or phone calls, which may be delayed, inconsistent, or inaccurate . The absence of automated alert systems implies that parents and school authorities are often notified about the problems in a significant delay, which decreases the possibility of responding promptly. Most of the available transportation solutions also do not have live tracking facilities which are based on GPS. As a result, the parents are unaware of the location of the bus, the exact time when it is likely to arrive, or the ability to avoid the route as much as

possible in case of deviation of the route . Also, the lack of a coordinated communication between the transport personnel, school administration, and parents can cause the issue of a lack of understanding in the event of the traffic jams, malfunctioning of the vehicle, or any other alterations in the routes. The other significant disadvantage of traditional systems is that there is no centralised data management. The records of attendance are normally kept in either paper form or segregated electronic records, and there is no single platform of safe storage, analysis or automated reporting of the records . The methodology increases the workloads of the administration and results in slow, inefficient, and unreliable data retrieval mechanisms. In general, the current school transportation systems are highly dependent on manual intervention, which leads to inaccuracies, communication gaps, and inefficiency. The absence of real-time tracking, automated attendance control, and instant notification features highlights the necessity of a more dependable, efficient, and transparent transportation monitoring system .

3 Proposed Methodology

The suggested real-time college bus monitoring and alert system is created to address the limitations of manual attendance processes and the methods of transportation that do not include real-time tracking options . The system incorporates RFID-based student identification, GPS-based vehicle tracking, GSM-based communication, and IoT cloud services to improve safety, transparency, and overall operational efficiency in student transportation.

3.1 Automated Student Identification and Attendance

Every student will have a personal RFID tag, which they will use as an ID. In this case, the RFID reader will be mounted at the bus entrance and will be used to read the tag when a student is boarding the bus vehicle. A microcontroller reads the captured data, authenticates the student and updates immediately on the attendance records. Upon achieving the stage of confirming an individual, the confirmation messages are sent to the parents and school authorities. It is an automated system which removes the flaws that are associated with the manual registers and verbal attendance records.

3.2 Real-Time Bus Tracking

The bus has a GPS module that records and transmits real-time location parameters such as latitude, longitude, and vehicle speed during the trip and records this information all the time in real-time . The data obtained are transmitted to the microcontroller and sent to an IoT-based cloud platform. Parents and school authorities can know the bus routes, stopages and approximate time of arrival through a mobile application. Automated notifications are activated in situations of unforeseen delays or route diversion to notify the concerned parties.

3.3 Instant Communication and Alert

The system uses a GSM module to send SMS messages to parents in the event that a student does not pick up on time or board the bus as scheduled . Such messages are included with the necessary information about the position of the student on the board and the position of the bus. A student can deliver a confirmation message once he or she boards successfully. In case of an emergency, school authorities are also notified of the alerts so that they can respond immediately.

3.4 Cloud-Based Data Storage and Analysis

All the attendance data and vehicle location data are safely stored on an IoT cloud platform to provide constant monitoring and accessibility. Auditing, reporting, and performance evaluation can be done by retrieving historical records. The data collected and stored contribute to the analysis of the route efficiency, the determination of delays, and transportation planning optimization. Cloud storage provides security in handling data, reliability, and ease of verification.

3.5 Visual Confirmation Inside the Bus

A visual confirmation of the student boarding is offered by an LCD screen installed inside the bus, showing the name of the student or the identification number of the student boarding the bus. This feature will help the driver and the staff in attendance verification in real time. The display also assists in avoiding unauthorised boarding and also makes sure that no student is left behind during pick up.

3.6 System Integration and Scalability

The suggested system will combine hardware (RFID readers, GPS modules, GSM modules, LCD displays, and microcontrollers) and software (cloud services and mobile applications) components [8]. The architecture is designed in a way that it can be applied not only in a single bus and route, but also in large clusters of students. The framework can also be extended to encompass university shuttles, corporate transport systems, and transport services that are event-based.

3.7 Advantages of the Proposed System

The proposed solution is more efficient in the aspect of student safety because of proper tracking of attendance and timely delivery of notification. The real time tracking makes sure that their parents and the authorities track the movement of the vehicles and the status of the students. Automation will save on the labour force, enhance the accuracy of the scheduling, and reduce operational errors. The data management based on clouds helps to increase the level of transparency, accountability, and reliability in the records maintenance, and the instant alerts will help to respond instantly in case of an emergency, delay, or unexpected circumstances.

3.8 System Workflow

The overall workflow of the proposed system is summarised as follows: 1) The students approaches to the bus and read the given RFID tag. 2) The microcontroller verifies the identity and changes attendance records. 3) The GPS module continuously tracks the real-time location of the bus. 4) Attendance and location information is uploaded to the IoT cloud platform. 5) Parents and school authorities receive real-time notifications. 6) The LCD display provides visual boarding confirmation for driver awareness. 7) GSM-based alerts are generated in cases of missed boarding or route deviation. 8) Historical data is stored for analysis, reporting, and auditing purposes. The proposed system will integrate identification, tracking, communication, and cloud-based data management to form a comprehensive transportation monitoring system. This combined solution also raises the level of safety, raises the level of transparency, and raises the efficiency of operations in transportation systems in terms of student transportation systems .

4 WORKING PRINCIPLE

The proposed real-time system of college bus monitoring and alert is operated on the principle of the synchronised work of the variety of hardware and communication devices that will help to identify vehicles automatically, track them in real-time, and deliver notifications in real-time to the user The system combines RFID, GPS, GSM, IoT cloud services, a microcontroller, and a display unit, with each component having a specific role to play and communicating with each other via predefined interfaces to realise end-to-end transportation monitoring. The operation begins by the start of the microcontroller, which provides a regulated power to all the connected peripheral modules using the power management unit. When the system is enabled, the GPS module receives the real-time vehicle location parameters, such as latitude and longitude and speed constantly .These parameters are sent to the microcontroller at specific intervals to be processed. The processed location data is then sent to the IoT cloud platform by an internet communication interface, where parents and school management can follow the live bus position by means of a mobile app or web-based dashboard. Simultaneously, RFID-assisted student identification is conducted at the bus entry point. Every student has a special RFID tag that he/she has to scan to board the vehicle . On detection of the RFID tag, the identification information is transmitted to the microcontroller to be verified. After verification, the attendance record of the student is updated and synchronized with the cloud server, providing secure storage and real-time access to the attendance information. GSM module is the module which does the alert generation and communication. When a registered student fails to scan the RFID tag within the stipulated time slot of the assigned bus stop, the system reports a missed boarding event. When this happens, the microcontroller will turn on the GSM module and send an SMS notification to the parent or guardian that the absence has occurred. After the student has been scanned by the RFID, a confirmation message is automatically delivered to parents to inform them that the student has successfully boarded the bus . An LCD or LED display unit installed inside the bus provides visual confirmation of each boarding event by displaying the student's name or identification number following a successful scan . This option is useful in assisting the driver to confirm attendance in real time and to deter unauthorised access. The display is also used as a confirmation that the scanning process has been carried out properly. Information acquired by the GPS, RFID, and GSM modules is constantly updated on the IoT cloud platform throughout the trip. The cloud server keeps the current records of the location of the vehicles, attendance and alerts. The authorised users may have access to real-time information, get historical records and analyse transportation performance when it is necessary. To conclude, the principle of operation is a cyclic process of data acquisition, validation, communication, and cloud synchronisation. The proposed system is safer, more reliable, and more transparent in the management of student transportation by integrating automated identification, real-time vehicle tracking, and instant alert features .

5 SYSTEM ARCHITECTURE

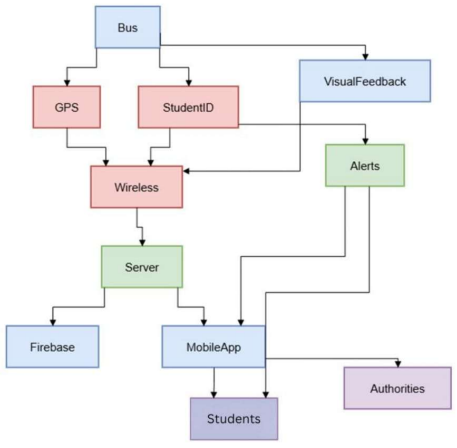


Fig. 1. System Architecture of the Proposed School Transportation Safety and Tracking System

5.1 Architecture Overview

The proposed AI-Based Real-Time College Bus Location Predictor and Alert System is a combination of hardware and software that will guarantee student safety, real-time tracking, and effective transportation management. The buses have GPS tracking and automated student identification modules, alert generation modules, and visual confirmation modules, which are coordinated with a central microcontroller. The system automates the routine processes and gets rid of manual errors; it also gives real-time information to the parents, school authorities, and transport coordinators. It has a modular and scalable architecture allowing support of various buses, extended routes, and institutional transport services integration .

5.2 Architecture Explanation

Every bus will have a GPS unit, which constantly measures its real-time position (latitude, longitude, speed) and transmits it to the microcontroller, which will update a centralised cloud server . The authorities and parents can monitor the buses in real-time, follow the routes they take, and predict the arrival times. RFID readers are used to automate student identification at bus entry points. The students scan the RFID tags and are verified by the microcontroller and sent to the cloud to get immediate confirmation of attendance response instantly . This reduces the administration and errors of the manual. The microcontroller coordinates the information between all modules and stores the attendance and GPS data in an online system like Firebase, which can be viewed by parents, school officials, and administrators in real-time without any risk of security breaches. The visual confirmation of a boarding provided by LCD/LED displays on the interior of the bus makes the driver more aware and prevents unauthorised access. The microcontroller synchronizes information among all modules and saves attendance and GPS data on an online system such as Firebase, where parents, school officials, and administrators can view them in real-time safely . The bus interior LCD/LED displays provide visual validation of a boarding, enhancing driver awareness and preventing unauthorised boarding. The GSM based alert system notifies the SMS or a push notification when one of the students has missed the boarding or when he or she has entered successfully, thus it is transparent and communicated in time . The system provides a system of student transportation management that is reliable, efficient, and fully automated by combining GPS tracking, RFID attendance, cloud storage, GSM alerts, and visual feedback, thus offering a system that is reliable, efficient and fully automated in nature. A GSM-based alert system can be used to send SMS or push notification when a student fails to board or when they successfully enter the building to maintain transparency and ensure timely communication [6].The system provides an effective, highly dependable, and fully automated method of managing student transportation by integrating GPS tracking, RFID attendance, cloud storage, GSM alerts, and visual feedbacks to offer a student transportation management solution to the problem of student transportation management issues in schools and colleges and universities .

6 WORKFLOW

The proposed real-time college bus location and alert system workflow explains the series of processes of automated student identification, vehicle tracking, data synchronization, and notification delivery of the proposed system in that order. It shows how the hardware modules in the plane can be interconnected with the microcontroller, the cloud services, and the end-user applications to guarantee reliable and transparent transportation tracking. It starts in the relevant bus stop, where the students must swipe in with their RFID cards before they get into the vehicle . The RFID reader reads the unique identification number of the student and transmits it to the microcontroller which verifies it. Once authenticated, the attendance status will be updated and sent to the IoT cloud platform to be stored safely and accessed in real-time [10]. In an event where a student fails to scan the RFID card within the given time, the system will automatically raise an alarm and send an SMS message to parents and school authorities through the GSM module . At the same time, the GPS unit constantly monitors the actual position of the car and transmits latitude and longitude values to the microcontroller periodically. It is stored in the cloud server, where the parents and the administrators can track the bus position with a mobile application. This system is also able to provide notifications in the event of deviations in the route, unforeseen delays or long stops, so that the communication is timely and transparent. The bus has an LCD display unit that gives the visual confirmation where the name or unique ID of each student is displayed as they board the bus . This will aid the driver in ensuring attendance and also ensure that unauthorised boarding is avoided. A combination of RFID authentication, GPS positioning, GSM-related notifications and cloud synchronisation ensures the accuracy of the data, the level of security, and effective transportation control along the route. The overall workflow of the system is illustrated in Fig. 2, highlighting the interaction between students, onboard hardware modules, microcontroller processing, cloud server integration, and user interfaces.

7 HARDWARE AND SOFTWARE COMPONENTS

7.1 Architecture Overview

The proposed system integrates multiple hardware modules to ensure accurate and real-time monitoring of both student attendance and vehicle movement . Every hardware is selected to perform a particular task in the overall system, which leads to a stable and integrated

transportation monitoring system. The key hardware items are as follows:

• Arduino UNO: Acts as the main microcontroller that processes the information received by the RFID reader and GPS module, organises communications with the GSM module, and communicates with the IoT cloud platform .

• Power Supply: Delivers controlled and constant power to all the hardware parts, which will guarantee continuous functionality of the microcontroller, sensors, and communication modules.

• RFID Reader: Read the RFID tag identifications of students on the train, which allows them to record attendance automatically.

• RFID Tags: Unique tags assigned to each student, containing encoded identification data that allows fast and reliable authentication.

• GPS Module: Constantly monitors the position of the bus on the ground by recording the latitude, longitude, and speed of the bus.

• LCD Display: Displays the name or unique identifier of students once they are successfully boarded which gives the driver visual confirmation.

• IoT Module: Allows wireless communication between the microcontroller and the cloud platform, which provides the opportunity to upload attendance and location data in real-time .

• GSM Module: Supports SMS-based communication through sending alert and notification to parents and school authorities on missed boarding events or safe boarding confirmation .

• Android Device / Mobile Application: The user interface that will allow parents and administrators to track bus position, student attendance, and receive real-time notifications.

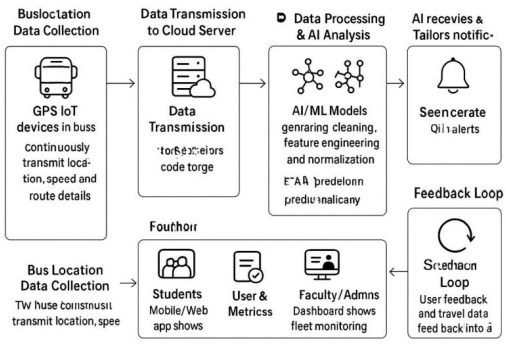


Fig. 2. Workflow of the Intelligent School Transportation Safety and Tracking System

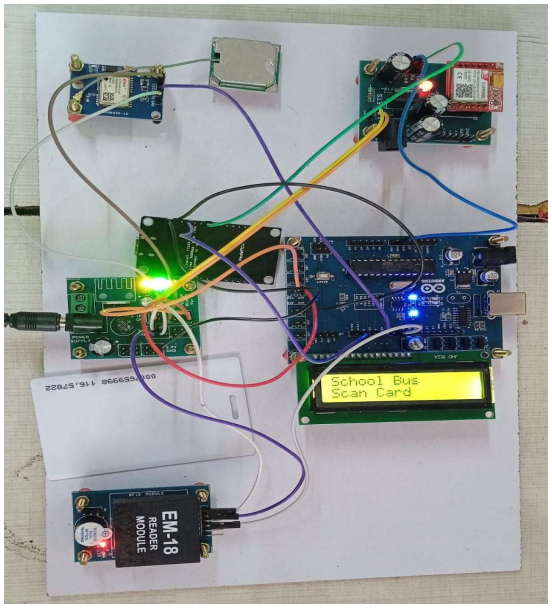


Fig. 3. Hardware Components

7.2 Software Components

The software component provides the required platform of hardware integration, processing of data and cloud communication, and interaction with the user. The important software components employed in the system include:

- Arduino IDE: Used for writing, compiling, and uploading embedded programs to the Arduino UNO microcontroller.
- Embedded C/C++: Employed for low-level programming of the microcontroller to control sensors, process data, and manage communication with GSM and IoT modules.
- Java: Android mobile application used to show real-time bus position, attendance, and notification.
- IoT Cloud Platform: Offers real-time data storage, synchronisation, and secure access to mobile applications and web dashboards .
- SMS Gateway API: Allows the automatic sending of messages via GSM communication with the purpose of notifying parents and school officials.

The integration of this hardware and software leads to a complete system of transportation monitoring that is automated, scalable, and reliable. The proposed solution will guarantee an improved level of student safety, real-time visibility, and efficient communication between all stakeholders due to the combination of microcontroller-based sensing with cloudbased data management and mobile applications.

8 Results and Discussion

The proposed AI-Based Real-Time College Bus Location Predictor and Alert System was developed and tested to assess its usefulness in improving safety, real-time monitoring, and efficiency of students and operations.

8.1 Results

The system demonstrated the following outcomes during testing :

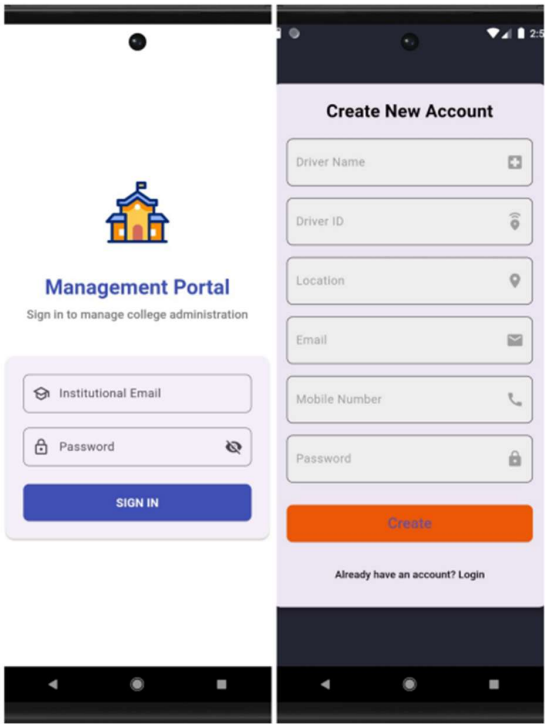
• Automated Attendance Accuracy: Student identification using FID in student attendance registered almost accurately at 100 %.

• Real-Time Location Tracking: GPS modules were used to give constant updates of bus position with minimal latency (2–3 seconds), allowing parents and administrators to monitor the bus in real time.

• Instant Alerts and Notifications: Late boarding and safe boarding confirmations were forwarded as SMS straight away via GSM.

• Display Functionality: The ID or name that was shown in the LCD on the bus was accurate, and this helped in identifying the driver and prevented unauthorised boarding.

• Cloud Data Management: The IoT cloud implementation provided an uninterrupted and secure storage of the information of attendance and location users that can be accessed and analysed to present analytics, reports, and history.



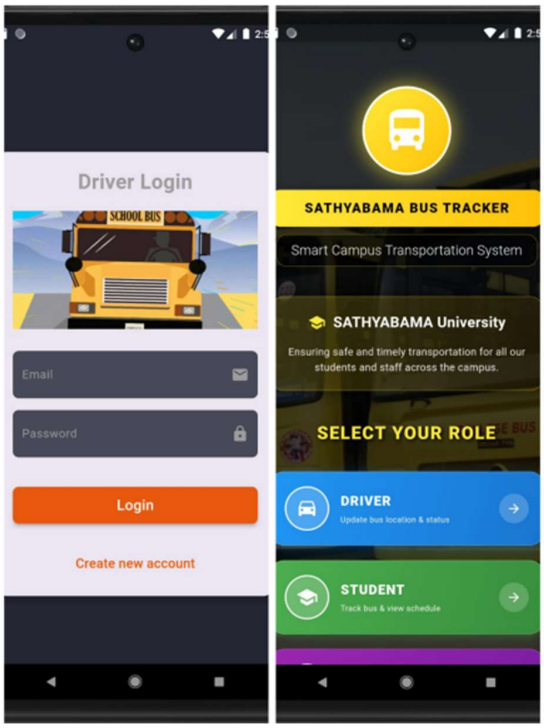


Fig 4. Output Visualisation

8.2 Ablation Study

To determine the value of each of the components, an ablation test was carried out by disabling the components [16]:

Configuration	Attendance (%)	Notification (%)
Full System (RFID + GPS + GSM + IoT)	99.8	100
Without RFID	0	50 (Unreliable)
Without GPS	99.8	70 (Location alerts missing)
Without GSM	99.8	0 (No SMS alerts)
Without IoT Cloud	99.8	90 (Delayed notifications

Table 1. Ablation Study Results

The study indicates that:

• RFID is critical for accurate student identification and attendance recording.

• GPS provides real-time positioning and position alerts.

• GSM is necessary to send SMS notices immediately to parents and authorities • IoT cloud provides real-time synchronization, secure data storage, and accessibility via mobile applications.

8.3 Discussion

Ablation study shows that each of the modules contributes greatly to the overall performance of the system . Key insights include:

• All the modules are integrated to enhance higher student safety by issuing accurate attendance, position, and realtime notifications.

• The operational efficiency is optimised, since automation decreases the level of manual labour and enhances transparency.

• Parental assurance is improved with real-time alerts and mobile app monitoring.

• The limitations that have been noted are that sometimes there are delays in the delivery of SMSs when the network is weak; push notifications can be incorporated in the future as an addition.

In conclusion, the system is a safe, scalable, and smart system that can deliver transportation to schools, guaranteeing safety, transparency, and efficiency in operations.

9 Conclusion

The AI-Based Real-Time College Bus Location Predictor and Alert System offers a detailed, automated, and dependable solution to the contemporary student transportation problem in the XXI century . The system combines the RFID-based student identification, GPS-tracked vehicle tracking, GSMbased communication, IoT-based cloud storage, and mobile apps, which will make sure that boarding is safe, the vehicle location is tracked, and parents are notified about the situation in the school, and school authorities can effectively manage the transportation processes, since all these elements are seamlessly integrated. This system significantly enhances the security of the students as it enables real time confirmation of boarding and automatic alerts on missed stops and continuous tracking of buses by GPS. The in-bus LCD display will allow the drivers to monitor student boarding on the bus in real-time, which will assist in avoiding unauthorised access and probability of a human factor . The system will also assist in keeping the administrative load to a minimum (to automate attendance records, track the location, and send notifications), improve the efficiency of the work, and reduce potential delays or misunderstandings. Moreover, the proposed solution is highly scalable and flexible which implies that it can be implemented in school transportation, in corporate shuttles, university buses, and other organised transportation services. The information is kept on a cloud that gives the possibility to analyse past data, perform performance evaluation and reporting which allow to improve the process continuously and make the route planning smarter. On the whole, this system may be referred to as a new open and efficient solution to the organisation of the student transportation that has numerous positive implications on students, parents, and even the educational institutions .

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