

# RFID based clinic presence system as an effective attendance monitoring solution

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**Abstract.** To improve employee attendance efficiency and accuracy, this study developed an RFID-based attendance system for Watumas Clinic in Purwokerto, Central Java, Indonesia. Sistem mengatasi keterbatasan metode manual dengan mengumpulkan dan mengakses data attendance melalui cloud server melalui teknologi Internet of Things (IoT). The development followed the Waterfall methodology, which included analysis of requirements, design, implementation, and testing. Untuk memastikan bahwa sistem berfungsi dengan baik, sebuah sensor RFID dan ESP8266 microcontroller adalah komponen penting. Test menunjukkan keakuratan dan kemudahan sistem. Sangat akurat dalam peramalan, menurut tes Mean Absolute Percentage Error (MAPE), yang menghasilkan tingkat kesalahan 3,75%. Test kotak hitam menunjukkan bahwa sistem dapat secara otomatis mencatat waktu dan memberikan feedback instan melalui layar OLED, yang mengkonfirmasi fungsi fitur. Hasil Tes Pengakuan Pengguna (UAT) menunjukkan skor rata-rata.

## 1 Introduction

In the rapidly advancing digital era, technology has become a fundamental element in various aspects of life, including the management and monitoring of employee attendance in organizations such as companies, educational institutions, and healthcare facilities like clinics. Beyond simplifying data recording, technology enables faster and more accurate decision-making based on real-time data. One technology that provides significant convenience and efficiency is the Radio Frequency Identification (RFID) system, which allows for automated attendance management and reduces the risk of errors from manual data entry. This technology not only streamlines attendance tracking but has also become integral to broader human resource management systems, encompassing productivity analysis, performance evaluation, and compliance with organizational regulations. RFID systems are widely applied in various sectors, including education, business, and healthcare [1].

Watumas Clinic in Purwokerto, Indonesia, a healthcare institution continually striving to improve the quality of its services, faces various challenges in managing employee

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attendance, especially with the manual system still in use. Traditional attendance systems were prone to recording errors, making it difficult to monitor aspects such as tardiness or unexcused absences and complicating integration with other management systems, such as payroll and performance management. These limitations added complexity to data management and potentially disrupted the clinic's operational efficiency, which ultimately impacted the quality of patient care. RFID technology evolved from a simple identification tool into a system capable of integrating real-time data collection and automation, making it suitable for application in various industries, including healthcare [2]. Previous studies showed that implementing RFID technology provided an effective solution, reducing the likelihood of fraud and accelerating the attendance process [3], thus enhancing the clinic's operational accuracy and efficiency.

RFID has proven to be effective in improving the accuracy of attendance data and reducing errors commonly found in manual attendance systems. Moreover, other studies show that the implementation of RFID systems in the workplace can increase management's trust in monitoring staff attendance, as the system can automatically identify and record attendance without human intervention [4]. IoT-based RFID systems also enable automated attendance monitoring, reducing reliance on manual methods and enhancing accuracy and reliability in time and attendance tracking. The integration of IoT with RFID technology allows real-time data transmission and remote monitoring, providing administrators with instant access to attendance information. This integration can also support predictive analytics, enabling organizations to identify attendance patterns and optimize workforce management proactively [5]. Furthermore, other studies demonstrate that RFID allows for the automatic and real-time collection and transfer of data without human intervention, making it highly effective for tracking healthcare workers while improving patient safety and operational efficiency in hospitals [6].

The gap in RFID technology usage in small and medium-sized clinics presents opportunities for further research on its application. Watumas Clinic in Purwokerto often faces challenges in managing attendance, particularly due to the limited number of staff and a more flexible working environment compared to large companies or educational institutions. An RFID system tailored to the clinic's needs is expected to ease management processes and improve overall operational efficiency [7]. This allows organizations to integrate real-time data to optimize operational efficiency and reduce administrative burdens [8]. This transparency also fosters trust between employees and management, creating a more accountable work environment, which is crucial in a clinic with a limited staff.

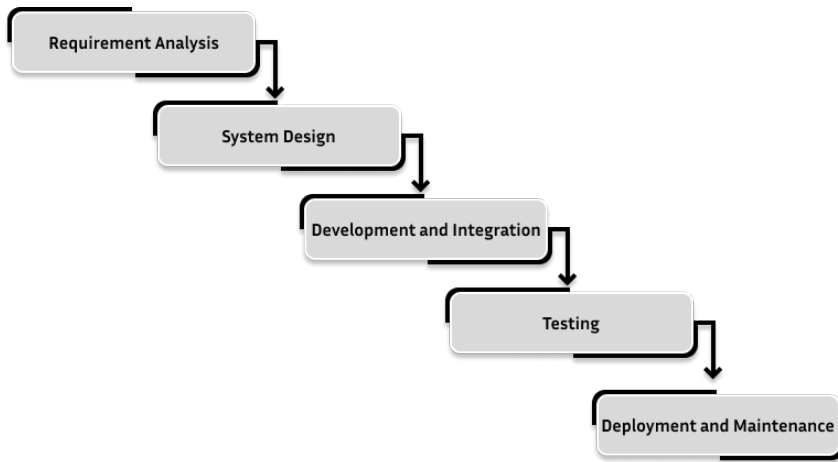
## **2 Research Methodology**

In developing the RFID-based attendance system for the clinic, the system development followed the waterfall methodology. During the requirement analysis process, one of the methods used was interviews, where a direct Q&A session was conducted with Dr. Nadila, the owner of Watumas Clinic Purwokerto, to gather relevant information regarding the requirements for the RFID-based attendance system. Additionally, administrative data collection was conducted using Google Forms, which was used to gather basic information such as employee names and emails. This data was later utilized in the administration and management of the attendance system.

### **2.1 Waterfall Method**

The development methodology used for the RFID-based attendance system was the Waterfall method, a sequential software development model initially proposed by Dr. Winston W. Royce in 1970 [9]. Waterfall methodology is a sequential software development cycle where

each phase must be completed before the next phase begins [10]. This method was chosen because it allows each phase to be completed in order, helping to avoid process repetition, keeping the project on track, and ensuring that the system is developed on time [11]. The stages of developing the RFID-based attendance system using the Waterfall method are illustrated in Figure 1.



**Fig. 1.** Waterfall development method on RFID-based attendance system, inspired by Dr. Winston W. Royce's original methodology.

Figure 1 explains that the Waterfall method consists of several stages that must be completed sequentially, starting from Requirement Analysis, System Design, Development and Integration, Testing, to Deployment and Maintenance.

### 2.1.1 Requirement Analysis

The first stage, Requirement Analysis, includes the analysis of software and hardware requirements, system functions, and the identification of potential problems in the development of the RFID-based attendance system [12].

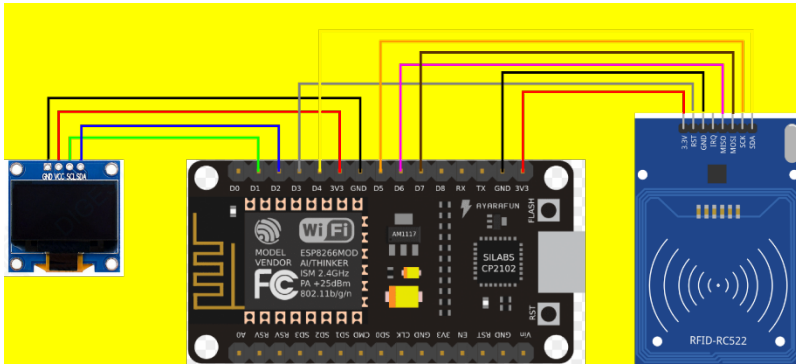
In building the RFID-based attendance system at Watumas Clinic, two main components are used: hardware and software. On the hardware side, the ESP8266 (NodeMCU) functions as the primary microcontroller in the hardware setup, serving as a wireless data transmitter from the RFID sensor to the server. It not only processes data received from the RFID sensor but also facilitates real-time communication with the server, enabling efficient and seamless attendance tracking. Other components, such as the RFID sensor module RC522 were selected for their accuracy and speed in reading and receiving data from RFID Tags, ensuring reliable and quick data capture for the system, while the RFID cards themselves serve as unique identifiers for employees. Additionally, the OLED LCD is used to provide visual feedback related to attendance status, ensuring that information is displayed clearly and efficiently.

On the software side, the system utilizes a cloud server for flexible, secure, and efficient data processing and storage. The Laravel Framework was chosen for its ease of development, security, and ability to integrate with IoT devices via API. MySQL was used as the database due to its fast performance, scalability, and replication mechanisms that ensure data reliability. This combination of technologies enables the attendance system at Watumas Clinic to operate in real-time and securely.

### 2.1.2 System Design

In the System Design stage, decisions made impact the overall system development, where technical solutions, architectural design, interfaces, and data flow are planned, and development technologies are selected [13]. In this phase of the Waterfall development methodology, the focus is on designing technical solutions that implement the identified system requirements for the RFID-based attendance system.

To support an understanding of physical hardware design and development, a schematic diagram of the hardware is provided in Figure 2.



**Fig. 2.** Physical hardware schematic design.

Figure 2 depicts the connections and interactions between various components, such as the RFID sensor, ESP8266 module, and OLED LCD Display, thereby ensuring clarity in the setup used for attendance system. The following figure shows a hardware schematic, which visually represents the physical architecture of the system

### 2.1.3 Development and Integration

In the Development and Integration stage, the system design is translated into code using C++ for the IoT components and PHP with the Laravel framework for the cloud-based web service, which functions as the system’s server, where developers write and implement modules and functions according to specifications, while also integrating hardware and software components to ensure harmonious system operation [14].

### 2.1.4 Testing

During the Testing phase, thorough testing is conducted to ensure that the system functions according to specifications without bugs or functional errors. This includes both functional and non-functional testing to detect potential issues [15]. The testing methods used in the development of the RFID-based attendance system include Mean Absolute Percentage Error (MAPE), Black box testing, and User Acceptance Testing (UAT).

### 2.1.5 Development and Maintenance

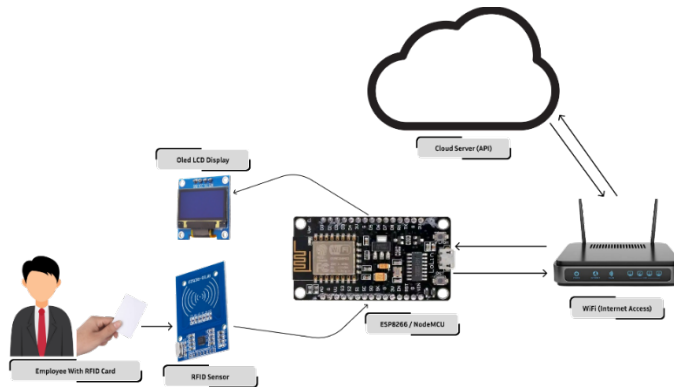
Once testing is complete, the system is implemented in a real-world environment, where users can begin to utilize it. The Maintenance phase involves fixing bugs, improving performance, and adding features based on feedback to ensure the system’s performance and relevance in the long term [16].

During the implementation phase, the RFID-based attendance system will be deployed at Watumas Clinic in Purwokerto. Initial steps include preparing the infrastructure, ensuring that hardware such as RFID Readers, RFID Tags, and servers are properly installed, along with a stable network infrastructure. Subsequently, the software system will be installed on the server, encompassing database setup, web application configuration, and integration with RFID devices. End users, such as employees and administrators, will also be trained in using the system and basic troubleshooting.

After implementation, routine maintenance of the system will be performed to ensure its reliability. Periodic monitoring will be conducted to detect issues such as hardware malfunctions or RFID reading errors. Additionally, hardware maintenance will involve inspecting and replacing damaged components. The system will also be evaluated regularly by gathering user feedback and analyzing performance to ensure that the RFID attendance system continues to meet the needs of Watumas Clinic.

## 2.2 IoT Architecture

In this research, an integration between Internet of Things (IoT) technology and cloud servers was conducted to monitor employee attendance in real-time. Data from RFID cards is sent via the ESP8266 module to the cloud server over a Wi-Fi connection using the HTTPS protocol, as it ensures secure data transmission through an API from the web server, while providing instant feedback through an OLED LCD display. The IoT architecture can be seen in Figure 3.

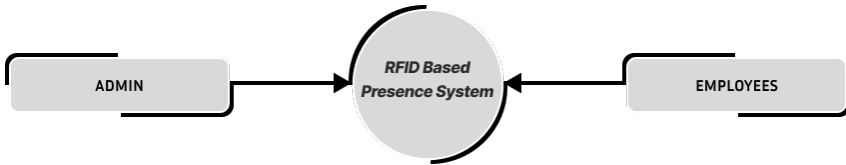


**Fig. 3.** IoT Architecture.

The flow of the RFID-based attendance system begins with employees using RFID cards. These cards are read by the RC522 RFID sensor, and the data is then sent to the ESP8266 (NodeMCU) module as the microcontroller. The ESP8266 is responsible for transmitting the data to the cloud server via a Wi-Fi connection. Once the data is received by the server, a response is sent back to the system, and the results are displayed on the OLED LCD, providing feedback to employees on whether the attendance process was successful or not. All of these processes occur in real-time over the internet to ensure efficiency and accuracy in attendance tracking. As described in the research, the internet-based attendance system provides improved efficiency and accuracy, especially in the digital recording of attendance [17].

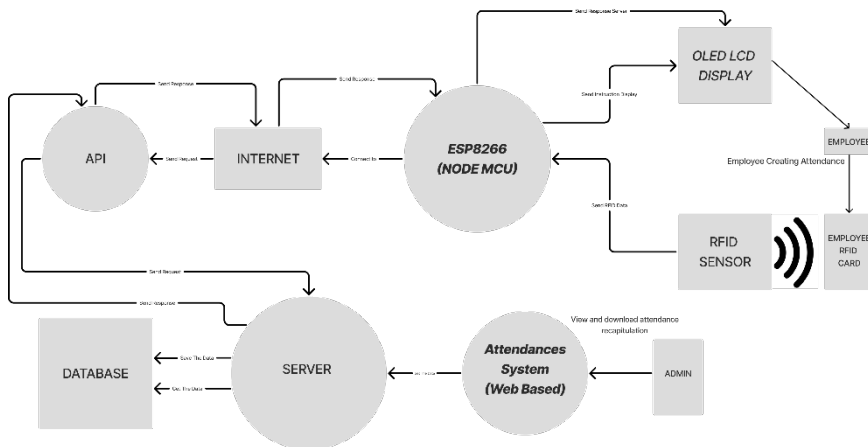
### 2.3 System Design

In this system design, a Data Flow Diagram (DFD) is used to visualize the data processing, where the data flow originates from external sources or internal storage towards internal processes [18]. the level 0 DFD of the RFID-based attendance system can be seen in Figure 4.



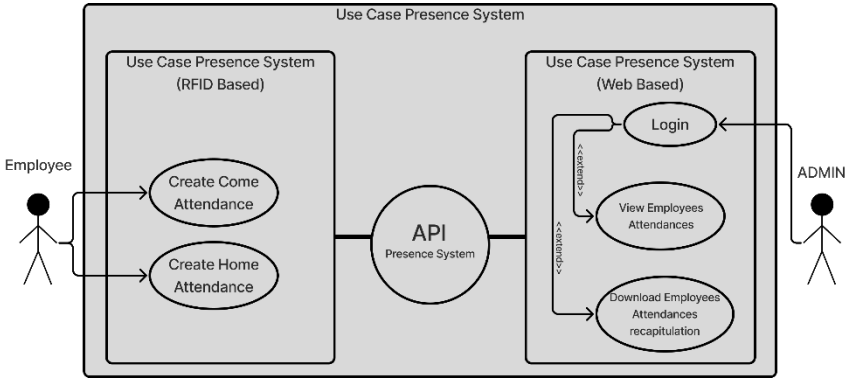
**Fig. 4.** Level 0 DFD of the RFID-based Attendance System.

Meanwhile, the level 1 DFD provides further details by breaking down the main processes into more specific sub-processes, illustrating the data flow between processes in detail. Data Flow Diagrams (DFD) are also often used as a basis for transforming models into Petri Nets for further analysis in rule-based systems [19]. The level 1 DFD of the RFID-based attendance system can be seen in Figure 4.



**Fig. 5.** Level 1 DFD of the RFID-based Attendance System.

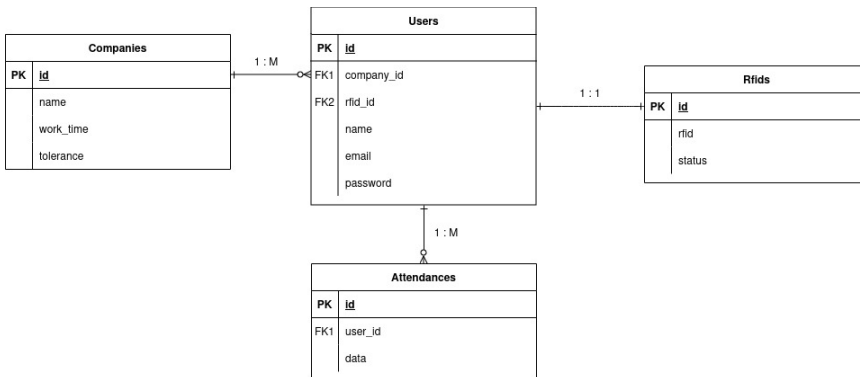
The Use Case representation of the RFID-based attendance and web system, showing the interactions between system components, can be seen in Figure 6.



**Fig. 6.** Use Case of the RFID-based Attendance System.

In Figure 6, the left side shows that the RFID-based system allows users to record attendance for clocking in and out, which is then processed through the API. Meanwhile, on the right side, the web-based system enables users to log in, view employee attendance, and download attendance recaps. This web-based solution can enhance the accuracy and operational efficiency of tracking employee attendance [20]. The API serves as a bridge between the two systems, ensuring that employee attendance data can be accessed and processed efficiently across various platforms. Utilizing IoT and cloud technology demonstrates effectiveness in managing data in real-time through API integration, allowing the web and RFID systems to work synchronously for recording employee attendance [21].

Database design is a crucial element in the development of the RFID-based attendance system. In this system, the database is designed to store and manage employee information, RFID devices, and attendance history. An efficient and structured design can ensure that the attendance recording and reporting processes run optimally. The database design of the RFID-based attendance system can be seen in Figure 7.



**Fig. 7.** Database Design of RFID based attendance

The database design of the RFID-based attendance system consists of four main entities: Companies, Users, Rfids, and Attendances, which are interconnected to record employee information, RFID devices, and attendance history. The Companies entity stores company data, including working hours and tolerance limits for lateness, while the Users entity records

the identities of employees associated with the company through a one-to-many relationship. Each employee has a unique RFID card linked to the Rfids entity in a one-to-one relationship, with the status of the card (active or inactive) recorded to ensure its validity. Employee attendance records are stored in the Attendances entity, which is connected to the Users entity through a one-to-many relationship, allowing for real-time and accurate attendance monitoring. This design integration supports an efficient attendance process and facilitates the management of attendance data.

## 2.4 Model Testing

In the IoT device, the testing method used in the RFID-based attendance system is the Mean Absolute Percentage Error (MAPE) method. This method is frequently used to evaluate research outcomes using IoT technology [22], [23], [24]. This method helps identify issues, analyze the data obtained, plan corrective actions, and execute necessary steps to improve system performance. The MAPE process begins with a monitoring stage, where data related to system performance is collected. The next stage is analysis, where this data is examined to identify the root causes of problems. Following this, a corrective action plan is created and implemented during the execution phase. Mathematically, MAPE is calculated using the formula where A represents the Actual Value, P is the Predicted Value, and n is the Number of Observations. The formula for the RMSE model can be seen in (1)[25].

$$MAPE = \frac{1}{n} \sum_{i=1}^n \left( \frac{|A_i - P_i|}{A_i} \right) \times 100 \quad (1)$$

Testing on the Web Admin, which is used for monitoring employee attendance data, employs black box testing that focuses on the core functionalities, such as authentication and attendance data management. With this approach, key functions such as attendance recording and reporting can be tested without being affected by technical implementation.

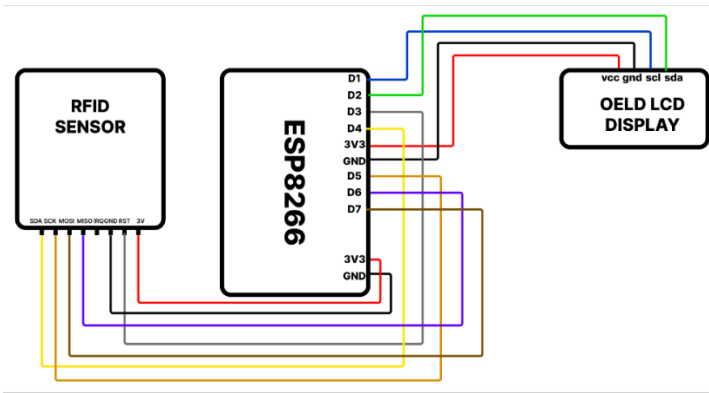
In addition to testing using MAPE and black box testing, the RFID-based attendance system is also tested using User Acceptance Testing (UAT). UAT is the final testing method performed by users or stakeholders to ensure that the system functions according to operational needs and meets user expectations. This testing involves end users from various parts of the system, such as web admins and employees using RFID cards.

## 3 Results and Discussion

The development of the RFID-based attendance system involves the integration of two technology stacks: IoT and Web, both developed using the waterfall method. Each stage in this system development is outlined to demonstrate how each step contributes to the overall success of the development. The Waterfall method provides a systematic and sequential approach, where each phase must be fully completed before proceeding to the next phase, thus minimizing errors in system development [26].

### 3.1 IoT Design

Based on the results from the Requirement Analysis phase, the hardware used in the development of the RFID-based attendance system includes the RFID Sensor, RFID Card, ESP8266, and OLED LCD Display. All these hardware components are then assembled and coded, as shown in Figure 8, which illustrates the IoT circuitry in the RFID-based attendance system.



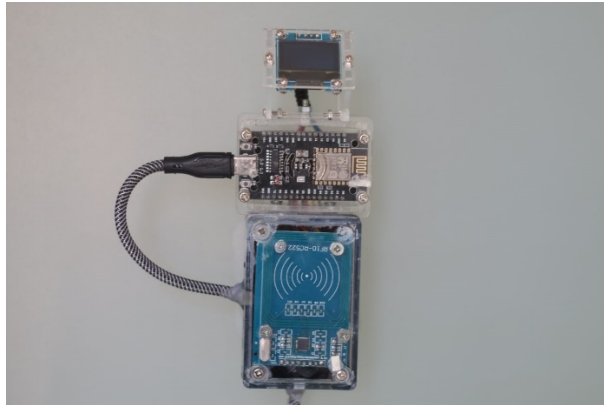
**Fig. 8.** IoT circuit in RFID-based attendance system.

The explanation of the IoT circuit in Figure 7 can be seen in more detail in Table 1.

**Table 1.** IoT circuit explanation.

Component	Pin on Components	Pin on ESP8266
RFID Sensor	SDA (Serial Data)	D2 (GPIO4)
	SCK (Serial Clock)	D5 (GPIO14)
	MOSI (Master Out Slave In)	D7 (GPIO13)
	MISO (Master In Slave Out)	D6 (GPIO12)
	IRQ (Interrupt Request)	-
	GND (Ground)	GND
	RST (Reset)	D1 (GPIO5)
	3V (3.3V Power Supply)	3V3
OLED LCD Display	VCC (Power Supply)	3V3
	GND (Ground)	GND
	SCL (Serial Clock Line)	D1 (GPIO5)
	SDA (Serial Data Line)	D2 (GPIO4)

After the IoT circuit design is complete, each device will be placed in a special box that has been prepared in advance. This placement process is carried out carefully so that the circuit is in accordance with the designed scheme, ensuring that the connection between the components runs well and the device can function optimally. Proper placement also aims to protect the device from external factors and facilitate future system maintenance and management. Figure 9 shows the devices that have been placed in the box and arranged according to the circuit.



**Fig. 9.** An IoT circuit that has been assembled in a box.

### 3.2 IoT Testing

Testing was conducted using the MAPE (Mean Absolute Percentage Error) method that has been conducted for RFID-based attendance systems. Several studies support this approach in the context of IoT, where this framework can be applied to systems that adapt to dynamic environmental conditions [27], such as in RFID-based attendance applications. In addition, the application of edge computing-based IoT architecture also offers solutions for connection stability and latency reduction in real-time applications [28]. The data used in this test is actual attendance data (A) compared to predicted data (P) generated by the system, as shown in Table 2.

**Table 2.** Test result data using RFID.

No	Employees Card	Actual Data (A)	Prediction Data (P)
1	Employee Card 1	12	11
2	Employee Card 2	8	8
3	Employee Card 3	10	10
4	Employee Card 4	8	7
5	Employee Card 5	8	8
6	Employee Card 6	12	12
7	Employee Card 7	12	11
8	Employee Card 8	10	10
9	Employee Card 9	12	12
10	Employee Card 10	12	11

Based on the data above, the MAPE calculation is done by calculating the percentage of error for each observation, then taking the average of all the errors. For each observation, the percentage of error is calculated using the following formula at Equation (1).

$$MAPE = \frac{1}{10} \left( \frac{|12 - 11|}{12} + \frac{|8 - 8|}{8} + \frac{|10 - 10|}{10} + \frac{|8 - 7|}{8} + \frac{|8 - 8|}{8} + \frac{|12 - 12|}{12} + \frac{|12 - 11|}{12} + \frac{|10 - 10|}{10} + \frac{|12 - 12|}{12} + \frac{|12 - 11|}{12} \right) \times 100 = 3.75\%$$

From the calculation above, the MAPE value obtained is 3.75%, which shows that the RFID-based attendance system has a fairly good level of accuracy in detecting employee attendance. With an error of only 3.75%, this system can be relied on for monitoring attendance at the Watumas Clinic in Purwokerto.

### 3.3 RFID Based Attendance System Admin Web Visualization

This admin web is designed to provide easy access for users in managing employee attendance data in real-time and is presented in the Indonesian language. This web-based system has proven to be able to overcome various challenges, such as increasing efficiency in data management and accessibility from various locations, according to the latest study on the use of cloud and IoT technology for attendance management systems [29], [30]. The following is an explanation of some of the main pages available in this system.

#### 3.3.1 Login Page

This page serves as the entry point for the system administrator. The administrator must enter valid credentials, in the form of an email and password, to gain access to the dashboard and attendance management features. Access security is maintained with an authentication mechanism to ensure that only authorized users can log in to the system. The login page can be seen in Figure 10.

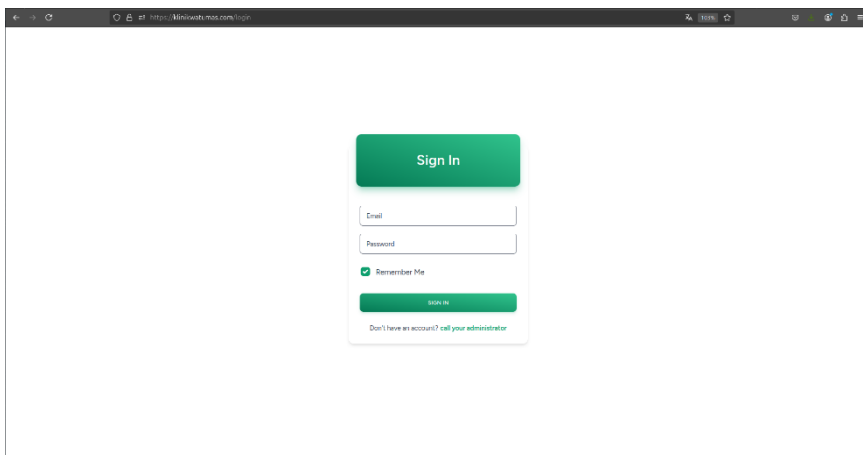


Fig. 10. Login page web admin

### 3.3.2 Dashboard Page

The dashboard page presents real-time employee attendance data, allowing admins to monitor the attendance of clinic employees at that time. On this page, important information such as the number of employees present, lateness, and other attendance statuses are displayed in easy-to-understand graphs or tables. The dashboard page can be seen in Figure 11.

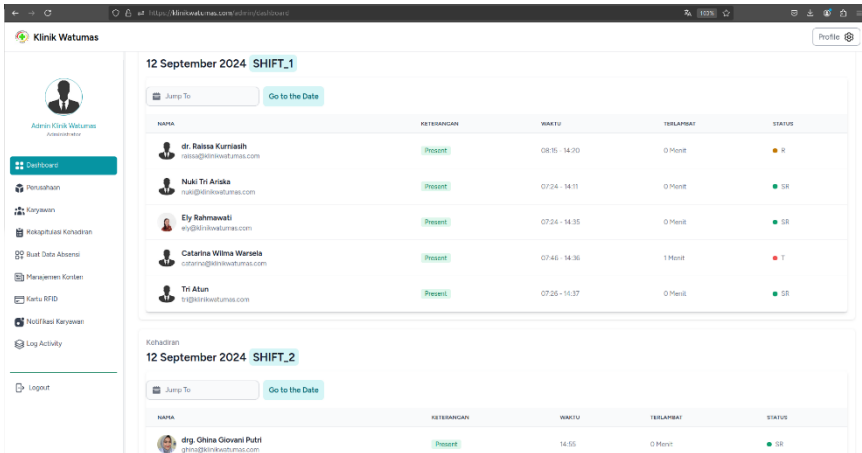


Fig. 11. Dashboard page web admin.

### 3.3.3 Attendance Recap Page

This page provides a recapitulation of employee attendance data in a certain period. Admin can review monthly attendance data. The data presented can also be exported in various excel formats for further administrative needs. The attendance recap page can be seen in Figure 12.

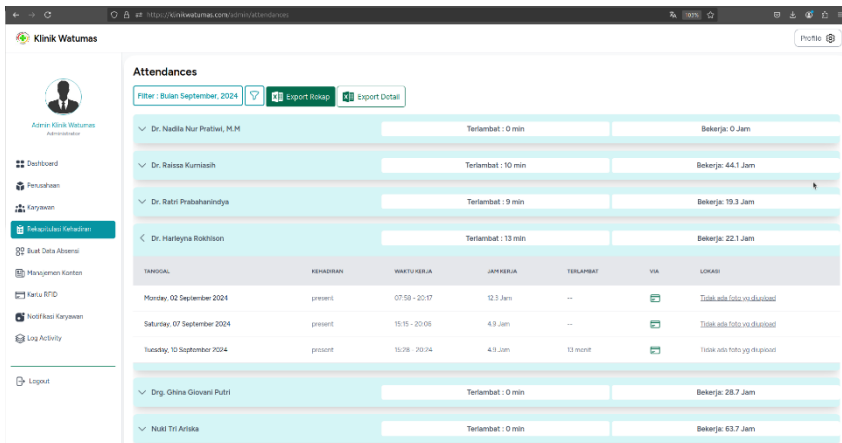


Fig. 12. Attendance Recap Page web admin.

### 3.4 Web Admin Testing

Testing on the admin web of the RFID-Based Attendance System will be carried out using the black box testing method. This black box testing is used to test the main functionality of the login page, dashboard, and attendance summary without requiring in-depth knowledge of the program code. This method is often used to evaluate the performance of RFID-based systems in various sectors, including attendance management, by ensuring the system works according to predetermined specifications [31]. According to research, RFID-based attendance systems successfully overcome the weaknesses of manual systems by increasing the accuracy and efficiency of the attendance process [32]. The test results are presented in tables 3, 4 and 5.

**Table 3.** Black box testing login page

Test Case	Input	Expected Output	Status
Login with valid credentials	Correct email and password	System allows admin to login and redirected to dashboard page	Pass
Login with wrong username	Wrong email, correct password	Error message “The provided credentials do not match our records.” appears and access is denied	Pass
Login with wrong password	Correct email, wrong password	Error message appears “The provided credentials do not match our records.” and access is denied	Pass
Login without entering credentials	Did not enter Email or password	Login form is not sent and the system directs to fill in an empty email or password	Pass

**Table 4.** Black box testing dashboard page

Test Case	Input	Expected Output	Status
View real-time attendance data	Open the dashboard page	Clinic employee attendance data is displayed in real-time in a table	Pass
View the total number of employees present	Open the dashboard page	The number of employees present is displayed correctly according to the latest attendance data	Pass
Check late notifications	Open the dashboard page	Notifications of employees who are late appear on the screen if an employee is late	Pass
Check employee status "Absent"	Open the dashboard page	Data on absent employees is displayed in the appropriate section	Pass

**Table 5.** Black box testing attendance recapitulation page

Test Case	Input	Expected Output	Status
Filter attendance data by month	Select a specific month filter	Employee attendance data summary according to the selected month is displayed	Pass
Export attendance data	Click the export excel button	Attendance data successfully exported in the selected excel format	Pass

Based on the results of the tests that have been carried out on the RFID-based attendance system, all test scenarios have successfully provided results that are in accordance with expectations. From login testing to checking employee attendance data, the system has proven to be able to handle various inputs correctly, both in valid and invalid login scenarios, and display attendance data in real-time and accurately.

### 3.5 UAT Testing (User Acceptance Testing)

User Acceptance Testing (UAT) aims to evaluate the extent to which the developed RFID-based attendance system meets user expectations. This survey involved Watumas Clinic employees who were asked to rate various aspects of the system using a scale of 1 to 4. Where, number 1 means "Not Satisfied" and number 4 means "Very Satisfied". The survey results taken from UAT respondents can be seen in table 6.

**Table 6.** UAT survey results

Name	System successfully detects	Accurate attendance info	System response speed	Transparent system	Trusted system	System increases efficiency	Satisfaction Towards the system
Employee 1	4	4	4	4	4	4	4
Employee 2	3	4	3	4	3	4	4
Employee 3	4	4	4	4	4	4	4
Employee 4	4	4	3	4	4	4	4
Employee 5	4	4	4	4	4	4	4
Employee 6	4	4	4	4	3	4	4
Employee 7	4	4	4	4	4	4	4
Employee 8	4	4	4	4	4	4	4
Employee 9	3	4	3	4	4	4	4
Employee 10	4	4	4	4	3	3	4

Based on the results of the UAT, which used a scale of 1 to 4, the RFID-based attendance system at Watumas Clinic received very positive feedback from users, with an average score of 3.87. Most respondents gave the highest ratings for aspects such as attendance detection, accuracy of attendance information, transparency, and increased efficiency, indicating that the system generally performs very well. However, there is room for improvement in terms of response speed and trust in the system, with some respondents giving a score of 3. Overall, the system was rated satisfactory with high average scores across almost all categories, indicating that the RFID attendance system is suitable for broader implementation and has been well-received by users.

The results of this study indicate that the implementation of an RFID-based attendance system at the Watumas Clinic increases efficiency, accuracy, and transparency in recording employee attendance, in line with the findings of previous studies that developed similar systems for educational institutions. Our system uses a similar approach, utilizing IoT and cloud servers to monitor attendance in real time, providing instant feedback to employees at the Watumas Clinic. In addition, this system strengthens trust between employees and management, similar to how the attendance system in previous studies. builds transparency and trust among users, ensuring that every recorded attendance data is accurate and reliable [33].

RFID-based attendance system integrated with the NodeMCU module and PHP & MySQL servers is able to record attendance with high accuracy at a maximum distance of 3 cm [34], This study is in line with the results of the development at the Watumas Clinic, where the RFID and IoT-based attendance system is able to increase the efficiency and accuracy of recording attendance data in real time. The implementation of RFID not only minimizes errors in the manual attendance process but also increases transparency and trust in attendance management, as expected in cloud-based systems in various service sectors.

Similar research on the RFID attendance system at Pizza Hut Antasari supports the findings obtained in the development of the system at the Watumas Clinic. Both studies show that RFID implementation significantly improves the accuracy of attendance recording and the efficiency of the attendance process, replacing error-prone manual methods. Consistent test results, such as a hardware success rate of up to 98.81% at Pizza Hut Antasari [35] and a MAPE of 3.75% at the Watumas Clinic, prove the effectiveness of RFID technology as a reliable and efficient attendance solution in various sectors.

## 4 Conclusions

This study shows that the RFID-based attendance system implemented at the Watumas Clinic in Purwokerto directly meets the research objectives in several main aspects, namely providing an effective and efficient solution to monitor employee attendance in real-time. By utilizing RFID technology, the attendance process that was previously done manually and prone to errors becomes faster, more accurate, and more transparent. This system not only improves operational efficiency but also provides more valid data for human resource management.

The system can automatically record employee attendance in real-time through the integration of IoT, RFID, and cloud server technologies. The Mean Absolute Percentage Error (MAPE) test results show that the system has a high level of accuracy, with a prediction error rate of only 3.75%. Additionally, Black box testing revealed that all major system features, such as user authentication, attendance recording, and reporting, functioned well according to the expected specifications. Furthermore, the User Acceptance Testing (UAT) results, with an average score of 3.87 out of 4, indicate that most users were satisfied with the system's performance, particularly in terms of attendance detection, accuracy, and transparency. Based on these results, the RFID-based attendance system is suitable for broader implementation in other clinics or similar healthcare institutions that require an automated and efficient attendance solution.

As a recommendation, further development of system features such as leave and overtime management should be considered for integration into this attendance system. It is hoped that this study can serve as a reference for other healthcare institutions looking to adopt similar technologies. With improvements in system quality and adequate infrastructure support, RFID technology has the potential to enhance efficiency and accuracy in various other sectors.

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