IOT ENABLED SCHOOL BUS TRACKING AND STUDENT MONITORING SYSTEM

A PROJECT REPORT

Submitted By

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BONAFIDE CERTIFICATE

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

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ABSTRACT

The Smart School Bus Tracking and Student Monitoring System is an IoT-based hardware solution developed to enhance the safety, transparency, and operational efficiency of school transportation. It uses the NodeMCU ESP32 microcontroller combined with RFID scanners to automate student attendance and provide instant updates to both parents and school authorities. In this system, each student is issued a unique RFID tag, which they are required to scan when boarding or alighting the school bus. The RFID reader detects the tag and passes the ID data to the ESP32, which then processes and logs the exact time and event whether the student boarded or exited. This automated process removes the dependency on manual attendance-taking, reducing human error and ensuring highly accurate travel records.Once the scan is processed, the system uses a Telegram Bot to send real-time alerts directly to parents and school staff through the Telegram messaging app. These alerts include information such as boarding time, drop- off time, and even emergency notifications when needed, significantly improving communication and ensuring peace of mind for stakeholders. The ESP32 microcontroller is responsible for executing the internal logic, including identifying entry/exit actions, managing RFID data, and triggering Telegram messages. This architecture results in a compact, cost-effective, and energy-efficient system.Importantly, this solution does not depend on GPS or GSM modules, which makes it more affordable and accessible for schools operating on tight budgets.

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LIST OF ABBREVIATIONS

SYMBOLS	ABBREVIATIONS
IOT	Internet of Things
RFID	Radio Frequency Identification
ESP	Espressif Systems Protocol
USB	Universal Serial Bus
PCB	Printed Circuit Board
MCU	Microcontroller Unit
SMS	Short Message Service
Wi-Fi	Wireless Fidelity
API	Application Programming Interface

LIST OF TABLES

CHAPTER 1
INTRODUCTION

Ensuring the safety of students during transit is a critical concern for parents, schools, and transportation authorities. Traditional school bus monitoring systems often rely on manual attendance tracking and outdated communication methods, leading to inefficiencies and potential safety risks. To address these challenges, we propose a hardware-based solution that integrates RFID authentication and real-time notification mechanisms.

The core objective of this system is to monitor student attendance through RFID-based authentication while providing real-time updates to parents and school authorities. Unlike conventional manual methods, this approach enhances accuracy, reliability, and efficiency. A NodeMCU-ESP32 microcontroller is utilized to manage data processing and communication between system components and the cloud server.

A key feature of this system is its instant alert mechanism. In the event of emergencies such as bus breakdowns, route changes, or unexpected delays, real-time notifications are sent to parents and school management via the Telegram application. This ensures immediate communication, reducing uncertainty and enhancing parental trust.

By integrating RFID-based attendance, automated real-time updates, and proactive emergency notifications, this system promotes accountability, transparency, and enhanced security in student transportation. It provides an efficient, cost-effective, and user-friendly solution that benefits schools, parents, and students alike, making school transportation smarter and safer.

1.1 OBJECTIVE

- To enhance student safety by implementing real-time attendance monitoring and preventing unauthorized boarding using RFID authentication.
- To develop a smart student tracking system that updates boarding and alighting information in real-time, allowing parents and school authorities to monitor student status efficiently.
- To implement an automated student authentication system using RFID scanning, replacing traditional manual attendance methods for improved accuracy and reliability.
- To provide instant notifications and alerts to parents and school authorities via Telegram regarding bus delays, emergencies, or route changes, ensuring timely and effective communication.
- To establish a secure and centralized data management system that protects student information through cloud storage with appropriate access control measures.

1.2 SCOPE

- **RFID-Based Attendance Monitoring:** The system automates the attendance process by scanning RFID tags when students board and exit the bus.
- **IoT-Based Real-Time Student Status Update:** Using NodeMCU (ESP8266/ESP32) and cloud connectivity, the system provides real-time updates on student boarding and alighting activities for parents and school authorities.
- **Instant Emergency and Delay Notifications:** Immediate alerts about emergencies, bus delays, are sent to parents and school administrators through Telegram, ensuring prompt communication and quick decision-making.
- **Data Logging and Reporting:** The system securely logs detailed records of student attendance, boarding times, and alerts, allowing school authorities to generate reports for efficient transportation monitoring and management.

CHAPTER 2

LITERATURE SURVEY

TITLE	**:**	IoT-Based Smart School Bus and Student Tracking System.
AUTHOR	**:**	Bhanudas Gadade, A. O. Mulani, A. D. Harale
YEAR	**:**	2024
PUBLICATIONS	**:**	Naturalista Campano

Concept Discussed:

This study presents an innovative IoT-based solution utilizing an ESP32 microcontroller, RFID reader, RTC module, LCD display, and Google Sheets integration. The system aims to enhance student safety by providing real-time monitoring and tracking capabilities, automating attendance through RFID technology, and maintaining accurate records via Google Sheets.

Problem Identification:

The safety and attendance of students, particularly in large institutions or during school transportation, are major concerns. Traditional methods of attendance tracking and student monitoring can be time-consuming and prone to errors. The lack of real-time tracking and automated attendance systems limits the ability of schools to effectively monitor student activities, especially during transit or in large crowds. A more efficient, automated solution is needed to enhance safety and improve attendance management.

Work Done:

The study developed an IoT-based system using an ESP32 microcontroller, GPS module, RFID reader, RTC module, and LCD display. The system automates student attendance by utilizing RFID cards, while the GPS module provides real-time tracking to monitor student location. The data is integrated into Google Sheets for easy access and management. This setup enables school authorities and parents to monitor students' whereabouts and attendance in real-time, ensuring improved safety and data accuracy.

Knowledge Gained:

The implementation of the IoT system demonstrated how various technologies can be integrated to create a comprehensive solution for student safety and attendance tracking. RFID technology automates attendance logging, reducing manual errors and ensuring accuracy. Real-time GPS tracking allows for the continuous monitoring of students, enhancing safety by keeping track of their movements. The integration with Google Sheets streamlines record-keeping and data analysis, making it accessible and manageable for school authorities

Gap:

While the system improves attendance and safety, it has some limitations. The reliance on RFID cards requires that every student carries their card, which may not always be feasible. Additionally, the system's GPS tracking may not work effectively in areas with poor signal reception, such as inside buildings or remote locations. The integration with Google Sheets is simple but may not be scalable for larger schools or institutions, requiring a more robust data management system. Lastly, the system does not address potential privacy concerns related to real-time location tracking.

TITLE	**:**	IoT-Based Smart School Bus and Student Tracking System
AUTHOR	**:**	Srinivas S, Shreyas V B, Sriram, Vishnuraata PY
YEAR	**:**	2023
PUBLICATION	**:**	International Journal for Research in Applied Science and Engineering Technology.

Concept Discussed:

The paper explores an IoT-based system that monitors and tracks school buses in real-time using sensors and GPS tracking devices. It emphasizes improving safety, reducing operating costs, and enhancing transportation efficiency by providing real- time data on bus location, speed, and safety, thereby facilitating better communication between schools and parents.

Problem Identification:

Traditional methods of tracking school buses are often inadequate as they do not provide real-time updates, leading to safety concerns and inefficient communication between schools and parents. Additionally, managing transportation costs and ensuring operational efficiency is challenging without accurate data on bus location, speed, and safety. There is a need for a more reliable system that enhances safety, reduces costs, and improves overall transportation management**.**

Work Done:

This study designed an IoT-based monitoring system that uses GPS devices and sensors to track school buses in real-time. The system provides continuous updates on bus location, speed, and safety status, allowing parents and school authorities to monitor bus movements more effectively. It also improves communication by sending real-time notifications to parents, enhancing transparency and safety.

Knowledge Gained:

The study revealed that real-time monitoring significantly enhances student safety and operational efficiency by providing accurate location and speed data. It also improves communication with parents, reducing anxiety and ensuring timely updates. Additionally, the system helps optimize bus routes and fuel usage, leading to cost savings. The integration of GPS and sensor technologies proved to be reliable and effective in ensuring accurate tracking and safety monitoring.

Gap:

Although the system improves safety and operational efficiency, it is dependent on stable internet connectivity, which may be unreliable in certain areas. There are also concerns about data privacy and security related to real-time tracking. Furthermore, the system could be enhanced by incorporating emergency alert features and predictive maintenance capabilities to improve safety and vehicle management.

TITLE	**:**	IoT-Based School Bus Monitoring System
AUTHORS	**:**	Aniket Tota war, Umakant Sonawane, Abhisek Suryawanshi
YEAR	**:**	2023
PUBLICATION	**:**	International Journal for Research in Applied Science and Engineering Technology

Concept Discussed:

This research proposes an IoT-based approach combining GPS and Wi-Fi modules to track school buses' real-time location and monitor student safety. It offers an interface for students, parents, and administrators to monitor bus status and integrates with existing school management systems to optimize transportation safety and efficiency.

Problem Identification:

The IOT Monitoring Smart School Bus system addresses critical issues in traditional school transportation. The lack of real-time tracking prevents parents and school authorities from monitoring the bus's location, raising safety concerns. Additionally, there is no automated system to track student attendance or ensure their safe boarding and exit. Existing manual processes often lead to errors and delays, causing miscommunication between drivers, parents, and school staff.

Work Done:

The integrates IoT technology to provide real-time tracking of school buses, ensuring enhanced safety and efficiency. It automates student attendance, confirming safe boarding and exit, and provides live updates to parents and school authorities. The system improves communication between drivers, parents, and school staff, reducing delays and errors. This IoT-based solution addresses the limitations of traditional manual systems by offering a more secure and reliable school transportation experience.

Knowledge Gained:

The system has provided valuable insights into the integration of IoT technology for real-time school bus tracking. It demonstrated how automated systems can enhance student safety, improve attendance monitoring, and streamline communication between parents, school authorities, and bus drivers. Additionally, the project highlighted the importance of reducing human error and delays in transportation management. Overall, it showcased the potential of IoT to create a more efficient, secure, and reliable school transportation system.

Gap:

The gap in the current school bus tracking and student monitoring systems lies in the lack of real-time data integration and automation. Existing systems often rely on manual tracking methods, leading to inefficiencies, errors, and delays. There is also a lack of comprehensive monitoring for student safety and attendance during transit. The IoT-based system aims to fill this gap by offering real-time tracking, automated attendance, and enhanced communication for improved safety and operational efficiency

TITLE **:** A Smart IOT System for Enhancing Safety in School Bus Transportation

AUTHORS **:** Yousef H.Allfaifi, Tareq Alhimiedat, Emad Alharbi,Ahad Awadh AI Grains, Maha ALtalk, Abdelrahman Osman Elfaki

YEAR 2024

PUBLICATION **:** International Journal of Advanced Computer Science and Applications

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Concept Discussed:

The study addresses five major obstacles to safe school transportation, including unattended students on buses and abnormal driver behavior. It proposes an intelligent IoT system using RFID sensors and a processing unit to monitor the bus and its surroundings, aiming to enhance student safety comprehensively and cost- effectively.

Problem Identification:

The primary issue identified in this study is the lack of comprehensive safety measures in school bus transportation, which poses risks such as unattended students being left on buses and unsafe driving behaviors by drivers. These challenges highlight the need for an effective monitoring system to ensure student safety during transit.

Knowledge Gained:

From this literature, it is understood that integrating IoT technologies, particularly RFID sensors and processing units, can significantly enhance the safety of school bus systems. The system's ability to monitor both the internal environment of the bus and its external surroundings provides a holistic safety solution.Additionally, the approach demonstrates a cost-effective and efficient method to track student attendance and driver behavior.

Work Done:

The authors developed an intelligent IoT system tailored to enhance the safety of school transportation. This system employs RFID sensors to track student presence on the bus and monitors driver behavior, ensuring that no student is left behind and that drivers adhere to safety protocols. The system's architecture effectively processes and analyzes data, providing real-time alerts and reports to parents and school authorities**.**

Gap:

While the proposed IoT system addresses key safety concerns, there is a gap in integrating advanced data analytics and machine learning models that can predict potential safety threats. Additionally, the study could further explore scalability and adaptability to different geographical regions or varied transportation conditions, ensuring broader applicability and effectiveness**.**

TITLE **:** IOT-Based Smart Attendance System

AUTHORS **:** Kashif Ishaq, Samara Bibi

YEAR 2023

PUBLCATION **:** arXiv

Concept Discussed:

This systematic literature review examines the development of student attendance systems using RFID technology integrated with IoT. It highlights the automation of attendance tracking, addressing issues like time wastage and proxy attendance, and emphasizes the system's accuracy and reliability in educational institutions.

Problem Identification:

Traditional attendance systems in educational institutions are prone to issues such as time consumption and proxy attendance. These challenges compromise the accuracy and reliability of attendance records, highlighting the need for an automated and efficient solution**.**

Knowledge Gained:

This review emphasizes the effectiveness of integrating RFID technology with IoT for automating attendance tracking. It demonstrates how this combination enhances accuracy, reduces manual errors, and prevents proxy attendance. Additionally, the study showcases the potential of IoT systems to provide real-time attendance data and improve administrative efficiency**.**

Work Done:

The authors conducted a systematic literature review of existing RFID-based smart attendance systems integrated with IoT. The review explores various approaches and architectures used in developing these systems, highlighting their accuracy and reliability. It also examines the technologies and methods employed to automate attendance tracking in educational environments**.**

Gap:

Although the review showcases the benefits of RFID-IoT integration, it lacks an in-depth analysis of security and privacy concerns related to student data. Additionally, there is limited exploration of system scalability and interoperability with other educational management systems, which could enhance the system's functionality and adaptability.

CHAPTER 3
ANALYSIS

3.1 SYSTEM ANALYSIS:

3.1.1 Problem Identification

The lack of real-time student monitoring during school bus transit raises significant safety concerns for both parents and school authorities, as they are often unaware of student boarding and alighting status. Traditional manual attendance systems are time-consuming, prone to errors, and difficult to verify, making it challenging to accurately track students. This can result in students boarding or exiting buses without proper documentation, increasing security risks. Additionally, communication delays in reporting emergencies, delays, or route changes cause further uncertainty and anxiety among parents. These inefficiencies highlight the urgent need for a reliable system that provides automated attendance, instant alerts, and real-time updates. Implementing such a solution with RFID-based authentication and instant notifications through platforms like Telegram would enhance student safety, improve operational efficiency, and provide peace of mind to all stakeholders involved.

3.1.2 Existing System

The traditional school transportation system lacks an efficient real-time student monitoring and attendance mechanism. In most cases, parents and school authorities rely on manual communication or estimated times, leading to uncertainty and safety concerns. Student attendance on school buses is often recorded manually, making it difficult to ensure that students board and exit at the correct stops. Moreover, there is no automated notification system to instantly inform parents or school authorities about emergencies, delays, or route changes. The absence of a real-time student authentication and alert system increases the risk of errors and reduces overall accountability.

Disadvantages Of Existing System:

- **Lack of Real-Time Student Monitoring:** Parents and school authorities cannot monitor the exact location of the school bus in real time, leading to uncertainty and safety concerns.

- **Manual Attendance Marking:** Student attendance is manually recorded or sometimes not tracked, increasing the chances of human errors, unauthorized boarding, and missing students.
- **No Instant Emergency or Delay Notifications:** In the event of emergencies, route changes, or delays, there are no automated alerts to promptly inform parents and school authorities, leading to confusion, delayed responses, and parental anxiety.

3.1.3 Proposed System

The IoT- Enabled School Bus Tracking and Student Monitoring System is designed to enhance student safety and provide real-time status updates for parents and school authorities. This system leverages RFID technology for accurate student authentication and attendance monitoring. Instead of relying on manual attendance methods or QR code scanning, students scan their RFID cards when boarding and alighting the bus, allowing for automated and reliable attendance recording. Additionally, the system includes an instant notification feature, which sends real-time alerts via Telegram to parents and school authorities in case of bus delays, emergencies, or route changes. A NodeMCU (ESP8266/ESP32) microcontroller is used to efficiently manage data processing, cloud communication, and system operations. Attendance and event data are stored securely on a cloud-based server, allowing easy access for monitoring and reporting. By integrating RFID-based authentication, IoT-enabled communication, and real-time notifications, this system significantly improves accountability, security, and communication, making school transportation smarter and safer.

Advantages of Proposed System:

- **Real-Time Student Monitoring:** Uses RFID-based authentication to track student boarding and alighting activities in real time.
- **Automated Student Attendance:** RFID scanning ensures accurate and automatic attendance recording.
- **Instant Emergency and Delay Notifications:** Sends real-time alerts via Telegram to parents and school authorities in case of emergencies**.**

3.2 REQUIREMENT ANALYSIS

3.2.1 Functional Requirements

- **RFID-Based Students Authentication and Attendance**

  Each student is assigned a unique RFID tag that is scanned during boarding and exiting the bus, and the system validates the tag against registered entries to ensure secure and accurate attendance logging.

- .**Real-Time Status Update and Notifications**

  The system sends instant Telegram notifications to parents and school authorities when a student boards or exits the bus.It also provides real-time alerts for delays or emergencies with the student's name, status, and timestamp.

- **Data Logging and Storage**

  The system must maintain accurate logs of student attendance, including time, scan location, and store all records in a secure, centralized database accessible by school administrators. Historical data should be retrievable for audits and reporting.

3.2.2 Non-Functional Requirements

- **Performance:**

  RFID scans should register student attendance in under 3 seconds and trigger Telegram alerts immediately upon boarding or disembarking events, ensuring real-time updates.

- **Scalability:**

  The system should manage a large number of RFID tags (students) without performance degradation as the number of students or buses increases, and allow easy addition or updating of RFID tags without significant downtime or manual intervention.

- **Reliability:**

  The RFID attendance system should ensure 99.9% reliability in detecting students during boarding or disembarking, and Telegram notifications should be reliable with fail-safes to ensure parents or guardians receive alerts even during minor system glitches.

- **Security:**

  RFID data including student IDs and attendance logs, should be securely stored and transmitted using encryption protocols, and Telegram alerts should be sent only to authorized users through unique, verified channels or bot identifiers.

- **Error Handling:**

  Failed RFID scans should prompt backup methods like manual entry or re-scanning the Telegram alerts should handle errors gracefully, providing retry options or error messages if necessary.

3.2.3 Hardware Requirements

- **NodeMCU (ESP32) :** Microcontroller for processing and communication.
- **RFID Scanner :** Authenticates students during boarding and alighting
- **Power Supply :** 12V battery with voltage regulator
- **Wi-Fi Module :** Built in Wi-Fi for internet connectivity
- **Telegram Bot API :** Sends attendance updates and emergency alerts

3.2.4 Software Requirements

- **Arduino IDE :** Used to program the microcontroller.
- **Embedded C/C++ :** For firmware development

CHAPTER 4

DESIGN

4.1 OVERALL DESIGN

A Smart School Bus Safety and Attendance System ensures student security by using RFID technology to track when students board and exit the bus. Each student carries an RFID card, which is scanned to record their attendance. The Arduino Board processes this data and also monitors for any emergency situations using an Emergency Trigger. If activated, it alerts the system immediately. All collected information is transmitted through a Wi-Fi Module to the Telegram Bot API. This allows real-time notifications to be sent instantly to both parents and school authorities. Through this process, the system provides a reliable and efficient way to monitor student safety and maintain accurate attendance records during school transport

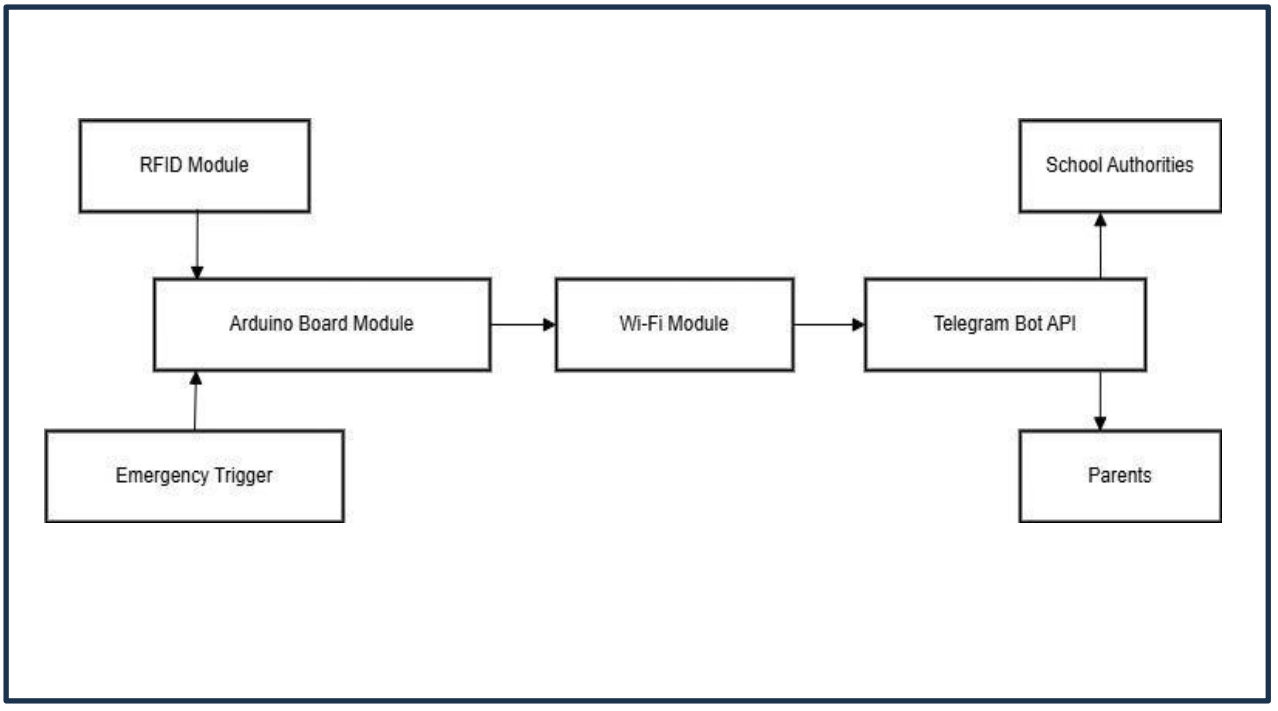


Fig 4.1 Overall Architecture

4.2 UML DIAGRAMS

4.1.1 Work Flow Diagram

The Work Flow Diagram begins when a student boards the bus and scans their RFID card. The RFID Module captures the student ID and sends it to the Arduino Board, which acts as the system controller. The Arduino also checks for any emergency situation using an Emergency Trigger. Once the data is collected, it is forwarded to the Wi-Fi Module. The Wi-Fi Module transmits the information to the cloud or server. Then, the Telegram Bot API sends real-time notifications. Parents receive updates regarding their child's status, such as boarding or emergencies. At the same time, school authorities are also notified with alerts or important student information.

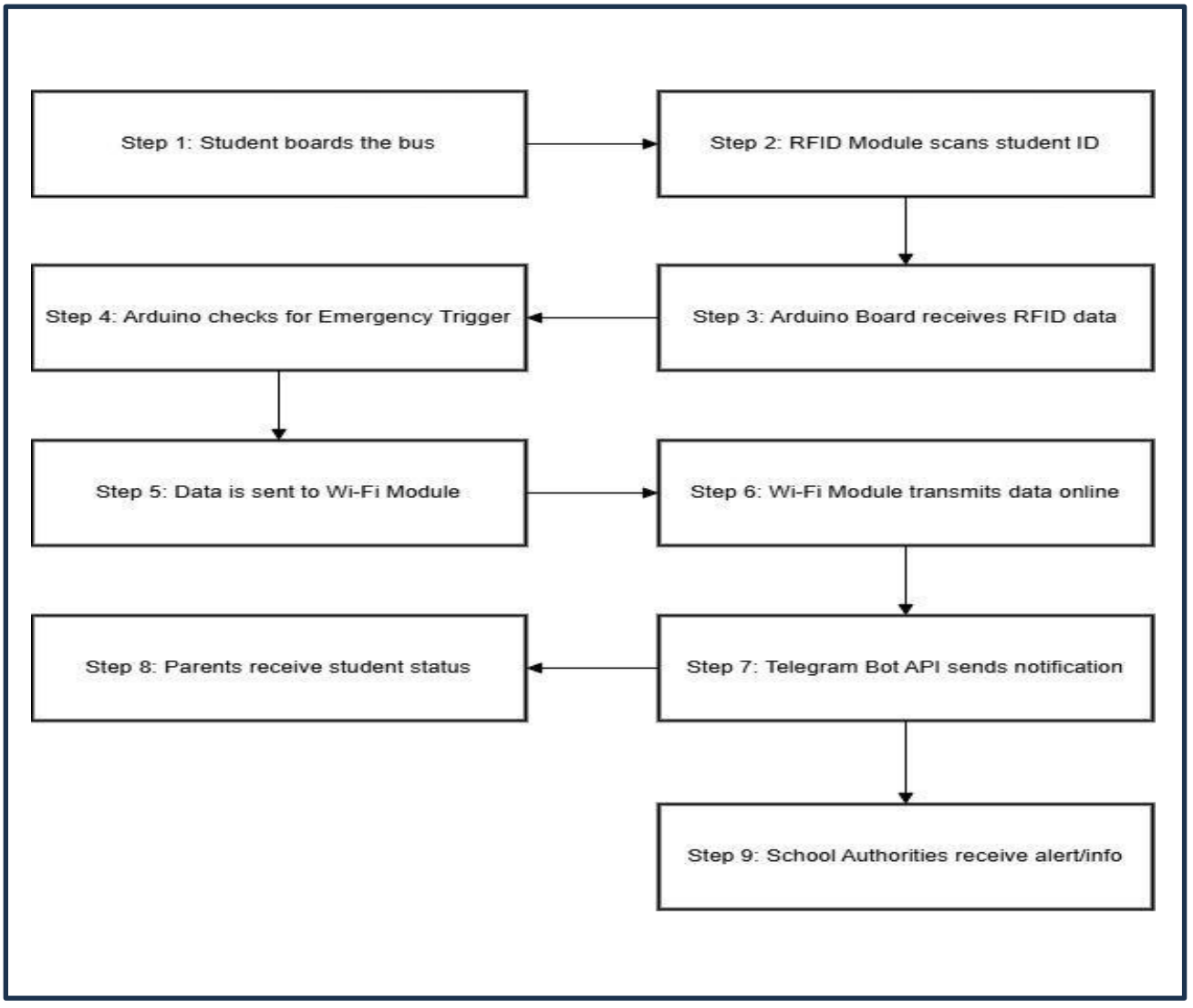


Fig 4.2 Work Flow diagram

4.1.2 Use case diagram

The class diagram includes Students scan QR codes using the QR Scanner, and attendance is stored in the Cloud Database. The bus's location is updated via the GPS Module and stored in the database, allowing parents to view real-time bus locations. The system triggers alerts through the Notification System, sending delay notifications to parents. School administrators manage student data and view reports to ensure a smooth and secure transportation process.

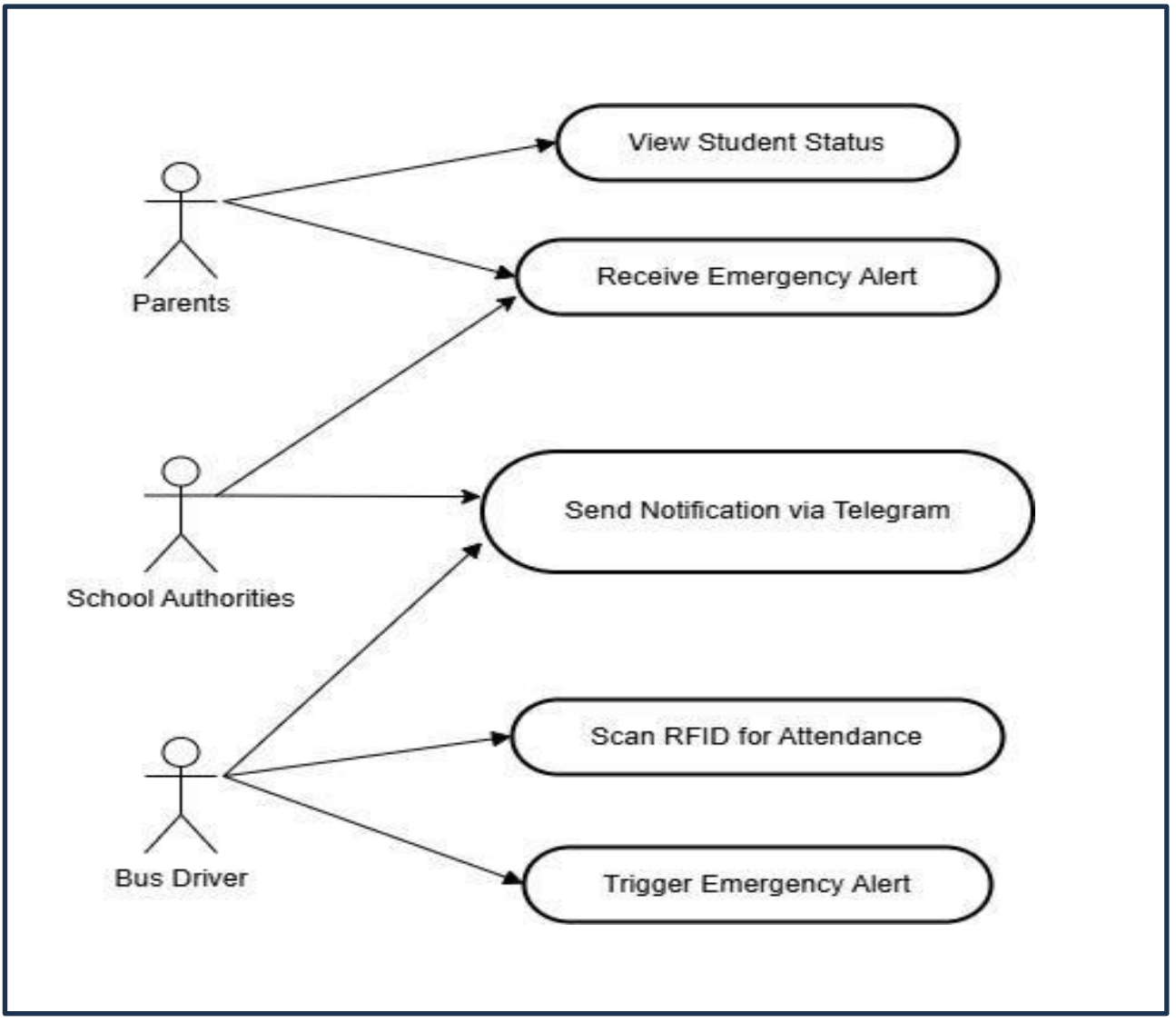


Fig 4.3 Use case Diagram

4.1.3 Class Diagram

The Class Diagram , RFID Module reads and sends student ID data, while the Emergency Trigger detects emergencies and sends alerts. The Arduino Board processes both RFID and emergency data, then transmits it to the WiFi Module, which sends the data online. The Telegram Bot API communicates with the WiFi module to deliver notifications and alerts.

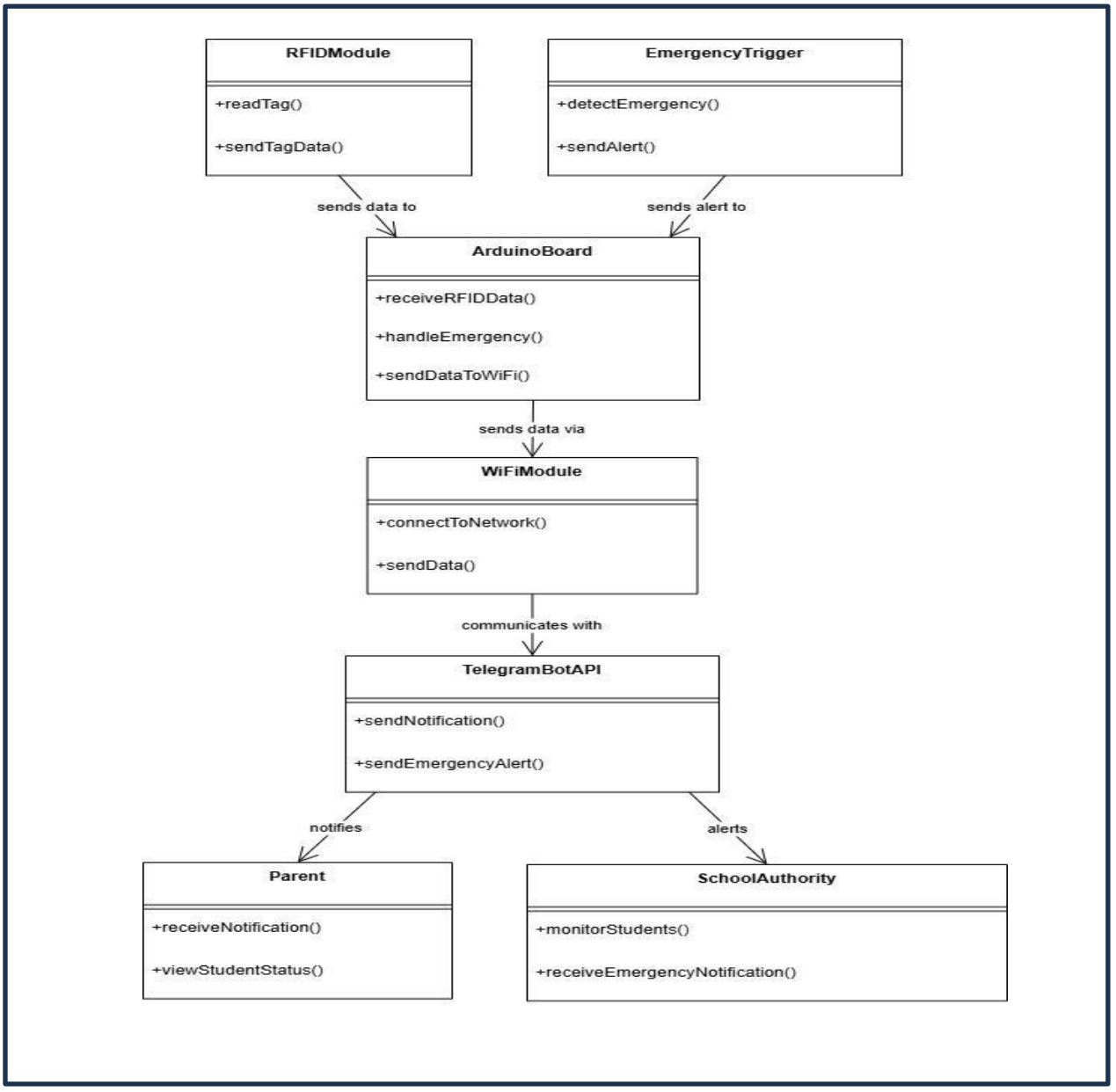


Fig 4.4 Class Diagram

4.1.4 Activity Diagram

The Activity diagram process begins by initializing the system and having the student scan their RFID code. If the code is valid, attendance is marked, and the bus journey starts; otherwise, boarding is denied. During transit, the system checks for delays and triggers a notification alert to parents and school if any issues arise. Upon reaching the destination, the student scans a RFID code again to complete the journey and confirm safe arrival.

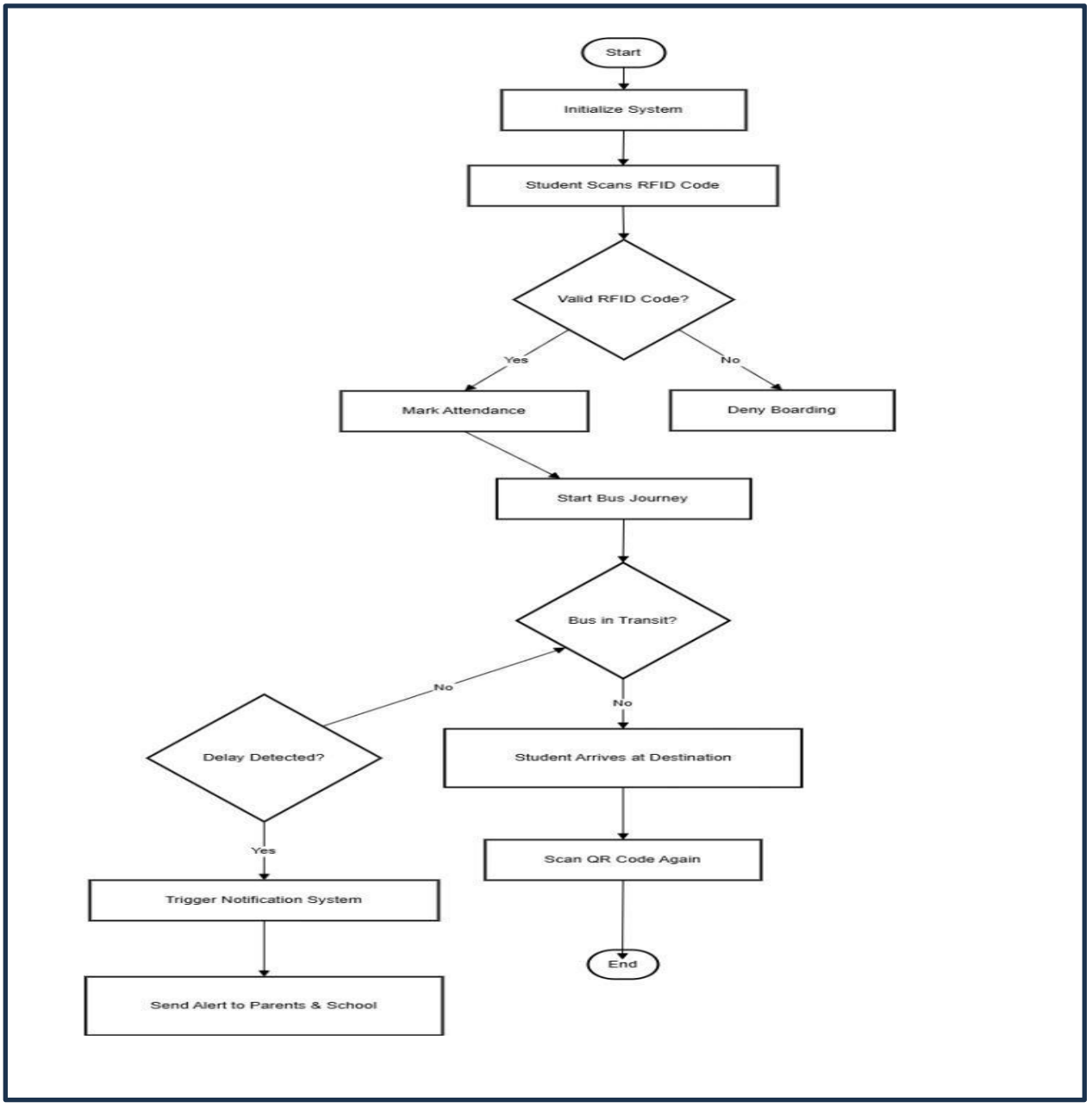


Fig 4.2.4 Activity Diagram

4.1.5 Sequence Diagram

This sequence diagram illustrates the process of a smart school bus system using RFID and emergency alerts. A student taps their RFID card, and the RFID reader sends the data to the Arduino for validation. If the RFID is valid, attendance is recorded and sent via a Wi-Fi module to the Telegram Bot, which notifies both parents and school. If the RFID is invalid, boarding is denied. In case of an emergency, the Arduino detects the trigger and sends an alert through the system, which also notifies parents and school via the Telegram Bot.

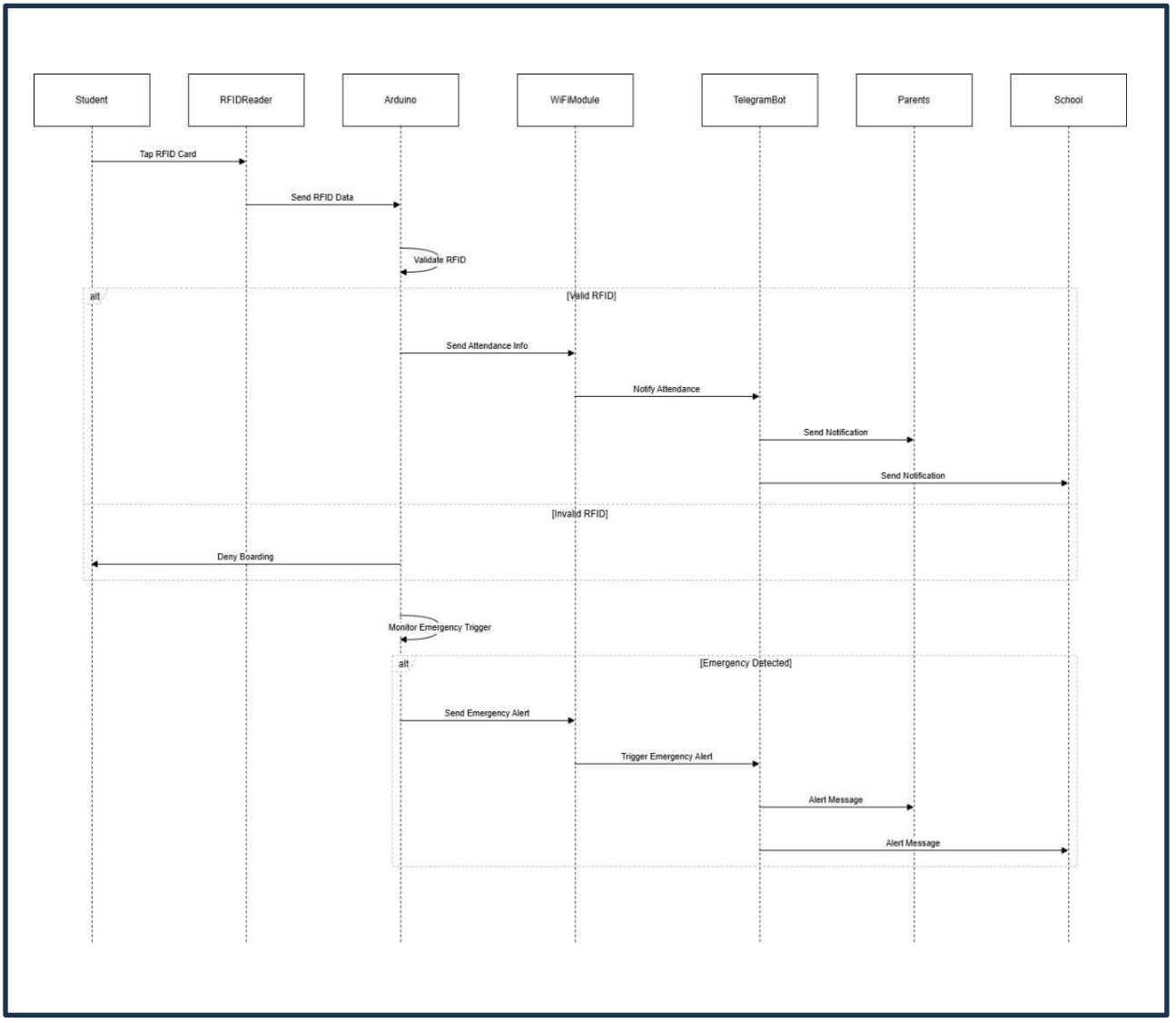


Fig 4.2.5 Sequence Diagram

CHAPTER 5

IMPLEMENTATION

5.1 MODULES

A module is a file or a collection of files that contain reusable code, often with a specific purpose. It can encapsulate a set of related functions, classes, or procedures to be imported and used in other parts of a program.

List of Modules:

- RFID Module
- Arduino Board Module
- Wi-Fi Module
- Telegram Bot API
- Emergency Tigger

5.2 MODULE DESCRIPTION

5.2.1 RFID Module:

The RFID Module (RC522) plays a critical role in the student attendance and tracking system, providing an efficient and automated method for monitoring students' movements. Each student is assigned an RFID tag containing a unique identification number, which is associated with their profile. When the student places their RFID tag near the RFID reader, the reader captures the tag's ID. This data is sent to the NodeMCU microcontroller via serial communication, allowing the system to process the information. The microcontroller logs the student's ID, capturing the student boards or exits the bus. This automated system eliminates the need for manual attendance, ensuring faster and more accurate records. The real-time logging of student activity helps prevent errors that may arise from human involvement. The system enhances safety by allowing authorities to track students boarding and alighting times. The RFID system’s efficiency also helps optimize the management of school transport by providing real-time data on student attendance and location. The use of RFID technology ensures that data is captured without delay, reducing

time spent on administrative tasks. The automated logging also helps improve accountability by creating an accurate record of each student's daily activities. Additionally, it allows for easy report generation and provides administrators with instant access to attendance data. The integration of RFID technology in the student monitoring system ultimately provides a more secure, accurate, and reliable method for ensuring student safety during school transport. This system removes the challenges of manual attendance-taking, supports timely emergency responses, and improves the overall efficiency of school transportation management.

5.2.2 Arduino Board Module:

The Arduino board, particularly the NodeMCU or ESP8266/ESP32, serves as the central control unit for the entire system, managing all core functions effectively. It receives data from the RFID reader, which identifies the student’s unique RFID tag. Once the RFID tag is scanned, the NodeMCU processes the data and cross-references it with the stored student information to accurately log attendance.It recording the exact time the student boards or exits the bus. With its built-in Wi-Fi capabilities, the NodeMCU connects to a mobile hotspot, enabling it to access the internet for real-time communication. This connectivity is vital for sending immediate updates and alerts to parents and school authorities through platforms such as Telegram. The real-time notifications can include student boarding, drop-off status and emergency alerts. In addition to attendance tracking and communication, the NodeMCU manages emergency triggers, ensuring that any urgent situation is promptly communicated to the relevant authorities. This may include sending alerts about delays, accidents, or unexpected circumstances on the bus. The board facilitates smooth interaction between various hardware modules like the RFID reader.The NodeMCU acts as the bridge, integrating all components and ensuring that they work in harmony to provide a reliable, real-time system. It simplifies system management, ensures operational efficiency, and helps enhance safety through seamless communication. Additionally, its compact design and low power consumption make it an ideal choice for the system, supporting its scalability and potential for future updates.

5.2.3 Wi-Fi Module:

The Wi-Fi module, integrated into NodeMCU or ESP8266/ESP32 boards, is a vital component that enables internet connectivity within the student monitoring system. This module allows the microcontroller to connect to a mobile hotspot or any wireless network using the SSID and password specified in the program code. Once connected, it establishes a reliable internet connection that facilitates real-time communication with external services. The primary function of the Wi-Fi module is to enable the transmission of student attendance data and emergency alerts to cloud platforms like Telegram. Whenever a student scans their RFID tag, the data is processed by the microcontroller and instantly sent through the Wi-Fi connection to parents and school authorities. This allows stakeholders to receive immediate updates about the student's boarding or alighting activity. The Wi-Fi module also plays a crucial role during emergencies, where fast and accurate alerts can significantly improve the response time of concerned authorities. This Wi-Fi connectivity also eliminates the need for physical data transfers or manual reporting, saving time and improving overall efficiency. Furthermore, the built-in nature of the Wi-Fi module in these boards makes the system compact, cost-effective, and easy to implement without requiring external components. It simplifies the setup process and reduces wiring complexity, making it ideal for educational institutions looking to adopt smart solutions. Overall, the Wi-Fi module is essential for transforming the student monitoring system into a smart, connected, and scalable IoT-based solution that enhances safety, communication, and operational performance.

5.2.4 Telegram Bot API:

The Telegram Bot API is a key component of the Smart School Bus Tracking and Student Monitoring System, providing a seamless method for real-time communication between the system, parents, and school authorities. Once a student scans their RFID card, the system processes the data through the NodeMCU or ESP32 and immediately triggers the Telegram bot to send an attendance update. These updates inform parents about the exact boarding or alighting time of their Student, ensuring they remain informed and reassured. The Telegram Bot API supports automated message delivery, reducing manual efforts and enabling instant alerts. In critical situations, such as a delay, a student not

boarding, the system uses the bot to send emergency alerts directly to the concerned recipients. These notifications help in quick decision-making and improve the safety response time. The Telegram platform's reliability ensures that messages are delivered instantly, making it suitable for dynamic, real-time tracking environments like school transport. Parents can receive notifications on their smartphones from anywhere, allowing them to monitor their Student's remotely and efficiently. Additionally, the bot can be programmed to send messages in different formats, including text, emojis enhancing the clarity and appeal of communication. The Telegram Bot API works via secure internet protocols, ensuring that the communication remains private and encrypted. By automating the flow of information, the system helps reduce communication gaps between schools and parents. With future enhancements, the bot can also collect feedback or allow parents to acknowledge alerts, making it interactive. This smart use of messaging technology brings convenience, safety, and transparency to the student monitoring process. Overall, the Telegram Bot API is not just a messaging tool but a real-time alert mechanism that transforms the way schools manage student transport communication.

5.4.5 Emergency Trigger:

The Emergency Trigger is a critical safety component of the Smart School Bus Tracking and Student Monitoring System. It can take the form of the bus or a special RFID card assigned to the Student. When activated, this trigger instantly signals the system that an emergency situation has occurred, prompting an immediate response. The microcontroller, such as the NodeMCU or ESP32, detects the trigger signal and quickly processes it to initiate an automated alert procedure. Within seconds, the system uses the Telegram Bot API to send a detailed emergency message to the registered contacts, including parents, school authorities, and transport managers. These messages include key information such as the type of emergency, This rapid communication ensures that all responsible parties are alerted in real time and can respond appropriately. These alerts can be customized in the Telegram bot to appear as high-priority notifications, possibly with visual indicators such as emojis or keywords to catch the recipient's attention. The use of internet-based messaging ensures instant delivery, even across remote or mobile environments.

CHAPTER 6

TESTING

6.1 TESTING AND VALIDATION

Testing is the process of running a system with the intention of finding errors. Testing enhances the integrity of a system by detecting deviations in design and errors in the system. Testing aims at detecting error-prone areas. This helps in the prevention of errors in a system. Testing also adds value to the product by conforming to the user requirements.

Unit Testing:

This Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application it is done after the completion of an individual unit before integration. This is a structural testing, that relies on knowledge of its construction and is invasive. Unit tests perform basic tests at component level and test a specific business process, application and system configuration. Unit tests ensure that each unique path of a business process performs accurately to the documented specifications and contains clearly defined inputs and expected results.

Integration Testing:

Integration testing is a critical phase in the software testing process that ensures individual software components work together as a unified system. It focuses on verifying the interaction between integrated modules to produce the expected outcomes. Unlike unit testing, which checks each module in isolation, integration testing is event-driven and emphasizes the flow of data through screens, fields, and interfaces. This testing helps identify defects in data exchange and communication between components. It exposes issues that may not arise during unit testing, such as mismatched data formats, incorrect method calls, or broken interfaces. By combining components and testing them as a group, developers can ensure that the system behaves correctly and consistently.

System Testing

This System testing is a comprehensive testing phase that ensures the entire integrated software system meets the defined requirements. It focuses on evaluating the system as a whole, verifying that all components work together seamlessly to deliver the expected outcomes. The testing process checks configurations to ensure known, predictable results, and it includes scenarios like configuration-oriented system integration tests. System testing is based on detailed process descriptions and workflows, emphasizing the integration points and pre-defined process links.

Black Box Testing

Black Box Testing is testing the software without any knowledge of the inner workings, structure or language of the module being tested. Black box tests, as most other kinds of tests, must be written from a definitive source document, such as specification or requirements document, such as specification or requirements document. It is a testing in which the software under test is treated, as a black box. you cannot “see” into it. The test provides inputs and responds to outputs without considering how the software works.

White Box Testing

White Box Testing is a type of testing where the tester has knowledge of the internal structure, design, and code of the software. This allows the tester to test specific paths, logic, and branches within the application. Unlike Black Box Testing, which focuses solely on inputs and outputs, White Box Testing delves into the internal workings of the system. It is used to verify that all components function as expected and to identify hidden issues such as logical errors or security vulnerabilities

User Acceptance Testing

User Acceptance Testing (UAT) is the final testing phase where end users validate the system to ensure it meets their expectations and requirements. It focuses on testing the system in real-world conditions to confirm that all functional requirements are correctly implemented. UAT ensures the system works as intended in the user's environment, addressing any usability issues or mismatches. This phase helps identify discrepancies between the system's design and how it is used in practice. UAT also helps verify that the system meets business needs before going live.

6.2 BUILD THE TEST PLAN

The test plan for the RFID-based School Bus Tracking and Student Monitoring System outlines the testing strategy and objectives to ensure the system functions as expected and meets user requirements. The system focuses on key features such as RFID-based student attendance, real-time Telegram alerts, and data synchronization. The testing process will verify that the RFID system accurately tracks student attendance and ensures that real-time notifications are promptly delivered. Performance testing will assess how the system handles varying loads, while security testing will focus on ensuring encrypted communication and secure data storage. Usability testing will be conducted to ensure the interface is user-friendly for parents and school staff, while compatibility testing will ensure the system works across different devices and platforms.

Test cases will be designed to simulate real-world scenarios, such as students boarding and alighting, to ensure the system accurately tracks attendance under various conditions. The test environment will include necessary components such as RFID tags, readers, a database, and user dashboards. Potential risks like scanning failures or network issues will be mitigated with retry mechanisms and offline syncing to ensure continuous functionality. The testing process will include multiple phases: unit testing, integration testing, system testing, and User Acceptance Testing (UAT).

Simulated test data, such as student profiles, bus routes, and network conditions, will be used to assess the system's behavior in different scenarios, including delays. Regression testing will be performed after updates to confirm that new changes do not affect existing functionality. Security tests will focus on ensuring proper access control and data encryption to protect sensitive information. Ultimately, the goal is to ensure the system provides accurate tracking, reliable alerts, and secure monitoring, thereby enhancing safety and efficiency during student transit.

Table 6.1 Test Case Design

Test Case ID	Test Description	Input	Expected Output	Status (Pass/Fail)
TC01	Power on the system	Connect to power supply	All components (NodeMCU, RFID, GSM) turn on	Pass
TC02	Scan a valid RFID tag	Present a registered student RFID tag	Student ID is read and attendance is logged	Pass
TC03	Scan an unregistered RFID tag	Present an unregistered RFID tag	Error or "Unknown Tag" message	Pass
TC04	Send SMS on student boarding	Scan student tag when boarding	SMS: "Student [Name] boarded at [Time]" is sent	Pass
TC05	Send SMS on student exiting	Scan student tag when leaving bus	SMS: "Student [Name] exited at [Time]" is sent	Pass
TC06	GSM module not inserted	Start system without SIM in GSM module	GSM module initialization error	Pass
TC07	Bus delay alert	Simulate delay condition manually	SMS: "Bus delayed due to [Reason]" is sent	Pass
TC08	Power supply failure	Disconnect power briefly	System resumes operation when power is restored	Pass
TC09	Multiple student scans	Scan multiple tags one after another	All attendance and SMS sent correctly	Pass
TC10	Invalid GSM number	Use wrong phone number format	SMS fails to send or shows error	Pass

Table 6.2 Test Case log

Test Case ID	Test Description	Input/Action	Expected Output	Actual Output	Status
TC01	Power on the system	Connect to power supply	All components turn on	NodeMCU, RFID, GSM powered successfully	Pass
TC02	Scan a valid RFID tag	Present a registered student RFID tag	Student ID is read, attendance logged	RFID tag detected, attendance timestamp stored	Pass
TC03	Scan an unregistered RFID tag	Present an unregistered RFID tag	Error or “Unknown Tag” message	Displayed: "Unknown Tag – Access Denied"	Pass
TC04	Send SMS on student boarding	Scan student tag while boarding	SMS: “Student [Name] boarded at [Time]”	SMS sent successfully to registered parent number	Pass
TC05	Send SMS on student exiting	Scan student tag while exiting	SMS: “Student [Name] exited at [Time]”	SMS sent successfully to registered parent number	Pass
TC06	GSM module not inserted	Start without SIM	GSM module initialization error	Displayed: “GSM Module Error – SIM Not Detected”	Pass
TC07	Multiple student scans	Scan multiple RFID tags sequentially	All logs and SMSs processed correctly	All scans recorded, respective SMSs sent	Pass

CHAPTER 7

RESULTS AND DISCUSSION

The implementation of the Smart School Bus and Student Monitoring System was carried out successfully, showing effective performance during both simulation and real-time testing scenarios. The RFID module consistently recorded students' entry and exit data, eliminating the need for manual attendance and reducing the chances of human error. This automation ensured accurate tracking of student movements. Notifications were delivered almost instantly via the Telegram messaging platform, keeping parents and school authorities well-informed about boarding, drop-off, and emergency events. This real-time communication significantly improved transparency and contributed to student safety. The Node MCU microcontroller played a central role by efficiently handling data processing and enabling smooth communication between hardware components and the cloud system. Throughout the testing phase, the system remained stable, supported by a reliable power supply, ensuring uninterrupted functionality even during long transit periods. Though the overall performance was highly reliable, a few RFID misreads were observed, primarily due to improper tag alignment or rapid student movement. These minor issues can be resolved in future versions by integrating visual or audio feedback mechanisms such as LED indicators or buzzers to confirm successful scans. Despite these small limitations, the system proved to be accurate, responsive, and practically useful in a real-world school environment. It not only streamlined the attendance process but also enhanced student monitoring, safety, and parent-school communication. The success of the implementation highlights the potential of IoT and embedded systems in addressing everyday problems in the educational sector. This project provides a solid foundation for future improvements, such as mobile app support and biometric integration, and paves the way for wider adoption across schools seeking smart transportation solutions.

CHAPTER 8

USER MANUAL

INSTALLING PROCEDURE

Step 1: Download and Install Arduino IDE Software Visit the official Arduino website, choose the appropriate version for your operating system (Windows, macOS, or Linux), and follow the installation instructions to install the IDE.

Step 2: Write the code in Arduino IDE. Open Arduino IDE, write a code for the Wi-Fi connection setup (to mobile hotspot), RFID reader setup (for scanning student cards), sending student details via Telegram bot, and emergency notification logic for notifying parents and management.

Step 3: Compile the Code. Click the Checkmark button in the Arduino IDE to compile your code, fix any errors in the console, and recompile until error-free.

Step 4: Upload the Code to the Controller Board. Connect the Arduino board to yours computer via USB, click the Upload button in the IDE to upload the compiled code, and once uploaded, the controller will be ready to execute the code.

Step 5: Turn on the Hotspot on Your Mobile Device. Enable the mobile hotspot on your phone, set the hotspot name (SSID) and password to match the credentials in your code, and the Arduino board will connect to the hotspot.

Step 6: The Arduino Board Connects to the Hotspot. The controller will attempt to connect to the Wi-Fi network (your mobile hotspot), so ensure your phone has a stable internet connection for proper communication with external services like Telegram.

Step 7: Scan the RFID Card to Retrieve Student Details. Place the RFID card near the reader, and the Arduino board will read the card, match it with the pre-programmed student details (name, roll number, attendance), and display or log the details for record-keeping.

Step 8: Send Student Details via Telegram Bot. After reading the RFID card, the system will send the student's details (name, attendance status) to a Telegram bot using the Telegram API, which will then automatically send a message to a predefined group or individual (e.g., teachers, parents, or management).

Step 9: Emergency Notification Trigger. If the system detects an emergency (e.g., a specific RFID card scan or a special button trigger), it will activate the emergency notification system, send an immediate alert to both parents and management via Telegram.

Step 10: System Acknowledgment and Resolution. The system will await acknowledgment from parents and management, logging their confirmation. If needed, further actions like emergency response teams or medical help will be triggered, ensuring continuous communication until the emergency is resolved.

CHAPTER 9

CONCLUSION

In conclusion, The IoT-Based Smart School Bus and Student Monitoring System provides a reliable, cost-effective solution aimed at improving both student safety and school transportation management. The system utilizes RFID technology to automate attendance by accurately detecting and recording when a student boards or alights the bus, removing the need for manual attendance and reducing human error. The Node MCU microcontroller processes the data efficiently, transmitting it to a centralized system. Through the Telegram messaging platform, instant alerts are sent to parents and school authorities, ensuring real-time communication about the student's status during transit. This addresses critical issues such as delayed updates, manual attendance errors, and the lack of transparency in student transit. The system has proven effective in delivering reliable RFID detection and prompt Telegram notifications, offering accountability and peace of mind to all stakeholders involved. By moving away from traditional methods, this smart, IoT-based solution demonstrates the potential of embedded systems to solve common challenges in safety and communication within the education sector. Looking ahead, the system could be further enhanced with features like mobile app support, biometric verification, and cloud-based analytics, which would boost its usability, security, and scalability. These future upgrades would expand the system's capability and effectiveness, paving the way for its broader adoption across schools looking to improve the efficiency and safety of their transportation systems.

CHAPTER 10

FUTURE ENHANCEMENT

In future,To enhance the existing school transportation system, a dedicated mobile application can be introduced to serve as a centralized platform for parents, school staff, and administrators. This app would offer essential features such as real-time bus tracking, allowing parents to monitor the exact location of the bus and ensure their child's safety. It can also maintain automated student attendance logs and send instant push notifications regarding delays, route changes, or emergencies. To strengthen security, biometric authentication methods like fingerprint scanning or facial recognition can be implemented, minimizing the dependency on RFID cards and ensuring only authorized students access the bus. Incorporating AI-based route optimization would help analyze real-time traffic data and historical patterns to recommend the most efficient routes, thus reducing travel time, fuel consumption, and operational costs.

Additional safety measures, including an onboard voice alert system for important announcements and an SOS button for emergency situations, would enhance communication and quick response. Geo-fencing technology could trigger automatic alerts when buses enter or leave designated zones, improving transparency and security during pick-up and drop-off. Monitoring driver behavior through telematics would promote safe driving practices by detecting patterns like harsh braking or overspeeding. Finally, a cloud-based analytics dashboard would provide school administrators with real-time and historical data, enabling them to generate reports, identify trends, and make informed decisions to optimize transport planning and overall management.

APPENDIX-I

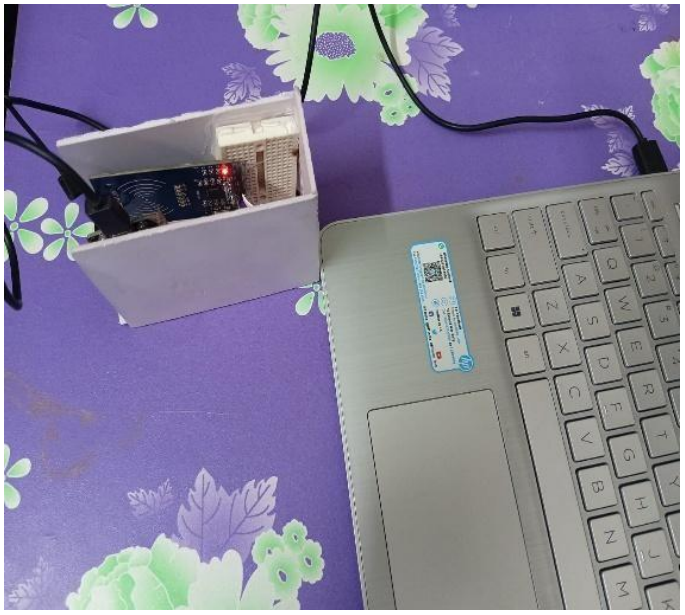
BASE PAPER

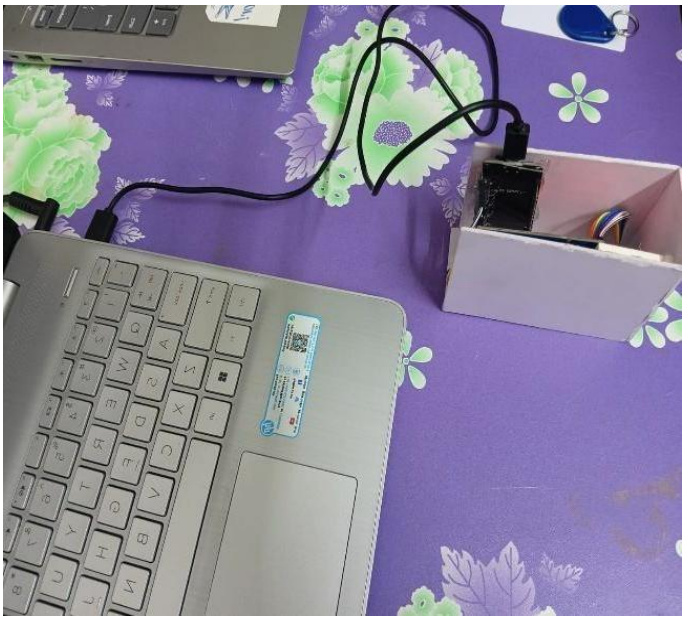
APPENDIX- II

SCREENSHOTS

SCREENSHOTS

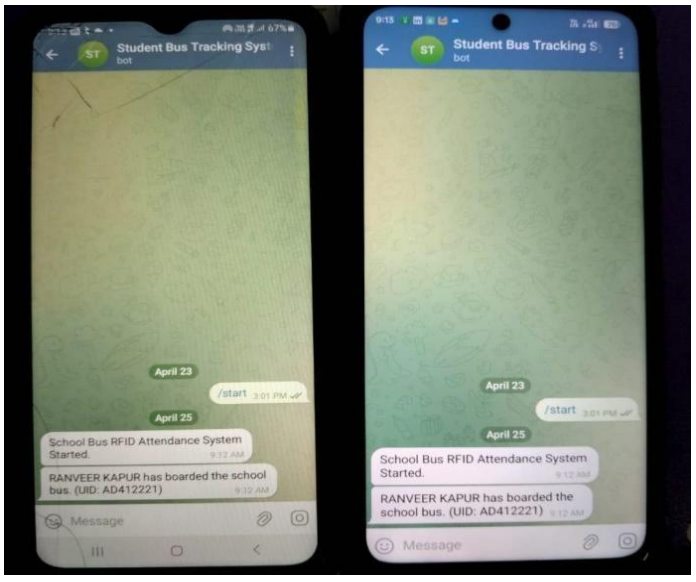
USB PORT IS CONNECTED WITH ESP32 NODEMCU AND RFID SCANNER TO SCAN THE ACCESS CARD TO SEND DATA FROM SENSOR TO CLOUD.

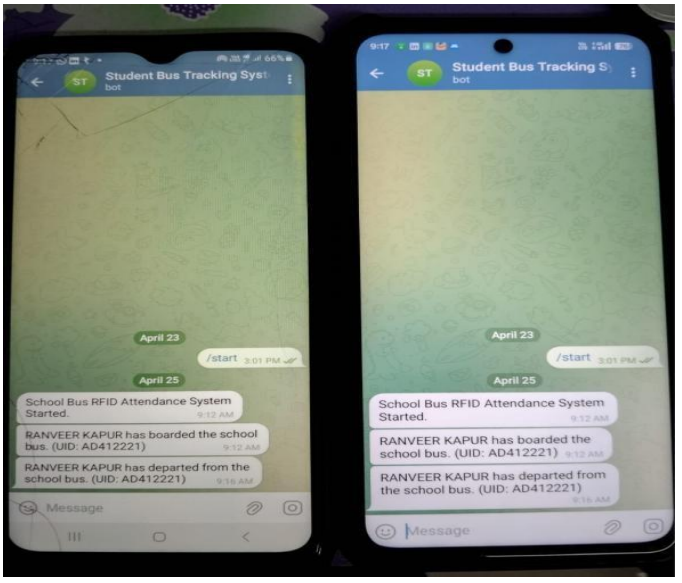




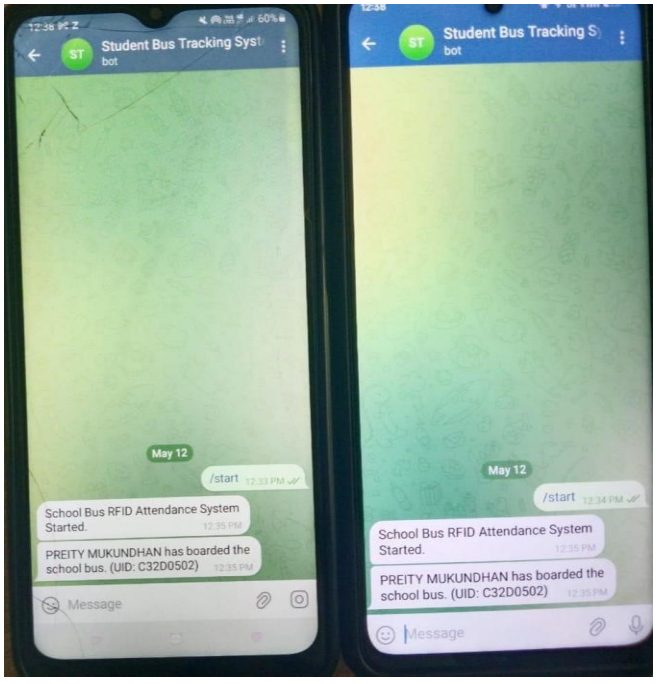
RFID SCANNER ACCESS CARD FOR STUDENT 1 AND STUDENT 2 TO DETECT WHEN THEY GET ENTRY OR EXIT THE BUS.

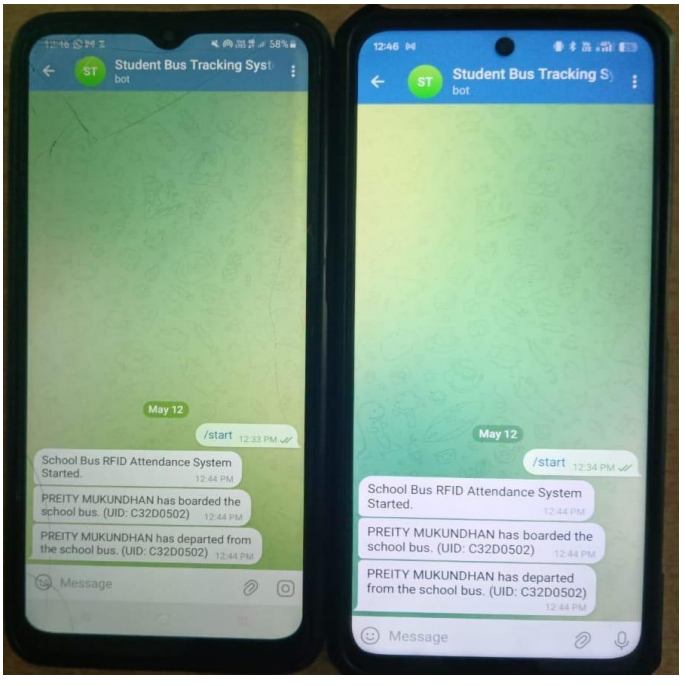
THIS IS A TELEGRAM BOT DESIGNED FOR PARENTS AND SCHOOL MANAGEMENT TO RECEIVE NOTIFICATIONS WHEN A STUDENT 1 (RANVEER KAPUR) BOARDS OR DEPARTS.



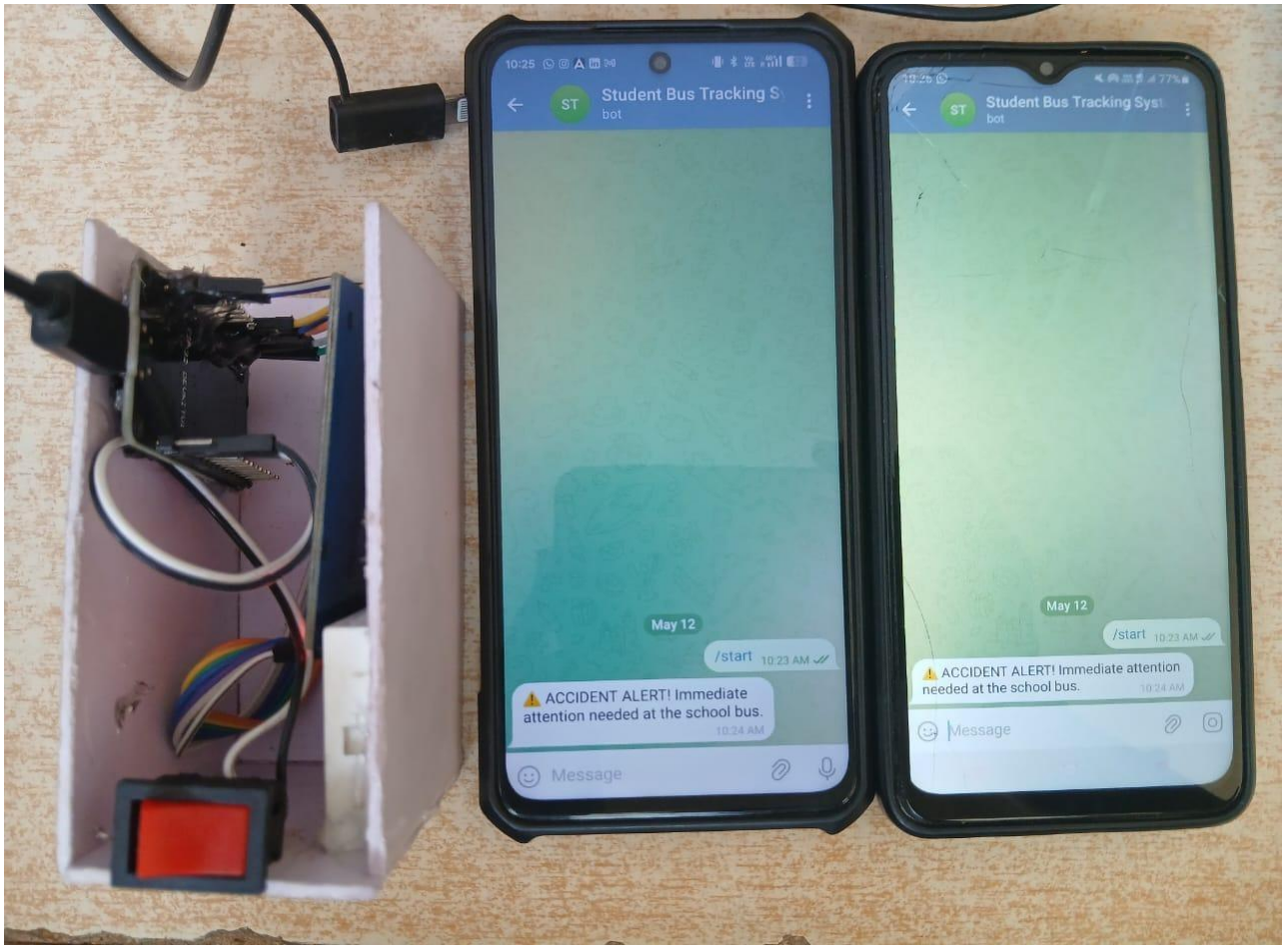


STUDENT 2(PREITY MUKUNDHAN)





EMERGENCY ALERT MESSAGE



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APPENDIX- II I

PUBLICATION AND PATENT

IJARCCE

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH IN COMPUTER AND COMMUNICATION ENGINEERING

A monthly Peer-reviewed & Refereed journal

Impact Factor 8.102

Indexed by Google Scholar, Mendeley, Crossref, Scilit,

SCIENCEOPEN, SCIENCEGATE, DORA, KOAR

Certificate of Publication

MRS. S.JANCY SICKORY DAISY

Associate Professor, Department of Computer Science and Engineering,

Anand Institute of Higher Technology, Kazhipattur, Chennai

Published a paper entitled

IOT Enabled School Bus Tracking and Student Monitoring System

Volume 14, Issue 5, May 2025

DOI: 10.17148/IJARCCE.2025.14509

Certificate# IJARCCE/2025/1

ISSN (Online) 2278–1021
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Editor-in-Chief
IJARCCE

SERTIFIKAAT 証明書 شهادة Sertifikat CERTYFIKAT CERTIFICADO 증명서 СЕРТИФИКАТ 证书 POTVRDA SERTIFIKA

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Published a paper entitled

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FORM 2

THE PATENT ACT 1970

(39 OF 1970)

AND

The patent rules, 2003

COMPLETE SPECIFICATION

(See section 10: rule 13)

TITLE OF INVENTION

A Multilingual Support Chatbot in Customer service

APPLICANT (S)

Name	Nationality	Address
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Mrs.M.Maheswari	Indian	Assistant Professor Department of Computer Science and Engineering Anand Institute of Higher Technology Kazhipattur, Tamilnadu, India
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PREAMBLE TO THE DESCRIPTION

[0001] The following specification particularly describes the invention and the manner in which it is to be performed.

DESCRIPTION

Technical field of invention:

[0002] This invention relates to the field of artificial intelligence, specifically to natural language processing (NLP), machine translation, and conversational AI systems. It pertains to the development and implementation of an intelligent chatbot capable of providing automated customer service in multiple languages, leveraging technologies such as language detection, multilingual intent recognition, machine learning, and dialogue management systems.

Summary of the invention:

[0003] The invention provides a multilingual customer service chatbot designed to interact with users in multiple languages through natural and intelligent conversations. It uses natural language processing, machine translation, and machine learning techniques to understand user queries, detect the language automatically, and generate accurate and context-aware responses.

[0004] The diagram represents the architecture of a chatbot system designed to process and respond to user queries. It begins with the user interface, typically a mobile or web platform, where users submit their requests. These requests are sent to the chatbot, where language understanding takes place. This component analyzes the user's message to determine the user intent and extract relevant context information, which helps maintain continuity in conversation. **FORM 9**

THE PATENT ACT, 1970

(39 of 1970)

&

THE PATENTS RULES, 2003

REQUEST FOR PUBLICATION

[See section 11A (2) rule 24A]

I/We Dr.S.Jancy Sickory Daisy, Mrs.M.Maheswari, Ms.J.Dharshini, Ms.N.Gayathri, Mr.R.Jagajith, Ms.B.Gayathri, Ms.S.Induja ,Ms.R.PriyaDharshini, Ms.S.Rasika,Mr.R.Bharath Kumar hereby request for early publication of my/our [Patent Application No.] TEMP/E-//2023-CHE.

Dated this 13th day of May 2025

M. Mah
[M.MAHESWARI]

1. Dr.S.Jancy Sickory Daisy
2. Mrs.M.Maheswari
3.Ms.J.Dharshini
4.Ms.N.Gayathri
5.Mr.R.Jagajith
6.Ms.B.Gayathri
7.Ms.S.Induja
8. Ms.R.PriyaDharshini
9. Ms.S.Rasika
10.R.Bharath Kumar

To,
The Controller of Patents,
The Patent Office,
At Mumbai

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DR. S. JANCY SICKORY DAISY

DR. S. JANCY SICKORY DAISY KALASALINGAM NAGAR IT CORRIDOR, RAJIV GANDHI SALAI ROAD, KAZHIPATTUR, TAMILNADU 603103 9751604273 jancysickorydaisys.cse@aiht.ac.in

Sr. No.	CBR No.	Reference Number /Application Type	Application Number	Title/Remarks	Amount Paid
1	28565	ORDINARY APPLICATION	202541045916	A MULTILINGUAL SUPPORT CHATBOT IN CUSTOMER SERVICE	1750
2		E-2/4615/2025-CHE	202541045916	Form2	0
3		E-3/9555/2025-CHE	202541045916	Form3	0
4		E-5/4242/2025-CHE	202541045916	Form5	0
5	28565	E-12/10924/2025-CHE	202541045916	Form9	2750
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Cash	---	---	---	4500

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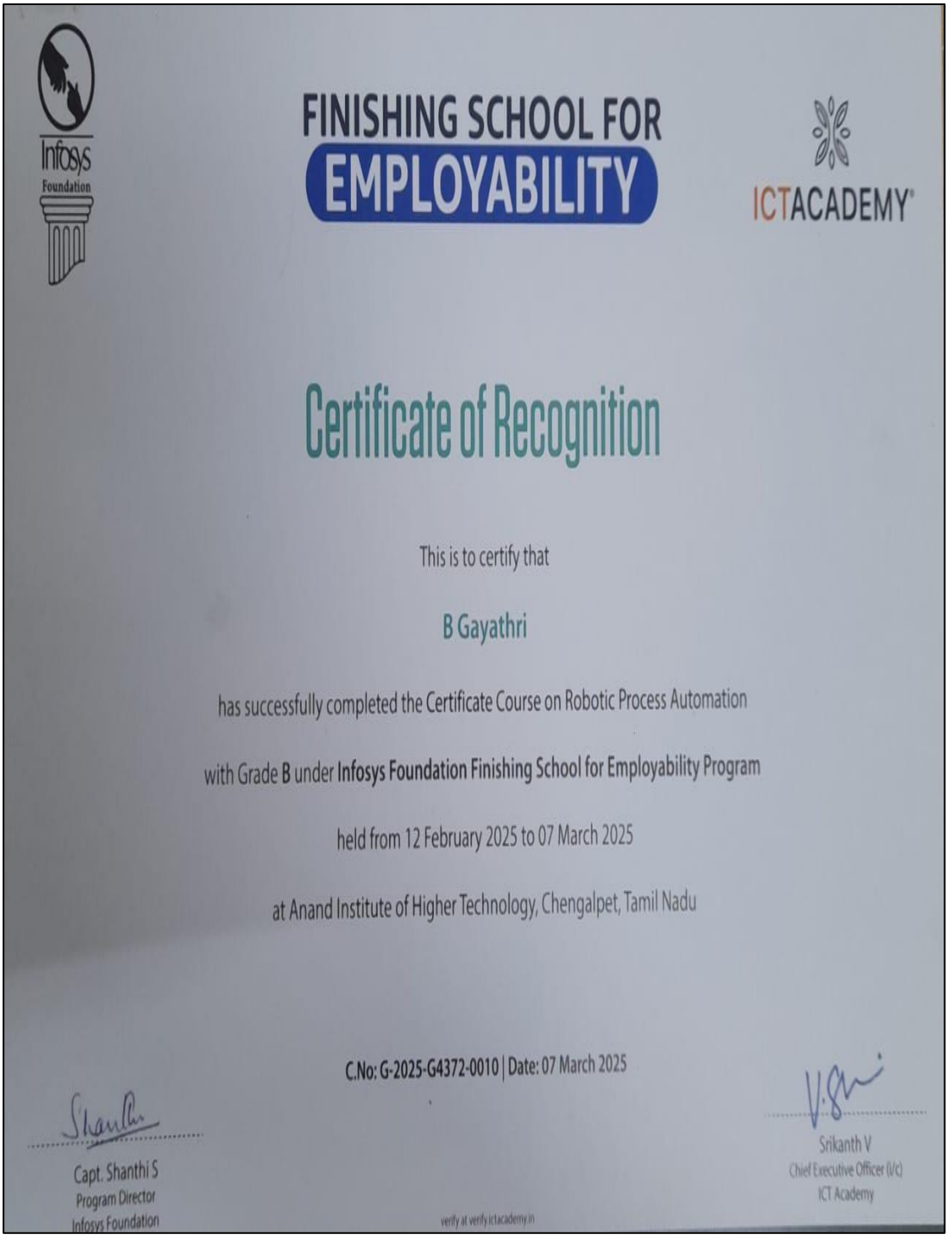
CERTIFICATION



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This is to certify that

B Gayathri

has successfully completed the Certificate Course on Robotic Process Automation

with Grade B under Infosys Foundation Finishing School for Employability Program

held from 12 February 2025 to 07 March 2025

at Anand Institute of Higher Technology, Chengalpet, Tamil Nadu

C.No: G-2025-G4372-0010 | Date: 07 March 2025

Capt. Shanthi S
Program Director
Infosys Foundation

Srikanth V
Chief Executive Officer (I/c)
ICT Academy

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HEXAWARE

Project Internship Completion Certificate

To whomsoever it may concern

April 06, 2025

This is to certify that **S Induja**, studying **B.E** in **Computer Science & Engineering** at **Anand Institute of Higher Technology** has successfully completed internship work from February 03, 2025 to March 31, 2025 at Hexaware Technologies Limited.

For Hexaware Technologies,

Satyendu Mohanty
EVP, Chief Learning officer
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