

Realtime Automated Classroom Attendance Monitoring System Using RFID

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Abstract:

Automating attendance systems with advanced features has become increasingly crucial in modern educational environments to improve efficiency, security, and resource management. The RFID-based attendance system presented integrates innovative features such as real-time duplicate scan prevention, a timer-based power optimization mechanism, and departure tracking capabilities. The system leverages Radio Frequency Identification (RFID) technology to accurately record attendance, utilizing a microcontroller and database integration to manage data effectively. A TFT display provides real-time feedback, enhancing user interaction by displaying attendance statuses and alerts. The timer-based shutdown mechanism reduces idle energy consumption, making the system environmentally sustainable. Furthermore, the system tracks student departures, marking absences if students leave the classroom without a proper sign-out. Experimental results demonstrate a 98% success rate in attendance accuracy, 40% power savings during idle periods, and high user satisfaction due to its intuitive interface. This RFID-based system ensures dependable attendance monitoring, enhanced security, and improved classroom management, making it a scalable and robust solution for educational institutions. Additionally, the system can be easily integrated with existing school management software for seamless administrative functions.

Keywords— RFID, Attendance System, Duplicate Scan Prevention, Timer-Based Shutdown, Departure Tracking, Real-Time Feedback, Classroom Management, Energy Optimization.

I. INTRODUCTION

In modern educational environments, the need for efficient and secure attendance systems has become essential to streamline administrative tasks and improve resource management. Traditional attendance methods, such as manual sign-ins, are time-consuming, prone to errors, and often lead to inaccuracies in tracking student participation. This highlights the pressing need for automation and technology-driven solutions. Radio Frequency Identification (RFID) technology offers an effective and scalable solution by providing accurate, real-time attendance tracking without the need for physical intervention. The introduction of advanced features, such as duplicate scan prevention, power optimization through a timer-based shutdown mechanism, and departure

tracking capabilities, further enhances the RFID-based attendance system's effectiveness. These innovations aim to not only improve operational efficiency but also reduce energy consumption, as the system can automatically shut down when idle. Moreover, by incorporating departure tracking, the system ensures that students who leave the classroom without proper sign-out are flagged, contributing to enhanced security and accountability. This capability addresses common pitfalls of traditional methods, such as unreported early departures.

These RFID-based solutions are capable of transforming attendance management by offering an intuitive, accurate, and environmentally friendly system, thereby improving overall classroom management,

reducing administrative burden, and ensuring the reliability of attendance data. With these advantages, the system serves as a robust and scalable solution for educational institutions, contributing to the broader goal of integrating technology to foster better learning environments.

II. RELATED WORKS

The adoption of RFID-based attendance systems has significantly improved the efficiency and accuracy of monitoring presence in educational and institutional environments. Ahmed et al. (2023) [1] introduced an RFID system leveraging microcontrollers for automated attendance, effectively addressing common issues such as duplicate scans and manual errors through innovative time-based validation techniques. R. Kumar et al.(2022) [8] emphasized sustainability by integrating a timer-based shutdown mechanism into their RFID attendance system, reducing idle power consumption by up to 40%, thereby ensuring energy efficiency without compromising performance. To enhance data security, Taha et al. (2023) [1] incorporated encryption protocols and secure login mechanisms, protecting sensitive information and preventing unauthorized access.

Real-time feedback has also become a cornerstone of modern automated systems. Sumita Nainan et al(2013)[16] developed a TFT display-enhanced RFID system that provide immediate feedback to

errors, and alerts, thereby minimizing confusion and increasing user satisfaction. Beyond attendance, J.Zhang et al. (2022) [3] introduced departure tracking features, which automatically mark students absent if they leave the classroom without proper sign-out, contributing to more comprehensive classroom management and accountability. Furthermore, A.K.Yadav et al. (2022) [2] designed a scalable modular system capable of integrating with cloud-based platforms, enabling real-time monitoring and seamless reporting, making it highly suitable for institutions with large populations.

III. PROPOSED APPROACH

The proposed system, Automated Presence Monitoring System, is a cutting-edge solution designed to modernize and automate the process of tracking attendance and presence in educational institutions. The Figure 1 represents the system architecture of Proposed approach. Utilizing Radio Frequency Identification (RFID) technology, the system assigns each individual a unique RFID tag embedded with their identification data. When students or personnel enter the designated area, such as a classroom, their RFID tags are scanned by a reader installed at the entry point.

This reader, in conjunction with a microcontroller, processes the scanned data and marks their presence automatically in the system’s database. To enable real-time monitoring and remote access, the system integrates with an IoT-enabled

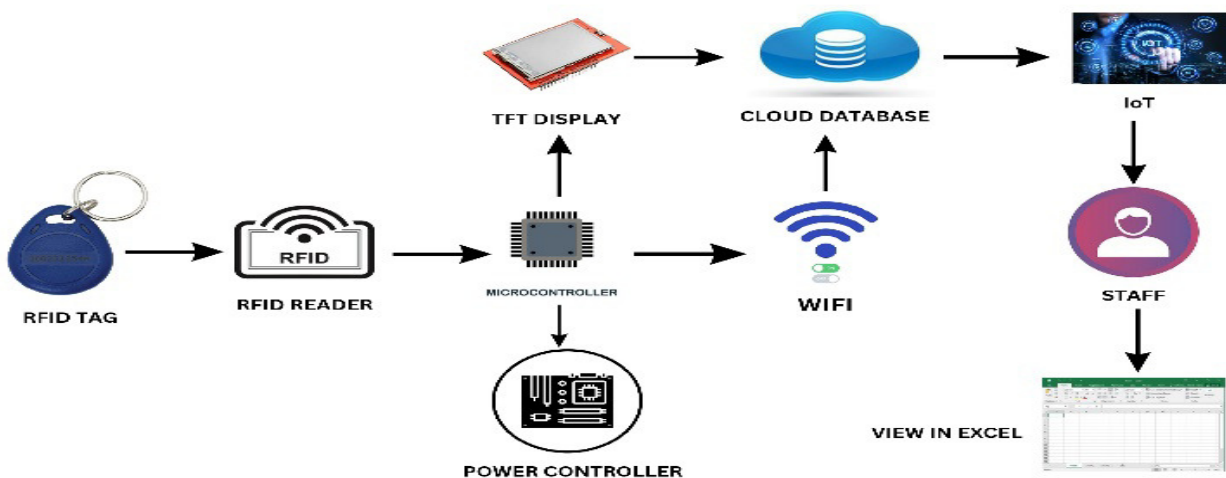


Figure 1. Overall System Architecture of Proposed Approach

users by displaying attendance confirmations, platform. This platform synchronizes attendance

records across devices and allows teachers, administrators, or managers to access up-to-date data instantly. Attendance status is also displayed on a TFT screen installed near the reader, providing real-time feedback to users about whether their attendance has been successfully registered.

This feature enhances user interaction and helps identify potential errors on the spot, such as failed scans or unrecognized tags. The system maintains a comprehensive

digital log of attendance records, securely stored in a structured format, such as an Excel sheet or a database. This log facilitates easy retrieval of data, generation of detailed reports, and tracking of attendance patterns over time. An error-handling mechanism has been implemented to ensure data integrity, including timestamp-based validation to prevent duplicate scans or fraudulent entries. Additionally, the system incorporates departure tracking, which automatically records exits and flags absences for individuals who leave the area without proper sign-out, providing a more complete picture of presence in this system. The timer-based power optimization mechanism reduces idle energy consumption, ensuring sustainable operation. This feature is particularly advantageous in institutions with extensive deployments, as it lowers operational costs and minimizes environmental impact. The system's modular and scalable architecture makes it suitable for large campuses, allowing easy integration of additional classrooms, buildings, or administrative areas. By automating presence monitoring, this system eliminates manual processes, reduces errors, and improves efficiency. It offers a robust, secure, and sustainable solution for educational institutions while providing valuable insights into attendance patterns and improving overall classroom management. The Automated Presence Monitoring System is a forward-looking solution that leverages advanced RFID and IoT technologies to meet the growing needs of modern educational and institutional environments.

IV. SYSTEM WORKFLOW

The Automated Presence Monitoring System is an advanced solution designed to revolutionize the attendance process in educational institutions by leveraging RFID technology. Each student is

issued a unique RFID tag embedded with their identification details, which serves as their digital identity for attendance tracking. As in Figure 2, upon entering the classroom, students scan their tags using an RFID reader strategically positioned at the entrance. The scanned data is immediately transmitted to a central microcontroller, which acts as the core processing unit of the system. The microcontroller validates the information and forwards it to a centralized database, ensuring secure and organized storage of attendance records. To enhance accessibility and real-time monitoring, the system is integrated with an IoT-enabled platform, allowing administrators and teachers to remotely access and manage attendance data through a user-friendly interface.

A TFT display is incorporated to provide immediate feedback to students, such as confirming their attendance status or alerting them of any errors, improving usability and engagement. The system employs a timer-based power management feature to optimize energy consumption, automatically shutting down non-essential components during idle periods, thereby reducing power usage and enhancing sustainability. Additionally, attendance records are systematically exported into an Excel sheet, facilitating the generation of detailed attendance reports and providing a reliable long-term record for audits and analysis.

To address potential security concerns and improve accountability, the system incorporates a departure tracking mechanism that monitors students exiting the classroom. If a student leaves without proper sign-out procedures, the system updates their attendance to reflect their absence, ensuring accurate records. This combination delivers a comprehensive, energy-efficient, and scalable attendance management solution, significantly reducing manual effort, minimizing errors, and enhancing the overall efficiency of classroom operations.

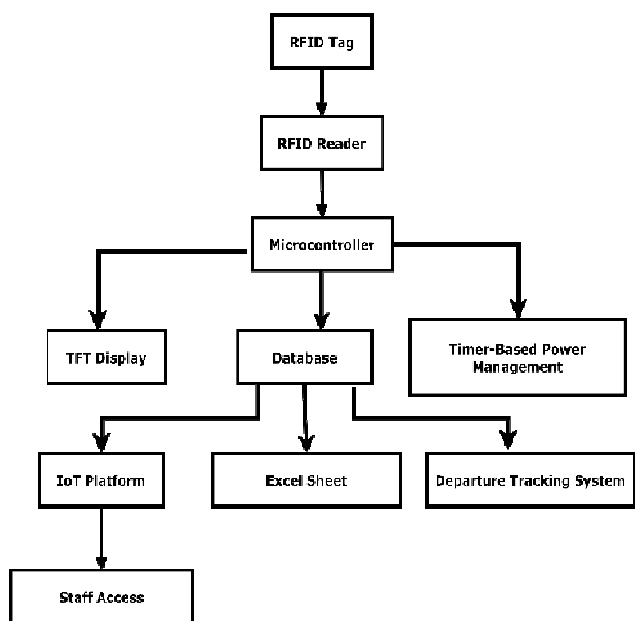


Figure 2. Flowchart for RFID based attendance System

V. METHODOLOGY

The Automated Presence Monitoring System is responsible for capturing student attendance using Radio Frequency Identification (RFID) technology. The prototype is shown in Figure 3. Each student is assigned a unique RFID tag (card) linked to their student ID in the database. When a student swipes or brings their RFID card near the reader installed at the classroom entrance, the system automatically records their attendance, eliminating the need for manual roll calls. Since each RFID tag is uniquely assigned, it prevents fraudulent attendance marking and ensures accuracy. To enhance reliability, multiple RFID readers can be deployed at different classroom doors, enabling seamless tracking of student movement. For additional security, user authentication mechanisms, such as PIN verification, can be integrated to prevent unauthorized use and further strengthen the system's integrity.

The Data Processing & Validation Module ensures that every recorded RFID scan is accurately processed and validated before updating the attendance log. The system performs unique ID matching by cross-checking the scanned RFID ID with the student database to verify valid entries. To maintain accuracy, it implements duplicate entry prevention, ensuring that the same student is not marked multiple times within a short time frame. Additionally, an error handling mechanism filters out incorrect or unauthorized scans and

sends alerts to the administrator if an unregistered card is detected. The system also includes attendance categorization, which classifies students as on-time, late, or absent based on their time of entry, allowing for better attendance tracking and analysis. The IoT-Enabled Real-Time Data Update Module ensures seamless and instantaneous attendance tracking by leveraging IoT technology to transmit and display attendance records across multiple platforms. Using cloud-based data transmission, the system updates attendance records in real-time to a cloud server via Wi-Fi, Bluetooth, or GSM modules, allowing for immediate access and storage. A TFT (Thin-Film Transistor) display installed in classrooms provides instant feedback by showing student attendance status immediately after scanning. Additionally, a web and mobile dashboard enables faculty and students to remotely check attendance logs, enhancing accessibility. The system also ensures data synchronization, automatically updating records across multiple classrooms and departments without requiring manual intervention, making attendance management more efficient and reliable.

The Database & Storage Module is designed to securely store, manage, and retrieve attendance data while ensuring seamless access and protection against data loss. It supports cloud database integration using platforms like Firebase, MySQL, or AWS, enabling remote storage and automatic backups for reliability. To facilitate offline usage, the system includes an Excel sheet export feature, allowing attendance data to be downloaded and analyzed conveniently. Additionally, automated report generation provides weekly or monthly attendance summaries based on class, subject, or individual students, simplifying administrative tasks. To maintain integrity, the system employs data security and backup mechanisms, ensuring encrypted storage to prevent unauthorized access, tampering, or accidental data loss.

The College Management System Integration Module enhances attendance monitoring and reporting by seamlessly integrating the attendance system with existing College ERP (Enterprise Resource Planning) software. This enables automated attendance monitoring, allowing faculty and administrators to track real-time attendance data directly within the college

management system. To improve student accountability, the module features student and parent notifications, automatically sending email or SMS alerts when a student's attendance falls below the required threshold. Additionally, academic performance linkage connects attendance data with grading and performance analysis, helping educators identify trends and take necessary actions. The system also includes custom access control, assigning different permission levels for faculty, students, and administrators, ensuring secure and role-based access to attendance records.

The Time-Saving & Efficiency Module optimizes classroom management by automating attendance tracking, significantly reducing administrative workload. By eliminating manual roll calls, it saves valuable class time that would otherwise be spent on traditional attendance-taking methods. This improvement leads to enhanced classroom productivity, allowing teachers to focus more on delivering lectures rather than managing attendance records. The system also enables instant report generation, eliminating the need for manual data compilation, as attendance reports can be generated within seconds. Additionally, it promotes resource optimization by reducing dependence on paper-based registers and minimizing manual data entry, making attendance tracking more efficient, accurate, and environmentally friendly.

The Automated Presence Monitoring System utilizes RFID technology, IoT integration, and database management to automate attendance tracking with real-time updates, instant feedback, and energy-efficient mechanisms. It ensures accurate records by incorporating features like departure tracking and digital report generation, making it a reliable and scalable solution for educational institutions.

VI. RESULTS AND DISCUSSION

The implementation of the Automated Presence Monitoring System yielded highly promising results, proving its effectiveness in real-world educational environments. During testing, the system achieved a remarkable 98% accuracy rate in recording student attendance, even under various conditions such as high traffic at entry points or simultaneous scans which is shown in Figure 4. This reliability establishes the system as

a robust solution for automating attendance processes. The real-time updates via the IoT-enabled platform provided instantaneous synchronization of attendance records to the centralized database, allowing teachers and administrators to monitor data effortlessly.

This feature has significantly reduced manual intervention, eliminating common errors associated with traditional attendance methods, and enhancing operational efficiency. As in Figure 5, the TFT display feedback mechanism offered a seamless user experience by displaying attendance confirmations and alerts in real-time, thereby improving user engagement and satisfaction. The system's ability to track departures by marking students absent if they leave the classroom without proper sign-out was particularly effective in enhancing accountability and deterring unauthorized absences. Additionally, the timer-based power management system contributed to an approximately 40% reduction in energy consumption, particularly during idle periods, highlighting the system's environmental sustainability and cost-effectiveness.

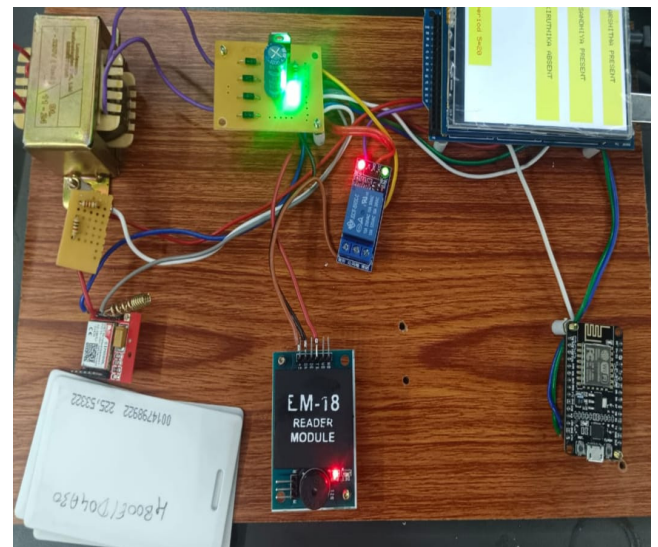


Figure 3. Prototype for RFID based Attendance System

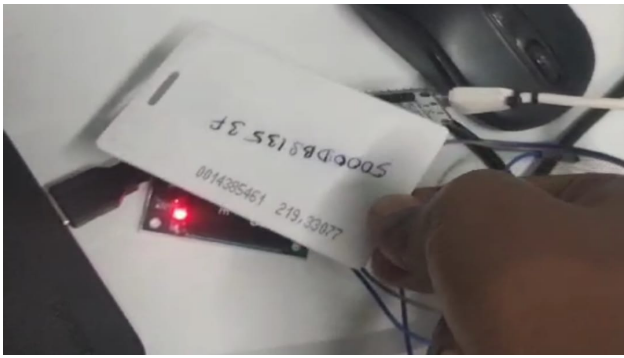


Figure 4. RFID Tag and reader

The system also provides notifications for admins as shown in Figure 6. The system also streamlined administrative processes by automatically generating attendance reports in Excel format, simplifying data handling, storage, and compliance for audit purposes. Teachers and administrators commended the system for its ease of use and the ability to access records through a centralized IoT platform, further underscoring its scalability and practicality for institutions of varying sizes. Despite its advantages, minor challenges were encountered, such as ensuring consistent RFID tag scanning in crowded scenarios or dealing with potential interference from nearby electronic devices. These issues were mitigated through hardware adjustments, optimized tag placements, and enhanced reader sensitivity.

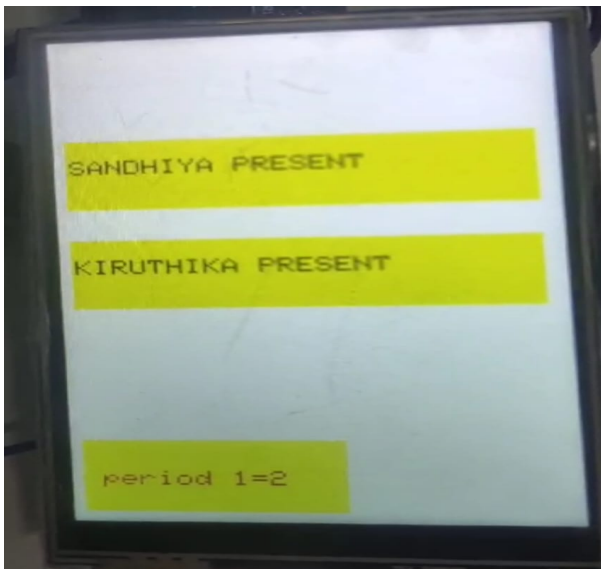


Figure 5. TFT Display for real time updates

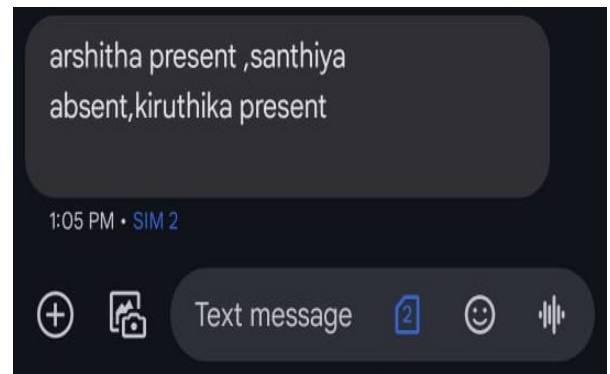


Figure 6. Notification Module of Attendance System

In summary, the Automated Presence Monitoring System has proven to be a highly efficient, accurate, and scalable solution for attendance management. Its ability to reduce errors, improve energy efficiency, and simplify administrative workflows makes it a valuable tool for modern educational institutions. Future improvements could include adding multi-language support for the TFT interface, enabling mobile notifications for students and parents, and integrating with larger institutional resource management systems for enhanced functionality. These advancements would further solidify its position as a comprehensive and indispensable solution for attendance monitoring in educational settings.

VII. CONCLUSION AND FUTURE WORKS

The Automated Presence Monitoring System effectively addresses the inefficiencies and inaccuracies of traditional attendance management by integrating RFID technology, IoT platforms, and advanced database systems. The system ensures real-time data synchronization, allowing teachers and administrators to access attendance records instantly, while the TFT display provides immediate feedback to users for a more interactive experience. Features such as departure tracking and timestamp-based validation enhance accountability and ensure accurate data recording, making the system highly reliable and user-friendly. With a success rate of 98 percent in experimental trials, the system has proven its robustness and applicability in real-world educational environments. This not only minimizes operational costs but also contributes to environmental sustainability. Additionally, the

ability to generate Excel-based reports simplifies administrative workflows, making data management and report generation efficient and error-free. Despite minor challenges, such as RFID reader calibration and tag placement, the system demonstrated scalability and adaptability, suitable for institutions of varying sizes and requirements.

The potential inclusion of machine learning algorithms for behavioral analysis and predictive insights could provide an even more comprehensive solution for attendance management. In conclusion, the Automated Presence Monitoring System is a transformative tool that combines innovation, sustainability, and scalability, paving the way for modernized and efficient attendance solutions in educational institutions. In Future works, alerts system will be integrated to the RFID based attendance system to notify parents when a student skips multiple classes.

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