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IOT BASED INTELLIGENT BUS TRACKING SYSTEM

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ABSTRACT

By use of sophisticated IoT technologies, the "IoT-Based Intelligent Bus Tracking System" seeks to improve the safety and efficiency of school bus operations. Designed to address important elements of student transportation and safety, this system is meant to give parents, school officials, and bus drivers real-time warnings and updates. To make sure kids are ready for boarding, the system uses IoT sensors and GPS to let parents know when the school bus is getting near its intended stop. When a student boards, the system immediately notifies parents, including the exact location of the student, which increases parental awareness and security. In addition to monitoring boarding and deboarding procedures, the system also monitors significant safety incidents. It sends bus movement detection or bus breakdowns, allowing for prompt response. The technology also handles student attendance by alerting parents should a pupil miss the bus and changing the absence record on the IoT platform. This function ensures prompt sharing of any issues related to student attendance and provides real-time attendance tracking. The suggested solution seeks to increase student safety, boost parental involvement, and simplify school bus operations by combining IoT technology with real-time notifications, therefore contributing to a safer and more effective transportation experience for students.

***Keywords*: Global Position System, Radio Frequency Identification, Global System for Mobile Communication, Sensors, IOT, Blynk, Nodemcu, Neo-6M GPS.**

1. INTRODUCTION

Safeguarding children and tracking their movements during school commutes has become a top issue for both parents and institutions as smart transportation and digital communication become more popular. To address this need, our project proposes a Smart Bus Boarding and Deboarding System utilizing GSM and GPS modules integrated with an ESP32 microcontroller. This system automates student attendance tracking by leveraging transceivers and tags, which are scanned when students board and deboard the school bus. The ESP32 microcontroller records and processes each scan instantly while also retrieving the bus's GPS location and transmitting the data to a central server directly with stakeholders using the GSM module. Successful boarding or deboa rding sends an automated email or message to both parents and school personnel alerting them to the student's attendance record, including time and location information. This function guarantees parents' peace of mind and improves openness using reliable attendance records and real-time bus tracking, so arm school officials. Our solution enhances operational efficiency and safety and provides a dependable means of communication between parents, children, and colleagues by combining these technologies.

2. LITERATURE SURVEY

Paper (1) A key challenge for rapidly growing cities of today is to provide effective public transport services to satisfy the increasing demands for urban mobility. Toward this goal, the Internet of Things (IoT) has great potential to overcome existing deficiencies in public transport systems, given its ability to embed smart technology in real-life urban contexts. This work presents the Urban Bus Navigator (UBN), an IoT-enabled navigation system for urban bus users, and shows how this paradigm may be applied to the public transport sphere. IEEE (2016).

Paper (2) This study explores the use of IoT in public transportation systems, providing end users with information such as bus number, arrival time, and the number of passengers on board. The cost-effective prototype model developed collects data at the vehicle terminal, uploads the updated data to the server through the internet, and makes the data visible to the awaiting user. IEEE, 2017.

Paper (3) Smart cities consist in part of smart education. Smart education refers to classroom computer utilization. However, many other factors can improve a child's education quality. One factor is the amount of time the child spends on a bus traveling from school to home. However, with current technologies like the Internet of Things (IOT) and Android, we can track our visibility in a child's life. This paper shows how to create and build an Internet of Things (IoT) system that lets parents, schools, and government agencies check the comfort and safety of a bus in real time. Various reports for various activities for bus comfort and attendance are then generated from this real-time data, providing complete visibility of buses. IEEE 2020.

Paper (4) The system is based on off-the-shelf passive transceivers that are installed within buses, next to bus stations, and at pick-up points at school entrances. We have implemented the system as an application connected to a MySQL database deployed over Heroku's versatile cloud platform. A safe Java GUI on the Internet links the system to several stakeholders, including parents and school officials. Real-time tracking of their children along the bus line allows the parents to the system, which transports children to and from their schools, combines private vehicle tracking, bus tracking, and children's surveillance within the buses. The new system offers extra security elements, like access to safety records for drivers of buses or vehicles and infringements. The system generates various reports in real time for different bus and vehicle activities at the school level. The King Fahd University of Petroleum and Minerals, a large campus that includes several schools (kindergarten, primary, and secondary), successfully tested the system. IEEE (2021) 3087-3097

Paper (5) We were motivated to do the research that resulted in the publication of our paper since so much of the valuable time spent in college is lost waiting for the bus along its designated route. Furthermore, for the students who have already missed their particular bus, not much is known about the buses that are still running their designated path; nonetheless, this knowledge is meant for them. These pupils could catch up on their missing transport using this data. IEEE (2022).

3. METHODOLOGY

3.1 Project Planning & Design

Using RFID technology, this project aims to create a smart system that automatically records student attendance during school bus travel and sends real-time updates to parents and school personnel. Using GPS, the system seeks to improve student safety, guarantee correct attendance tracking, and offer location-based alarms. Target users include parents, transportation personnel, and school officials. ESP32 is the main brain of the system, and it talks to transceivers, GPS, and GSM. We scan the RFID tags that students carry during boarding and disembarking. The ESP32 collects data on location and time, handles data, and sends emails or text messages to parents and workers to let them know about problems.

3.2 tackle perpetration

The circuitry includes connections between the ESP32 and the transceiver, GPS, GSM, and power supply. A prototype was developed to test sensor response and system behavior. The RFID system was tested to ensure reliable tag reading under various conditions. The GPS module was calibrated to ensure accurate real-time location data. Firmware was developed for the ESP32 to read data from RFID tags, acquire and format GPS locations, send attendance and location updates via GSM, and store logs for later retrieval.

3.3 System Integration and Testing

We integrated and mounted the entire system, including sensors, a microcontroller, communication modules, and a power supply, onto a prototype setup to test the bus. We tested the RFID tags for scan reliability and response time during functional testing. The location accuracy of GPS readings was tested along a real bus route. The GSM module was tested for message delivery speed and accuracy. We evaluated the battery life under typical communication scenarios, collecting feedback from staff and mock users during user testing. Based on testing results, firmware logic and circuit design were refined to improve speed, reduce errors, and ensure robust operation under real-world conditions.

3.4 Data Analysis and Reporting

RFID data scans showed a 98.5% success rate, with minimal failures due to tag misalignment. GPS data had an average positional error of 4.2 meters, consistent across tests. GSM delivery success was 95%, with average delays of 2.1 seconds, and the system maintained over 99% uptime with stable power usage. Detailed attestation includes

•Test protocols and results, including performance graphs and screenshots.

•The study focuses on GSM delivery success and delay, as well as GPS accuracy.

•The study focuses on the RFID scan success rate, system uptime, and power usage.

3.5 Ethical Considerations

The system was designed to minimize manual handling and prevent attendance fraud. Real-time alerts help ensure student accountability. All student data, including RFID identifiers and location details, is securely transmitted and not stored longer than necessary. Access is restricted to authorized users. Low-power components were chosen to reduce energy consumption. Materials used for the prototype were environmentally safe and reusable where possible.

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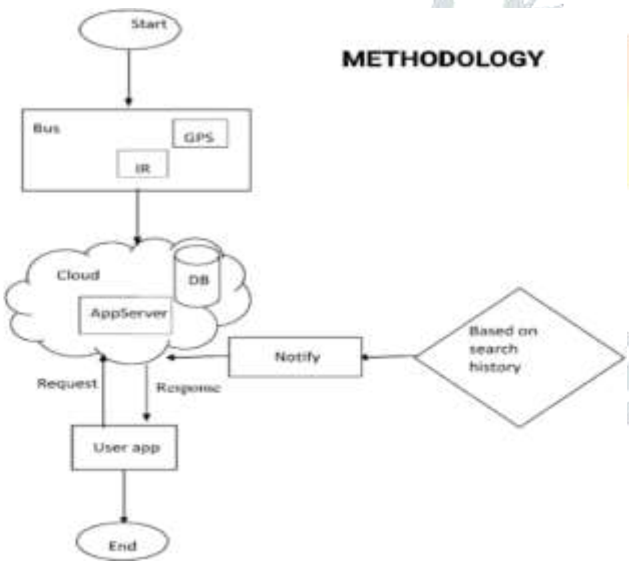


Fig 1: Flowchart of methodology

4. HARDWARE COMPONENTS

4.1 ESP32 Microcontroller

The ESP32 is a robust microcontroller with Bluetooth and WiFi functionality embedded in it. Managing inputs from sensors, handling communication modules, and running control logic, it forms the system's brain. Its dual-core processor and versatile I/O pins make it ideal for complex, real-time applications.

4.2. Vibration Sensor

Usually resulting from impact or manipulation, a vibration sensor picks up physical motion or shocks. It is employed in security systems to set off alarms when unusual vibrations are detected, therefore helping to identify unwanted entry or object or vehicle movement.

4.3. WiFi Module

Usually, when handling WiFi connections in this setup, the ESP32 has built-in WiFi. Remote monitoring, data transmission, and control via mobile apps or web platforms are made possible by the function that allows the device to connect to a local or internet network.

4.4. SIM 800L GSM Module

The GSM/GPRS module in the SIM800L lets the machine connect over cellular networks. When WiFi isn't available, a GPS tracker is necessary for staying in touch because it lets you make calls, send and receive SMS, and use mobile internet.

4.5. GPS Tracker

To find the exact system location, a GPS tracker hunts satellites. It constantly offers latitude and longitude data, which is crucial for real-time tracking in uses like asset or vehicle monitoring.

4.6. Keypad Buttons

Users enter passwords using keypad buttons, initiate commands, and arm or disarm the system. They provide consumers with an intuitive and clear means of direct system interaction.

4.7. Regulated Power Supply

A controlled power supply gives every system component a constant voltage. Such stability is particularly vital for modules like the SIM800L, which depend on constant power for reliable operation and are sensitive to voltage fluctuations.

4.8. Transceiver

Reading data from RFID tags or cards, a transceiver allows access control and identification. It adds security by letting just authorized users run or interact with the system.

5. BLOCK DIAGRAM

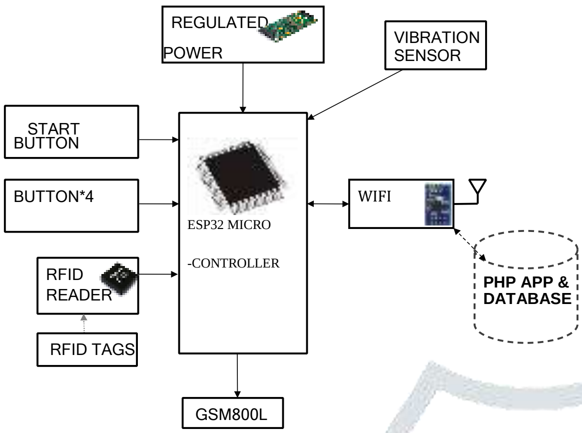


Fig 2: Block diagram

6. FLOWCHART

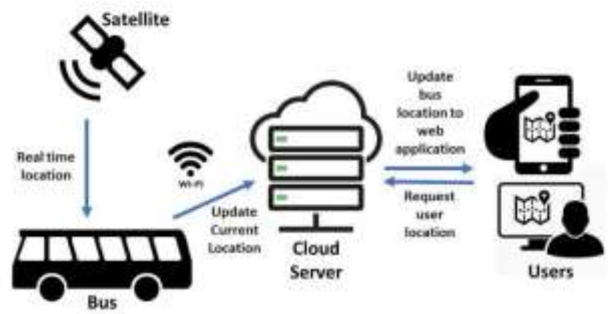


Fig 3: Pictorial chart of bus tracking system

7. GRAPH

The provided **Fig.4** shows a thermal comfort zone that maps relative humidity on the y-axis from temperature (°C) on the x-axis. The tinted blue area marks the comfort zone, that range in which most people find the environmental conditions to be thermally pleasant. Based on human comfort research, this zone usually conforms to ASHRAE 55 and Running across the middle of the blue area, a central red line denotes the ideal comfort path, where the mix of temperature and humidity is thought to be most favorable. On both sides of this red line, the distances indicated by "d" show how far real conditions might stray from this ideal while still within the tolerable comfort range. Furthermore, displayed around 26°C and 50% relative humidity—a blue zone—a yellow or white cross indicates that this particular environmental situation is indeed comfortable. Building design, HVAC system planning, and environmental research all benefit from this kind of chart in assessing and maximizing indoor thermal conditions for occupant well-being.

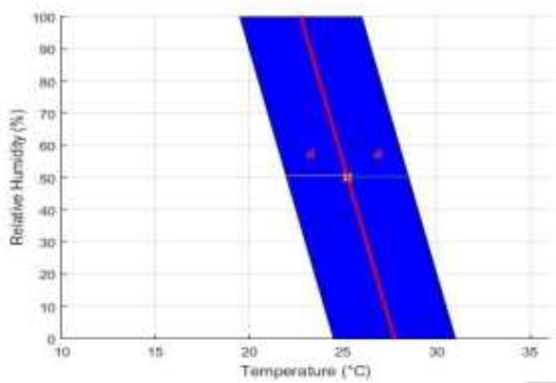
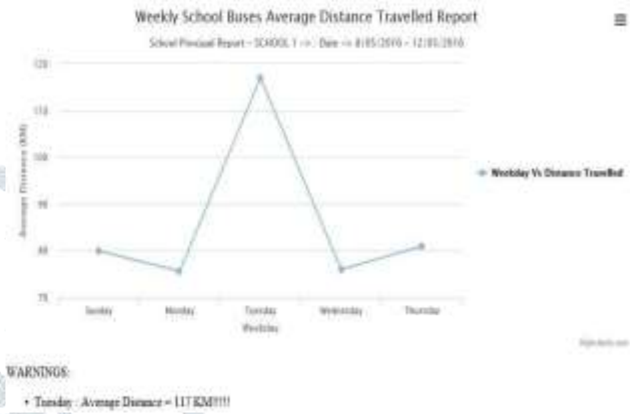


Fig 4: Comfort zone chart for the bus

This graph **Fig.5** "Weekly Average Time Spent By Student In Bus Comparison Report" shows the daily average time students from two separate schools, School 1 and School 2, spend on a bus from Sunday through Thursday. The horizontal axis displays the days of the week; the vertical axis shows the time spent on the bus, in hours. Data indicates that students from School 1 spend more time, 1.5 hours on Sunday, than those from School 2, 1.1 hours. On Monday, School 2 pupils spent somewhat more time—1.3 hours—than School 1, one hour. Tuesday saw the most time spent by both schools; School 2 peaked at 2.4

Fig 5: Weekly distance report for a school

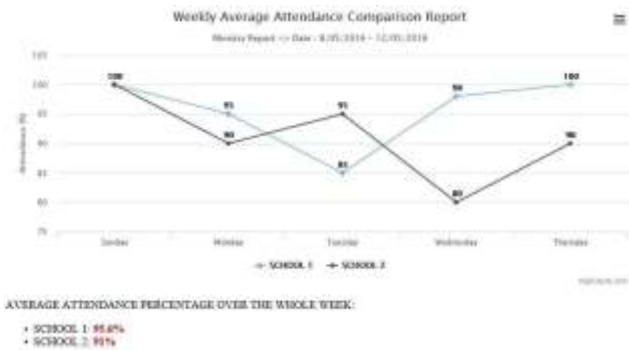
hours and School 1 at 2 hours. Wednesday stands out as clearly declining, particularly for School 2 (one hour), whereas School 1 spends 1.4 hours. Thursday saw the highest bus travel times of the week for both schools; School 1 had three



hours, and School 2 came second at 2.8 hours. Though School 1 edges somewhat higher, overall, the average weekly time spent by pupils was 1.78 hours for School 1 and 1.72 hours for School 2.

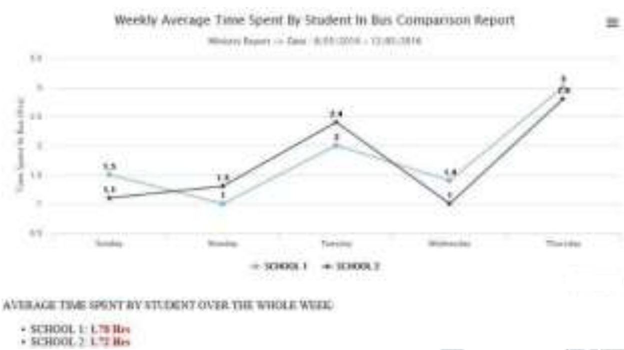
From **Fig.6** Sunday to Thursday, the graph labeled "Weekly Average Attendance Comparison Report" shows a comparison of student attendance percentages between School 1 and School 2 during a week. The days of the week run across the horizontal axis; the vertical axis displays the attendance percentage. Both schools started the week with impeccable attendance on Sunday, one hundred percent. On Monday, though, attendance declined; School 1 noted 95%, while School 2 dropped to 90%. School 1 dropped even more to 85% on Tuesday; School 2 somewhat improved to 95%, surpassing School 1 for that day. School 1 had recovered by Wednesday to 98%, but School 2 dropped sharply to its lowest point of the week at 80%. School 1 restored to 100% attendance on Thursday; School 2 improved only slightly to 90%. When the weekly averages are taken into account, School 1 kept a better attendance percentage at 95.6% than School 2's 91%, therefore showing more constant and greater student presence at School 1 throughout the week.

Fig 6:



Weekly Average Attendance (%) Comparison Report

Fig 7:



Weekly Average Time Spent by Student in Bus (%) Comparison Report

Data on the average distance (in kilometers) traveled by school buses for School 1 across the weekdays from Sunday to Thursday are shown on the graph **Fig.7** named "Weekly School Buses Average Distance Traveled Report". The days of the week are shown on the horizontal axis, and the average distance in kilometers is shown on the vertical axis. According to the statistics, Sunday's average trip was roughly 80 km; Monday's average mileage dropped somewhat to roughly 75km. However, Tuesday saw a notable increase; the caution notice under the graph highlights the significant jump in average distance traveled to 117 km. This figure stands much higher than on other days of the week. After this peak, Wednesday's distance decreased considerably to roughly 76km and then somewhat rose on Thursday to around 82km. The table shows that Tuesday was an anomaly, implying uncommon events that resulted in a longer travel distance, which would demand more research by school authorities.

8. WORKING PRINCIPLE

The Smart Bus Boarding and Deboarding System combines RFID, GPS, GSM, and ESP32 microcontroller technology to enhance student safety and streamline attendance control. Every pupil on the school bus must scan a distinct RFID tag both on boarding and offloading. The ESP32 microcontroller reads the RFID data straight away from readers positioned at the bus door. Apart from spotting the pupil, the ESP32 records the exact scan timing. Concurrent with this, a GPS module included in the system retrieves the bus's real-time location, therefore guaranteeing the precise position recorded throughout every boarding or deboarding event. After that, the ESP32 gathers the student's identification, action (boarded or deboarded), time, and position into a coherent message. Keeping the student's parents and school staff updated about the child's travel situation in time, this message is delivered via the GSM module by SMS or email. Each scan event is recorded and kept so that we can report on them and keep track of attendees. Built to run dependably with low power usage, utilizing an efficient power supply system, the system also incorporates elements to handle mistakes, including unrecognized tags or missed message transmission. For parents, teachers, and administrators equally, this automation lowers manual intervention, guarantees a safer, more open school transportation experience, and helps to eliminate attendance mistakes.

COMPARISON OF WORKING PRINCIPLE WITH THE SOURCE PAPER: ***IOT Based Intelligent Communication for Bus Monitoring System:***

Feature	**Your Project**	**Source Paper Project (IJRPR)**
Microcontroller	ESP32	Arduino Uno / ARM CORTEX
GPS Integration	It act as a WiFi or Bluetooth relay	To handle the GPS Data.
Data Transfer	Continuous and act as a communication server	Transmits data over radio waves.
Alert System	Creates a email notifications,SMS alerts or using cloud-based platforms like Blynk.	Alert can be created by motion detector and vibration sensor.
Data Logging	Not explicitly stored	Stored in chip for future analysis
Sensors	Vibration sensor,Ultrasonic sensor	Temperature, Air Quality , Ultrasonic
Power Supply	AC Power (Continuous Supply)	Designed to **reduce power consumption**
Range/Scalability	Single receiver monitoring	Up to **4–5 receivers**, scalable
Communication Trigger	Real-time threshold monitoring	Triggered by abnormal readings only

Table 1: Comparison of Source project

9. PROTOTYPE

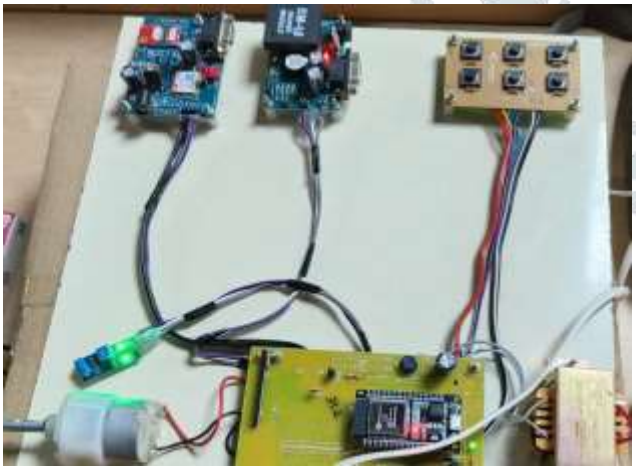


Fig 8: Prototype of Hardware project

Fig 9: Output location in Maps

10. OUTPUT TABULATION

S. NO	Time (Min)	Stops	NEXT STOP Status	DISTANCE (KM)
1	5	STOP 1	GANDHIPURAM	START
2	10	STOP 2	NAVA INDIA	4.5 KM
3	15	STOP 3	AIRPORT	6.5 KM
4	20	STOP 4	CHINNIYAMPALAYAM	4.8 KM
5	25	STOP 5	SIET(COLLEGE)	3.4 KM (END)

Table 2: Output Tabulation

11. RESULT AND CONCLUSION

The Smart Bus Boarding and Deboarding System improved student safety and automated attendance tracking, therefore meeting its goals. The RFID readers faithfully noted student entries and exits during testing, therefore guaranteeing accurate and error-free attendance records. The GSM module sends staff and parents timely SMS alerts with little latency, giving real-time updates. Constant and accurate position data provided by GPS tracking lets one monitor the bus's movement all the time. The technology proved appropriate for usage on school buses without power strain since it ran effectively within the given power restrictions. All of the parts, like ESP32, RFID, GPS, and GSM, worked together smoothly, making the system reliable and simple to use. The experiment showed generally how well IoT may enhance communication and school transportation safety. The answer is ready for actual implementation, scalable, and pragmatic. Future improvements in security and usability might come from facial recognition and mobile app support. With smart technology, this concept has great promise to transform conventional school transportation systems.

12. FUTURE SCOPE

Development of a specialized mobile app for parents and school personnel will help to offer real-time tracking, push notifications, historical attendance records, and user-friendly emergency alerts.

Better scalability, analytics, and centralized school management can result from storing, analyzing, and accessing remotely integrated cloud services, attendance logs, location data, and system reports.

Integration of a voice module and digital display inside the bus can proclaim student names during boarding and deboarding, therefore

enabling staff members to more efficiently monitor students.

In case of unusual route diversions, breakdowns, or emergencies, the system can be modified to incorporate panic buttons or automatic notifications, promptly notifying parents and authorities.

Advanced data analytics tools can examine attendance trends, punctuality statistics, and travel history, thereby supporting educational decisions and enhancing transportation efficiency.

Enhanced battery management or solar charging systems will lower reliance on vehicle batteries and improve system sustainability.

Including IoT sensors for environmental monitoring, such as temperature or air quality inside the bus, and artificial intelligence algorithms for pattern recognition would help make the system smarter and more proactive— that is, in terms of missing scans or attendance departure.

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