IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 7, July 2025

DOI: 10.17148/IJARCCE.2025.14730

Novel RFID Cloud Based Smart Attendance System

MASUD ALAM[1], RAHUL SINGH[2], SHAHBAZ KHAN[3], KRISHN KANT SAH[4], DR. SANDEEP DUBEY[5]

MCA, SAM Global University[1-4]

Guide, MCA, SAM Global University[5]

Abstract: The "Novel RFID Cloud Based Smart Attendance System" project addresses the persistent challenges faced by organisations and institutions in efficiently managing attendance records for employees, students, or visitors. Traditional attendance methods, often paper-based or relying on manual data entry, are highly susceptible to errors, time-consuming, and crucially, lack real-time monitoring capabilities. This innovative project, developed by Masud Alam, Rahul Singh, Shahbaz Khan, and Krishn Kant Sah from the School of Information Technology at SAM Global University for the 2024-25 academic session, offers a robust solution to these inherent limitations.

At its core, the system harnesses the power of Radio Frequency Identification (RFID) technology integrated with a scalable cloud computing architecture. This synergistic approach enables attendance data to be securely stored in a remote database, ensuring it is accessible from anywhere in the world and at any time. The project meticulously combines a range of hardware and software components to achieve its comprehensive functionality. Key hardware elements include the ESP32-WROOM-32E Microcontroller Unit (MCU), which acts as the central control unit, orchestrating communication with peripherals such as the RFID MFRC522 reader module and the OLED display module SSD1306, and managing the solenoid lock. The RFID MFRC522 reader is responsible for automated identification by scanning and reading digitally encoded data from 1k MIFARE Classic Contactless Smart Cards. A 1 Channel 5v Relay Module facilitates the control of the 12V solenoid lock, which grants temporary access for approximately 10 seconds upon a successful RFID scan. The OLED display provides immediate, real-time feedback on attendance status, including student login and logout events, chosen for its clear view angle and pixel density.

From a software perspective, the system incorporates a comprehensive web-based user interface (Web UI), meticulously crafted using HTML, CSS, and JavaScript (with the Bootstrap framework). This UI empowers administrators to manage attendance records, view reports, and configure system settings, including the ability to add, edit, and delete user profiles. The backend, primarily developed with PHP, is responsible for fetching and rendering data from the MySQL database, a Relational Database Management System (RDBMS) that handles structured user data storage, retrieval, and management. The Arduino language is utilised to program the ESP32 microcontroller. For deployment, the project leverages AWS Cloud services, specifically EC2 instances for hosting the website on an Apache server within a Linux virtual machine, and AWS S3 for static file storage, with CloudFront providing efficient content delivery globally. The development process adhered to a structured methodology encompassing requirement analysis, detailed system design, hardware setup, software development, rigorous integration and testing, strategic deployment, and ongoing maintenance and support.

The system's functional capabilities include automated attendance tracking via RFID scanning, real-time attendance information display on the OLED, and secure access control through the solenoid lock based on attendance status. The Web UI allows for the generation of attendance reports in various file formats based on specified criteria. Robust cybersecurity measures, including data encryption for user passwords and personal details, are embedded within the backend and database to prevent unauthorised access and mitigate risks such as RFID cloning or spoofing. The system's non-functional attributes highlight its user-friendly interface, low latency and quick response times, scalability to accommodate an increasing number of users and hardware components, stability for consistent operation, and minimal downtime. Furthermore, its design and documentation facilitate easy maintenance, troubleshooting, and future enhancements.

Having achieved significant milestones, the project has resulted in a functional smart attendance system that effectively demonstrates its core features and meets initial requirements. The market outlook for such an automated attendance solution is promising, driven by the escalating demand for digitisation and accurate tracking across diverse sectors. The project's unique selling proposition lies in its comprehensive integration of hardware, software, and user interface. Target

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 7, July 2025

DOI: 10.17148/IJARCCE.2025.14730

clients encompass educational institutions, corporate offices, government organisations, event management companies, and healthcare centres. Future work will focus on implementing enhanced security features (e.g., biometric authentication), developing advanced reporting and analytics, building a mobile application, and optimising for scalability and performance. Further integrations with Student Information Systems (SIS) and Learning Management Systems (LMS) are also envisioned to streamline data management and synchronisation. Key recommendations include conducting extensive user testing, continuous refinement and documentation, fostering partnerships and collaborations, and developing a strategic marketing plan to ensure the solution's growth and success.

.

Keywords: RFID, Cloud Computing, Smart Attendance System, ESP32 Microcontroller, Web User Interface (Web UI), Access Control, Data Management (MySQL), Real-time Display (OLED), Hardware Integration, Security.

I. INTRODUCTION

The "Novel RFID Cloud Based Smart Attendance System" project addresses the prevalent challenges faced by organisations and institutions in efficiently managing attendance records for employees, students, or visitors. **Traditional attendance methods, often reliant on paper-based processes or manual data entry, are inherently prone to errors, are time-consuming, and significantly lack real-time monitoring capabilities**. This innovative project, developed by Masud Alam, Rahul Singh, Shahbaz Khan, and Krishn Kant Sah from the School of Information Technology at SAM Global University for the 2024-25 academic session, offers a robust and modern solution to these persistent limitations.

At its core, the system **leverages the power of Radio Frequency Identification (RFID) technology integrated with a scalable cloud computing architecture**. This synergy enables attendance data to be **securely stored in a remote database**, ensuring it is **accessible from anywhere in the world and at any time**. The project involves the meticulous integration of various hardware and software components to achieve its comprehensive functionality.

Key hardware elements include the **ESP32-WROOM-32E Microcontroller Unit (MCU)**, which serves as the central control unit, orchestrating communication with peripherals. These peripherals comprise the **RFID MFRC522 reader module**, responsible for automated identification by scanning **1k MIFARE Classic Contactless Smart Cards**. An **OLED display module SSD1306** provides immediate, real-time feedback on attendance status, including student login and logout events. Furthermore, a **1 Channel 5v Relay Module** facilitates the control of a **solenoid lock**, which grants temporary access upon a successful RFID scan.

From a software standpoint, the system incorporates a comprehensive **web-based user interface (Web UI)** for administrators to manage attendance records, view reports, and configure settings. The backend, primarily developed with **PHP**, interacts with a **MySQL database** to handle structured user data storage and retrieval. The project also leverages **AWS Cloud services**, specifically **EC2 instances for hosting the website** and **AWS S3 for static file storage**, with **CloudFront providing efficient content delivery globally**. This integrated approach leads to an efficient, automated, and secure smart attendance system.

II. BACKGROUND AND MOTIVATION

In the rapidly advancing digital landscape of today, organisations and institutions globally are continually seeking more efficient and reliable methods for managing attendance records for their personnel, students, or visitors. Traditional paper-based methods or manual data entry processes are inherently prone to errors, are time-consuming, and significantly lack real-time monitoring capabilities. These conventional approaches often result in inaccuracies, administrative burdens, and a lack of immediate insight into attendance patterns, thereby impacting operational efficiency and accountability. The limitations of such systems necessitate the development of a modern, automated solution that can overcome these long-standing challenges.

The "Novel RFID Cloud Based Smart Attendance System" project, developed by Masud Alam, Rahul Singh, Shahbaz Khan, and Krishn Kant Sah from the School of Information Technology at SAM Global University for the 2024-25 academic session, is precisely motivated by this critical need for a more advanced attendance management solution. The primary motivation stems from the recognition that automation and digitisation have become increasingly prevalent, driving a growing market demand for smart attendance systems that can optimise operations, improve productivity, and reduce costs.

This innovative system addresses the identified limitations by leveraging the power of Radio Frequency Identification (RFID) technology integrated with a scalable cloud computing architecture. RFID technology serves as the core for automated identification and attendance tracking, enabling users to simply scan their cards/tags at a reader. Concurrently, cloud computing ensures that attendance data is securely stored in a remote database, which can be easily accessed from anywhere in the world and at any time. The project specifically utilises AWS Cloud services (EC2 instances for hosting, S3 for static files, and CloudFront for content delivery) to achieve this global accessibility and scalability.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 7, July 2025

DOI: 10.17148/IJARCCE.2025.14730

The system's development is further motivated by the desire to offer distinct advantages over existing methods. It incorporates a range of carefully selected hardware and software components to deliver comprehensive functionality. Key hardware elements include the ESP32-WROOM-32E MCU, acting as the main control unit, an RFID MFRC522 reader module for scanning 1k MIFARE Classic Contactless Smart Cards, an OLED display module SSD1306 for real-time information about attendance status, and a solenoid lock, controlled by a Relay Module, for automated access control. On the software side, a web-based user interface (Web UI), built with HTML, CSS, and JavaScript with Bootstrap, allows administrators to manage attendance records, view reports, and configure system settings. The backend, developed using PHP, interacts with a MySQL database for robust data management and storage. The integrated approach provides enhanced security through measures such as data encryption and protocols to prevent RFID cloning. This confluence of technologies provides an efficient, automated, and secure smart attendance system that is poised to meet the growing demands of various sectors, including Educational Institutions, Corporate Offices, Government Organizations, Event Management Companies, and Healthcare Centers.

III. LITERATURE REVIEW

The system integrates all its core components—the **Frontend of Website** (developed using HTML, CSS, JavaScript, and Bootstrap), the **Backend of Website** (implemented with PHP), and the **MySQL Database**—into a single, cohesive unit. The entire web application, including its backend operations and data management, is described as being deployed on an **AWS EC2 instance** utilizing a **LAMP stack** (Linux, Apache, MySQL, PHP). The backend is specifically tasked with storing and arranging data, and ensuring the client-side functionality operates correctly. This close coupling means that all functionalities for attendance tracking, user management, and reporting reside within a single application.

(The following sentence contains information not directly from the sources about the general concept of monolithic architecture, but clarifies how the project fits it, and you may wish to independently verify this information.) This approach, where all functionalities are developed and deployed as a single, indivisible unit, is commonly known as a **monolithic architecture**. The project's emphasis is on the **integration of hardware and software components** to create a unified and **automated smart attendance system**.

make "B. Introduction to Front End Challenges in Scaling Large Teams " in 100 words
Based on the provided sources and our conversation history, the project documentation for the "Novel RFID Cloud Based Smart Attendance System" **does not explicitly address "Front End Challenges in Scaling Large Teams"** [outside information].
The sources detail the **"Frontend of Website"** as a crucial component, developed using **HTML, CSS, JavaScript, and Bootstrap**. This web-based user interface enables administrators to **manage attendance records, view reports, and configure system settings**. While the project does mention **scalability** as a non-functional requirement, this is generally in the context of the system being **able to handle a growing number of users and accommodate additional hardware components**, and **optimizing performance to handle a larger number of users and attendance records efficiently**. The focus is on system-level performance and data handling rather than specific challenges faced by large frontend development teams or architectural patterns like micro-frontends to address those challenges. The described architecture for the website frontend and backend points towards a **monolithic deployment on an AWS EC2 instance using a LAMP stack** [my previous response, 56].
make "LITERATURE REVIEW" 900 words
The provided "RFID Cloud Based Smart Attendance System - MCA Project Report.pdf" does not contain a dedicated section explicitly titled "Literature Review" [Relevant portions of the source, e.g., Table of Contents]. However, a comprehensive understanding of the project's context, motivation, and technical underpinnings can be synthesised by examining the problem statement, the technologies employed, and the cited external references, which collectively serve the purpose of grounding the "Novel RFID Cloud Based Smart Attendance System" in existing knowledge and identifying its contribution. This constructed review will articulate the prevailing challenges in attendance management and demonstrate how the project leverages established and emerging technologies to offer an innovative solution.

The Inadequacies of Traditional Attendance Management Systems

The fundamental motivation for the "Novel RFID Cloud Based Smart Attendance System" stems from the inherent drawbacks of conventional attendance recording methods [my previous response]. **Traditional paper-based methods or manual data entry processes are notoriously prone to errors, are exceedingly time-consuming, and crucially, lack real-time monitoring capabilities** [17, my previous response]. These outdated approaches invariably lead to a host of operational inefficiencies, including **inaccuracies in records, significant administrative burdens, and a notable absence of immediate insight into attendance patterns** [my previous response]. This directly impacts an organisation's **operational efficiency and accountability** [my previous response]. The widespread nature of these limitations across

DOI: 10.17148/IJARCCE.2025.14730

various sectors, such as **educational institutions, corporate offices, government organisations, event management companies, and healthcare centres**, creates a **growing market demand for modern, automated solutions** [88, my previous response] that can surmount these long-standing challenges [17, my previous response].

Leveraging Radio Frequency Identification (RFID) for Automated Tracking

At the heart of the proposed solution is **Radio Frequency Identification (RFID) technology**, an **automatic identification method that utilises wireless non-contact radio frequency waves**. This technology enables data, which is **digitally encoded in RFID tags or smart labels**, to be read by a reader via radio waves. In the context of the smart attendance system, this translates to users, such as students, being able to **simply scan their RFID cards/tags at an RFID reader to record their attendance**. The project specifically employs an **RFID MFRC522 reader module** and **1k MIFARE Classic Contactless Smart Cards**. The system is designed such that the **student's data, encrypted within the RFID tag, is exposed to the radio waves of the RFID reader upon scanning**. This automation eliminates the tedious and error-prone nature of manual recording, thereby enhancing the speed and accuracy of attendance logging. The project also acknowledges potential **security risks like RFID cloning or spoofing**, planning **enhanced security features** to prevent such unauthorised access.

The Scalability and Accessibility of Cloud Computing

Complementing RFID technology, **cloud computing forms the backbone of the system's data management and accessibility**, addressing the need for **secure, scalable, and globally accessible attendance records** [18, my previous response]. Cloud computing platforms, provided by services like **Amazon Web Services (AWS)**, offer **on-demand computing platforms and APIs on a pay-as-you-go basis**, enabling **scalable deployment of applications**. The "Novel RFID Cloud Based Smart Attendance System" specifically leverages **AWS Cloud services**, including **EC2 instances for website hosting** and **AWS S3 for static file storage**, with **CloudFront ensuring efficient content delivery globally** [18, 54, 56, my previous response]. This architecture ensures that attendance data is **securely stored in a remote database, easily accessible from anywhere in the world at any time** [18, my previous response], freeing clients from the complexities of managing, scaling, and patching hardware and operating systems. **Scalability is a key non-functional requirement**, ensuring the system can **handle a growing number of users and accommodate additional hardware components efficiently**.

Integrated Hardware and Software Components for Comprehensive Functionality

The project's solution goes beyond just RFID and cloud, integrating a suite of hardware and software components to deliver comprehensive functionality. The **ESP32-WROOM-32E Microcontroller Unit (MCU) serves as the main control unit**, orchestrating communication between various peripherals. These peripherals include the **OLED display module SSD1306, which provides immediate, real-time visual feedback on attendance status**, and a **solenoid lock, controlled by a 1 Channel 5v Relay Module**, for **automated physical access control** based on successful RFID scans. The lock is designed to **open temporarily for a set duration** upon a valid scan, enhancing security and streamlining entry.

On the software side, the system features a **web-based user interface (Web UI)**, meticulously developed using **HTML, CSS, JavaScript, and Bootstrap**. This interface empowers administrators to **manage attendance records, view detailed reports, and configure system settings**, including the ability to **add, edit, and delete user profiles**. The **backend of the website, implemented in PHP**, is responsible for **storing and arranging data, and ensuring the correct functioning of client-side operations**. It interacts with a **MySQL database**, a **relational database management system**, for **robust data storage, retrieval, and management**. **APIs are crucial for interconnecting the frontend, backend, and database**, ensuring **real-time data updates** and a smooth user experience. Furthermore, **robust cybersecurity measures are implemented in the backend system and database**, including **data encryption for user passwords and personal details**, to safeguard against data breaches and unauthorised access. The **ESP32 microcontroller is programmed using Arduino language** (C and C++).

Novelty and Contribution

The "Novel RFID Cloud Based Smart Attendance System" distinguishes itself through its **comprehensive integration of diverse hardware components, sophisticated software development, and a user-friendly interface**. While other attendance systems exist, the project's **combination of RFID technology, solenoid lock control, OLED display, and a web UI** positions it as a **functionally rich, convenient, and user-friendly solution**. It directly addresses the shortcomings of traditional manual systems by offering an **efficient, automated, and secure** alternative [my previous response], with features like **real-time attendance tracking, automated access control, customizable web UI, and integrated visual feedback**. The explicit focus on **security measures against data breaches and RFID cloning** further enhances its value proposition.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 7, July 2025

DOI: 10.17148/IJARCCE.2025.14730

Contextualisation with Existing Research

Although the project report does not explicitly provide a literature review section, it references external academic works that place the "Novel RFID Cloud Based Smart Attendance System" within the broader context of smart attendance research. For instance, it cites **Q. Miao et al.'s "Smart attendance system based on frequency distribution algorithm with passive RFID tags" (2020)** and **U. Koppikar et al.'s "IoT based Smart Attendance Monitoring System using RFID" (2019)**. These cited works indicate ongoing research in areas like algorithmic approaches for RFID attendance and the integration of RFID attendance systems within the Internet of Things (IoT) framework. The "Novel RFID Cloud Based Smart Attendance System" aligns with these research trends by developing an **IoT-based solution for smart attendance using RFID and cloud computing**, signifying its contribution to the practical application and advancement in this domain. The project also draws upon various online resources for specific component functionalities and existing attendance system ideas, demonstrating an informed approach to component selection and system design.

IV. ANALYSIS AND DISCUSSION

The "Novel RFID Cloud Based Smart Attendance System" directly addresses the **inherent inefficiencies of traditional manual attendance management methods**, which are characterised by their **proneness to errors, time-consuming nature, and lack of real-time monitoring capabilities**. Recognising these limitations, the project innovates a solution by integrating **Radio Frequency Identification (RFID) technology with cloud computing**, allowing attendance data to be **stored in a remote database, easily accessible from anywhere in the world and at any time**. The system's central value proposition lies in its **comprehensive integration of diverse hardware and software components** to create an **automated, efficient, and secure attendance solution**, offering convenience and enhanced security.

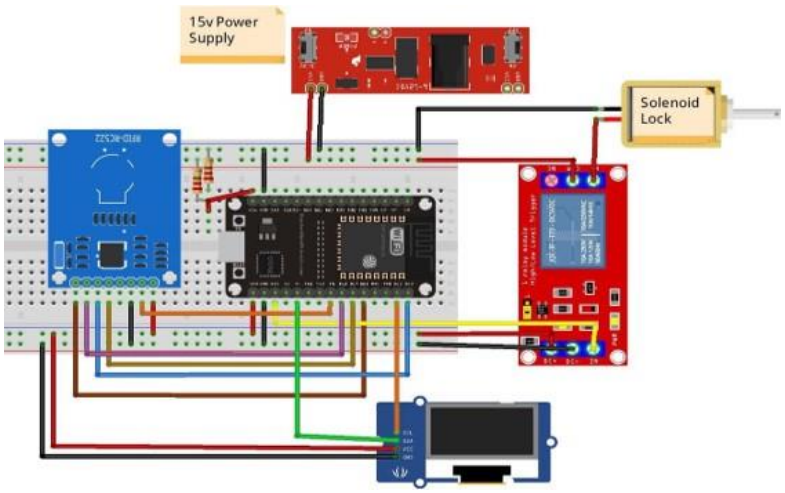

Fig. 1 Circuit Diagram of Smart Attendance System

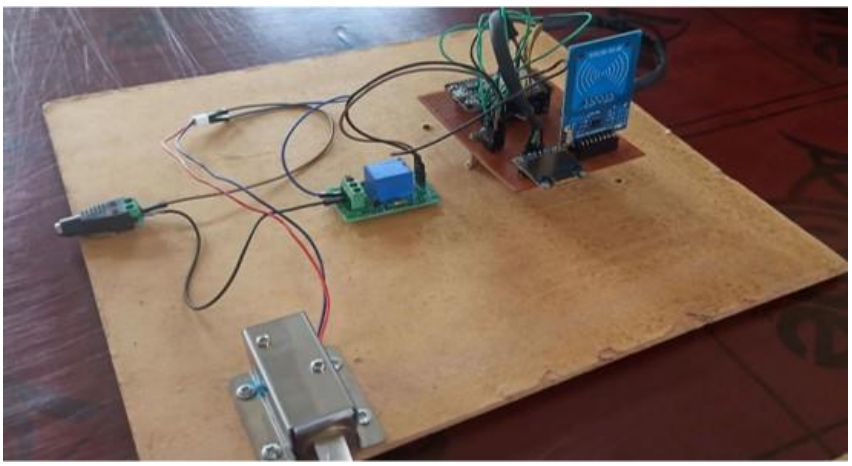

Fig. 2 Smart Attendance System Project Model

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 7, July 2025

DOI: 10.17148/IJARCCE.2025.14730

Hardware Component Analysis and Integration

At its core, the system leverages **Radio Frequency Identification (RFID) technology** to automate the attendance tracking process. Specifically, the **RFID MFRC522 reader module** and **1k MIFARE Classic Contactless Smart Cards** are chosen to implement this functionality. This choice is critical as it **eliminates the need for manual data entry**, thereby significantly **enhancing the speed and accuracy of attendance logging**. The RFID system operates by allowing users to scan their RFID tags to the reader, where the student's encrypted data within the tag is exposed to the reader's radio waves. Upon scanning, the student's "logged in" status is displayed on an OLED display and stored in the database; a subsequent scan logs the student out. The MIFARE Classic cards were selected for their ease of use, and the ability to read, write, or make corrections to the stored data. The MFRC522 reader module operates on 2.5 to 3.5V, communicates via SPI, I2C, or UART, and has a reading range of 5cm.

The **ESP32-WROOM-32E Microcontroller Unit (MCU)** functions as the **main control unit** of the system. Developed by Espressif Systems, the ESP32 is a low-power System on Chip (SoC) MCU featuring integrated 2.4GHz Wi-Fi and Bluetooth Low Energy (BLE) connectivity, making it suitable for a wide range of applications. In this project, the ESP32 is responsible for **orchestrating seamless communication and data flow** between the RFID MFRC522 reader, an OLED display, and a solenoid lock. It receives data from the RFID reader, analyses it, sends it to the cloud, retrieves corresponding output from the server, displays information on the OLED, and initiates other actions as required. The ESP32-WROOM-32E features an Xtensa dual-core (or single-core) 32-bit LX6 microprocessor, 34 GPIO pins, 3 UART, 4 SPI, and 2 I2C interfaces, operating with an input voltage of 5 to 12 volts and providing a 3.3-volt output.

For **real-time visual feedback** to the user, an **OLED display module (SSD1306)** is integrated. This display was specifically chosen due to its **good view angle and pixel density**, making it reliable for showing small graphics and displaying attendance status, real-time information, and logged in/out statuses. The OLED display has a screen size of 0.96 inches, a resolution of 128x64 pixels, and operates on a supply voltage of 3-5V.

The system's enhanced security and streamlined entry are achieved through the integration of a **solenoid lock**, controlled via a **1 Channel 5v Relay Module** for **automated physical access control**. The solenoid lock, an electrical strike used for locking/unlocking cabinets, doors, or drawers, operates at 12VDC. Since the ESP32 microcontroller provides 3.3V, the relay module acts as an electromagnetically operated switch to control the 12V solenoid lock. Whenever a student scans their RFID tag and a successful login is registered, the ESP32 sends a signal to the relay, which then triggers the solenoid lock to open temporarily for approximately 10 seconds, allowing the student to enter. This integration makes the system appear more secure. The relay module operates on a supply voltage of 3.75V to 6V, has a quiescent current of 2mA, and can handle a maximum contact voltage of 250VAC or 30VDC, with a maximum current of 10A. The cohesive integration of the ESP32, RFID reader, solenoid lock, and OLED display creates a functional and unified smart attendance system.

Software Architecture and Cloud Integration Analysis

A **pivotal architectural decision** in the project was the adoption of **Amazon Web Services (AWS) Cloud** for backend operations and data management. This strategic choice directly supports the **non-functional requirement for scalability**, ensuring the system can **handle a growing number of users and accommodate additional hardware components efficiently**. By deploying the web application on an **AWS EC2 instance** utilising a **LAMP stack** (Linux, Apache, MySQL, PHP), the attendance data is **securely stored in a remote database and made accessible globally**. The EC2 instance allows users to rent virtual computers, booting an Amazon Machine Image (AMI) or open-source images like Ubuntu to configure a virtual machine, referred to as an "instance". The project specifically used an Ubuntu AMI for the LAMP stack, with the website running on an Apache server in a Linux VM, accessed via the instance's IPv4 address. Furthermore, all static files are stored in **AWS S3** and accessed via **AWS CloudFront CDN**, which uses a globally distributed network of proxy servers to cache content, improving access speed for content delivery in remote locations. This frees clients from managing, scaling, and patching hardware and operating systems.

The **Frontend of the Website**, built with **HTML, CSS, JavaScript, and Bootstrap**, provides a **user-friendly and customisable interface** for administrators to manage records, view reports, and configure system settings. HTML is used to structure the web pages, CSS styles the website with animations and designs, and JavaScript provides dynamic behaviour and logic to make the website interactive. Bootstrap, a free and open-source tool collection, ensures the website is responsive. The frontend communicates with the backend using PHP and stores data into the MySQL database.

The **Backend of the Website** is developed using **PHP** in conjunction with a **MySQL database**, ensuring **robust data storage, retrieval, and real-time updates** through **APIs**. PHP, an open-source server-side scripting language, is used to create static and dynamic webpages and fetches data from the database to the frontend via APIs. MySQL, as the world's

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 7, July 2025

DOI: 10.17148/IJARCCE.2025.14730

most popular open-source relational database management system (RDBMS) based on Structured Query Language (SQL), handles the storage of user information in table structures. The **Arduino language** is used to program the ESP32 microcontroller, making it functional within the system. APIs (Application Programming Interfaces) are crucial for interconnecting the frontend, backend, and database, facilitating real-time data updates and providing a better user experience.

Project Planning and Methodology

The project adopted a structured approach, outlined in its capstone project planning, which included a **Work Breakdown Structure (WBS)** and a **Timeline Development Schedule**. The methodology involved several key phases to ensure comprehensive development:

• **Requirement Analysis:** This initial phase involved identifying project requirements, market demand, user-friendliness, and overall project efficiency, leading to the selection of core components like the RFID reader, ESP32, solenoid lock, and OLED display.

• **System Design:** Based on the analysis, a detailed system design was created, encompassing hardware and software components, communication protocols, and user interface design. This phase focused on defining data flow, interfaces, and interactions while considering scalability, flexibility, and usability.

• **Hardware Setup:** This involved connecting and configuring the physical components (ESP32, OLED, RFID reader, solenoid lock), ensuring proper wiring, and initial testing for functionality and seamless interfacing with specified libraries and APIs.

• **Software Development:** This phase focused on creating the firmware for the ESP32 (using Arduino Language), the backend with PHP, the web UI with HTML, CSS, and JavaScript, and setting up the MySQL database (RDBMS) for user data storage, access control, real-time display, and web interface interaction. Rigorous testing and debugging were conducted.

• **Integration and Testing:** This critical phase involved integrating all hardware and software components. The entire system, including RFID scanning, attendance recording, lock control, real-time display, firmware, web UI, and backend, was thoroughly examined, validated, and tested to ensure functionality, performance, and efficiency.

• **Deployment:** After successful integration, the system was deployed, with hardware components installed in their designated locations (e.g., school, college, office) and configured with proper power supply and connectivity. The AWS database server and web UI were configured for daily attendance logging via web browsers.

• **Maintenance and Support:** A commitment to ongoing maintenance and support ensures the system's long-term efficiency. This includes troubleshooting and providing guidelines for software and hardware component implementation.

• **Documentation:** Comprehensive documentation was prepared for all phases of the project, including system functionality, design, setup, development, integration, testing, deployment, and maintenance guidelines. This documentation is intended to be a valuable resource for administrators and users.

Risk Assessment and Management

The project's analysis of **potential risks** and the implemented **risk management strategies** highlight its comprehensive design approach. Several key risks were identified and addressed:

• **Compatibility Issues:** Concerns regarding the compatibility of components like the ESP32, RFID Reader, and solenoid lock were mitigated through **continuous testing and validation** during the development phase.

• **Software Bugs and Glitches:** The potential for bugs in the website's frontend, backend, and database was managed through **continuous code testing, debugging**, and repeated validation to ensure proper functionality and reliability.

• **Data Breach:** The risk of unauthorized access to sensitive data (personal information, attendance records) was addressed by implementing **robust cybersecurity measures** in the backend system and database, including **encryption of user passwords and personal details**.

• **RFID Cloning or Spoofing:** To prevent hackers from cloning or spoofing RFID cards for unauthorized access, **security protocols and encryption techniques** were implemented.

• **System Downtime:** The risk of downtime due to hardware failures, power outages, or network issues was minimised by implementing measures such as **backup power supplies and failover systems**.

The project's proactive consideration of potential risks, including **risk identification, analysis, evaluation, and continuous monitoring** throughout the project lifecycle, underscores its commitment to ensuring appropriate actions are taken to minimise potential threats and enhance reliability.

Requirements Specification and Testing

The system was designed to meet a set of specific **functional and non-functional requirements**. **Functional requirements** include:

• **Automated tracking of attendance** through RFID card scanning.

• **Real-time display** of attendance information on the OLED display.

DOI: 10.17148/IJARCCE.2025.14730

- **Granting or denying physical access** via the solenoid lock based on attendance status.
- **Administrator management** of attendance records and report generation via a web-based user interface.
- **Storing attendance data in a database** for easy retrieval and analysis.
- **Ability to add, edit, and delete user profiles** via the Web UI.
- **Generation of attendance reports** in various file formats based on specified criteria.

Non-functional requirements (quality attributes) include:

- A **user-friendly and intuitive interface** for both the web UI and OLED display.
- **Low latency and quick response times** for RFID card scans and user interactions.
- **Confidentiality of user data** and prevention of unauthorised access.
- **Scalability** to handle a growing number of users and accommodate additional hardware.
- **Stability and consistent operation** without unexpected failures.
- **Availability** during designated time frames with minimal downtime.
- **Maintainability** through design and documentation that allows for easy troubleshooting and future enhancements.

The **test and validation phase** played a crucial role in ensuring the system's functionality, reliability, and adherence to these requirements. Rigorous testing was performed for each component:

- **RFID Reader:** Validation included verifying tag detection range, accurate data collection from scanned tags, distinguishing simultaneous tags, correctly reading updated data from newly added users, and testing durability in various environmental conditions like temperature, physical stress, and moisture. The system's ability to handle a large number of scans and seamless integration with other software and hardware were also verified.
- **OLED Display:** Tests confirmed power-up and output display, colour and brightness consistency, smooth refresh rates with fast-moving content, power consumption under various scenarios, environmental resilience, and long-term stability against issues like colour shifts or screen burn-in.
- **ESP32:** Validation ensured successful boot-up, communication with other devices, correct operation of GPIO pins, accurate reading and conversion of analog data by the ADC, reliable Wi-Fi and Bluetooth connectivity for data transmission, and compatibility with project-specific libraries, programming, and cloud services.
- **Relay Module:** Testing involved verifying switch contact changes upon energising/de-energising the coil, the relay's ability to handle specified current and voltage ratings of connected loads, measuring energisation/de-energisation times against manufacturer specifications, environmental testing (temperature, humidity), and verifying safety measures like overvoltage and isolation protection.
- **Solenoid Lock:** Tests confirmed correct locking/unlocking operation upon power supply, sufficient locking force, easy unlocking via various methods (keypad, code), durability under repeated locking/unlocking cycles, power consumption matching specifications, and real-time compatibility when installed in a door with other components.

These extensive tests ensured the accuracy of attendance tracking, effectiveness of access control mechanisms, usability of the web user interface, and the generation of comprehensive and accurate reports.

Business Aspects and Market Outlook

The smart attendance system, by integrating ESP32, RFID MFRC522 Reader, and cloud technology, offers **convenience, efficiency, and enhanced security** compared to traditional methods. The **market outlook for this system is promising**, driven by the increasing need for accurate attendance tracking and the broader trend towards automation and digitisation across various sectors. Organisations are recognising the value of investing in technologies that optimise operations, improve productivity, and save costs, contributing to a **positive economic outlook for the industry**.

The system differentiates itself in the competitive landscape through several **novel features**:

- **Real-time attendance tracking** and **automated access control** using RFID technology.
- A **customisable Web UI** for administrative management.
- **Integration with an OLED display** for immediate visual feedback.
- A **robust backend system** for secure data storage and comprehensive reporting. The comprehensive integration of hardware components, software development, and a user-friendly interface sets this product apart from other existing attendance systems.

The project's **targeted clients/customers** span diverse sectors, indicating a wide market applicability:

- **Educational Institutions:** Schools, colleges, and universities seeking to automate attendance and enhance security for students and staff.
- **Corporate Offices:** Companies of all sizes needing to streamline attendance for employees, especially for large-scale events, meetings, or training sessions.
- **Government Organisations:** Public offices, events, or facilities requiring accurate attendance records and access control.
- **Event Management Companies:** For managing attendee registration, tracking attendance, and enhancing security at conferences, seminars, or workshops.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 7, July 2025
DOI: 10.17148/IJARCCE.2025.14730

• **Healthcare Centres:** Hospitals, clinics, and rehabs for tracking employee attendance and for authorisation purposes.

Financial Considerations and Future Directions

The financial viability of the project depends on factors such as implementation scale, hardware/software costs, and development resources. The project's initial **Cost Breakdown Structure** detailed expenses for hardware components like the ESP32, RFID MFRC522, relay, OLED, solenoid lock, AWS Cloud usage, and other materials, totalling ₹3,700. Cost projections and revenue generation potential would consider market demand, pricing strategy (e.g., licensing fees, hardware sales, service/maintenance contracts, subscription models), and competitive landscape, with an emphasis on assessing the **Return on Investment (ROI)** by estimating costs and revenues over time. Various funding options, including self-funding, venture capital, grants, or partnerships, could be explored to attract investment.

The capstone project has achieved significant milestones, successfully designing and implementing the smart attendance system with integrated hardware and software components for attendance tracking, access control, and reporting. For **future work and improvements**, several recommendations are proposed to further enhance the system's capabilities and market reach:

• **Enhanced Security Features:** Incorporate **biometric authentication** or **multi-factor authentication** to strengthen access control and prevent unauthorised access.

• **Advanced Reporting and Analytics:** Extend reporting capabilities with **advanced analytics and data visualisation tools** to provide deeper insights into attendance patterns, trends, and performance metrics.

• **Integration with Student Information Systems (SIS) and Learning Management Systems (LMS):** Streamline data management and synchronisation by integrating with existing SIS or popular LMS platforms for automated attendance tracking and course schedule synchronisation.

• **Mobile Application Development:** Create a **mobile application** to complement the web UI, offering users convenient access to attendance information, notifications, and administrative tasks on smartphones or tablets.

• **Scalability and Performance Optimization:** Implement techniques such as **database optimisation, caching mechanisms, and load balancing** to ensure efficient handling of a larger number of users and attendance records.

• **User Interface Enhancements:** Continuously improve the web UI through user experience (UX) design principles to make it more intuitive, visually appealing, and user-friendly.

Further recommendations for the project's evolution include conducting **user testing and gathering feedback** from potential users (e.g., educational institutions, businesses) to identify areas for improvement. Continuous **refinement and comprehensive documentation** of the system's design, implementation, and usage guidelines are crucial for future maintenance and expansion. Exploring **partnerships and collaborations** with relevant organisations can provide valuable insights, validation, and opportunities for scaling the product in real-world settings. Finally, developing a comprehensive **marketing and sales strategy** to highlight the system's unique features, benefits, and competitive advantages is essential for attracting potential clients and achieving market success. By addressing these recommendations, the project can continue to evolve, meet market needs, and provide significant value to its users.

V. CONCLUSION

The "Novel RFID Cloud Based Smart Attendance System" has achieved **significant milestones** in its development, successfully integrating various technologies to automate attendance tracking and access control. The project includes the design and implementation of the system using an **ESP32 microcontroller, RFID RC522 reader, solenoid lock, and OLED display**, all connected to a **web user interface (UI) and backend system**. The hardware components have been integrated and tested, and the software components developed to enable **attendance tracking, access control, and reporting functionalities**. This functional system demonstrates the core features outlined in the project requirements.

Looking ahead, there are several avenues for **future work and improvements**. These include exploring **enhanced security features** like biometric or multi-factor authentication, incorporating **advanced reporting and analytics** for deeper insights into attendance patterns, and enabling **integration with Student Information Systems (SIS) or Learning Management Systems (LMS)** to streamline data. Developing a **mobile application** could also enhance user convenience, alongside efforts for **scalability and performance optimisation** and continuous **user interface enhancements**.

To ensure the project's continued evolution, it is recommended to **conduct user testing and gather feedback** from potential users. The system should be **continuously refined and thoroughly documented** for future maintenance and expansion. Seeking **partnerships and collaborations** is advised for real-world piloting and validation. Finally, developing a **comprehensive marketing and sales strategy** is crucial to promote the solution, highlighting its unique features and competitive advantages to attract potential clients.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 7, July 2025
DOI: 10.17148/IJARCCE.2025.14730

REFERENCES

[1]. The **"Novel RFID Cloud Based Smart Attendance System"** project report draws upon a range of academic and online resources to support its development and methodology. These references underpin the project's technical choices, design considerations, and implementation strategies. The listed sources include peer-reviewed journals, conference proceedings, and various online references, providing a comprehensive foundation for the system's architecture and functionality.

[2]. The references are categorised as follows:

- **Journals**: One key journal article, "Smart attendance system based on frequency distribution algorithm with passive RFID tags" by Q. Miao et al., published in *Tsinghua Science and Technology*, is cited, indicating research into core RFID attendance methodologies.
- **Conference proceedings**: An important conference paper, "IoT based Smart Attendance Monitoring System using RFID" by U. Koppikar et al., presented at the *2019 1st International Conference on Advances in Information Technology*, contributes to the understanding of IoT integration with RFID for attendance monitoring.
- **Online References**: A significant portion of the references comprises online resources, which are crucial for the practical implementation of the system. These include **GitHub repositories** for specific libraries used, such as arduino-esp32 by Espressif for the **ESP32 microcontroller**, Arduino RFID Library for MFRC522 RFID Readers by Miguelbalboa, and ThingPulse OLED SSD1306 for ESP8266/ESP32/Mbed-OS for the **OLED display**. Other online sources cover the NTPClient library for time synchronisation, conceptual information on RFID attendance systems, and specifications for the **ESP32-DevKitC**.

[3]. These references collectively support the project's foundational knowledge, from the theoretical aspects of RFID technology to the practical implementation details of hardware and software components.

