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Designing a laboratory assistant attendance system using Radio Frequency Identification (RFID) technology based on IOT

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ABSTRAK

Tujuan penelitian ini untuk menghasilkan perangkat presensi RFID (Radio Frequency Identification) sebagai sistem presensi asisten lab di Lab Information and Communication of Technology (ICT) Terpadu Budi Luhur untuk mengatasi permasalahan yang sedang terjadi seperti antrean, kerumitan saat menginput, dan manipulasi waktu kehadiran sampai kepulangan. Pengembangan sistem ini menggunakan metode agile yang bisa menangani risiko ketidakberhasilan dalam tahap pengembangan sistem skala kecil maupun besar. Tahapan merancang sistem memanfaatkan Unified Modeling Language (UML). Pengumpulan data dilakukan dengan teknik observasi, wawancara, dan kuesioner terhadap lingkungan LAB ICT Terpadu Budi Luhur. Hasil penilaian ahli kelayakan pengujian mencapai persentase 90 (sangat pantas), pengujian praktis mencapai persentase 92 (sangat pantas), uji keamanan mencapai persentase 90 (layak), dan uji coba kelompok besar mencapai persentase 90 (sangat pantas). Dapat disimpulkan perancangan sistem dengan menggunakan UML dengan teknologi RFID dapat meningkatkan efektivitas presensi serta menyelesaikan permasalahan dalam presensi.

ABSTRACT

The current study attempted to generate an RFID (Radio Frequency Identification) attendance device as a bridge of attendance for the Computer Lab Assistant of Budi Luhur to overcome ongoing problems such as queues, complexity when inputting, and manipulation of attendance time to return. The development of this system uses agile methods that can handle the risk of failure in the small and large-scale system development stages. The system design stage uses UML. The data was collected using observation, interviews, and questionnaires in the Budi Luhur Integrated ICT LAB environment. The outcomes of the viability examination expert assessment attained a rate of 90 percent (highly achievable), the practicality test achieved a level of 92 (highly achievable), the security test attained a level of 90 (practicable), the large-group trial achieved a level of 90 (highly achievable). It can be concluded that designing a system using UML with RFID technology can increase the effectiveness of attendance and solve problems in it.

INTRODUCTION

Attendance is a method used to record someone's presence in an activity or event. It can be done in various ways, either manually or automatically. This attendance system is commonly utilized in settings such as workplaces, schools, and large-scale events. Attendance serves as disciplinary information, allowing supervisors to assess the level of discipline among employees (Meyliana, 2020). Common issues encountered in manual attendance systems include susceptibility to manipulation and data entry errors, as well as the time and effort required to manage attendance registers. Consequently, many organizations or membership-based activities have adopted alternative attendance methods such as online attendance, cards, electronic systems, and others. However, these methods still have limitations, particularly in terms of development and implementation costs as well as maintenance expenses (Aprilliani, 2023).

The Integrated ICT Lab of Budi Luhur University is one of the units within Budi Luhur University. The ICT lab has a membership structure consisting of a Lab Head, Supervisor, and Lab Assistants. To monitor the productivity and discipline of Lab Assistants, an attendance system has been implemented, initially using a manual system, which has since transitioned to an online system. However, common issues arise, including queueing during attendance that leads to losses for Lab Assistants who feel they are next in line, security disruptions, and susceptibility to manipulation of Lab Assistants' arrival and departure times.The development of technology to support attendance has been extensively pursued by previous researchers. These include biometric technologies such as fingerprint, facial recognition, or iris scanning. However, they are still considered expensive and have limitations in both implementation and development. RFID (Radio Frequency Identification) technology offers a solution to these challenges and serves as an electronic attendance application. In certain institutions where ID cards are equipped with RFID, they serve dual functions as identification tags and access keys, in addition to being attendance tools. This technology utilizes radio frequency to automatically identify objects, constituting RFID technology (Tungadi & Lisangan, 2020). The modest RFID tag transponders respond to reader queries by transmitting identification numbers (Tungadi & Lisangan, 2020). However, the limited range of data transceivers from simple RFID devices restricts their effectiveness (Wang et al., 2023). The implementation of this technology involves data communication between sensor devices and databases, which store attendance data using Laravel. Arduino serves as an intermediary to connect RFID with a web-based attendance system integrated with programming languages (Tungadi & Lisangan, 2020). In the research carried out by Wardana et al. (2023), a prototype RFID-based attendance system was developed utilizing Student ID Cards (*Kartu Tanda Mahasiswa*) as the means for attendance registration. This research employed a prototype method and conducted a case study on classroom or lecturer attendance for each course, resulting in limitations in the timing of attendance recording due to varying and restricted class schedules (Yuliono et al., 2023).

Based on the existing problems, advancements in technology, and previous research, it is necessary to develop an RFID-based attendance application utilizing ID cards for laboratory assistants. This research employs an agile methodology approach with a web-based attendance system integrated with RFID devices as attendance tools. The agile methodology emphasizes adaptability and close collaboration between developers and users, aiming to produce quick and responsive solutions to changing needs in the attendance system (Prastowo et al., 2023). An in-depth analysis of each requirement was implemented to ensure that the resulting solution not only meets functional needs but also considers important non-functional aspects such as security and scalability (Rolland et al., 2023).The benefits of this research include the ability to develop an automated and accurate attendance process, reducing the potential for human errors in time recording. Furthermore, the adoption of RFID technology is anticipated to downsize the likelihood of attendance fraud by restricting the usage of RFID cards to only the legitimate ones. This system will streamline processes and lessen error rates, both intentional and unintentional (Bharathy et al., 2021). Furthermore, the research focuses on enhancing system security by creating information that limits access for Lab assistant users, preventing data alteration by unauthorized parties.

METHOD

The Agile method was chosen as the foundation for developing a web-based attendance system with RFID. Agile methodology involves the engagement of developers and users as an approach in all aspects of software development projects (Bakar & Dorasamy, 2023). Agile methodology can serve as a preventive measure against the risks of unsuccessful systems development, ranging from small to large-scale, caused by various limiting factors such as budget, technology, or resources. It serves as a solution to overcome any reasons that may hinder the perfection of project development (Bakar & Dorasamy, 2023).

The Agile method emphasizes early product delivery and enables flexible and easily adaptable adjustments at each stage of the project. This strategy utilizes teamwork to divide extensive projects into more manageable segments (Işık & Çifci, 2023). There are several stages within the Agile Method, including Planning, Design, Development (Implementation), Testing, Deployment, and Maintenance (Kurnia et al., 2023) (see Figure 1).

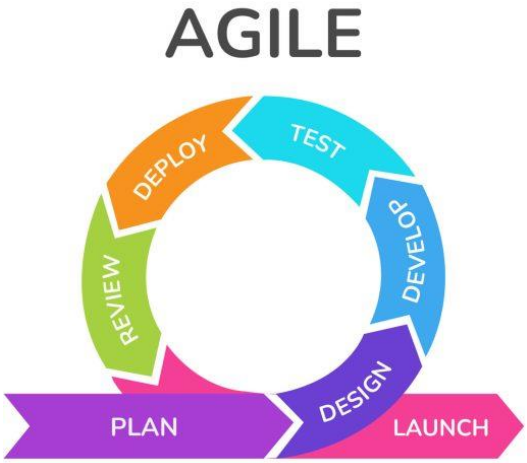

Figure 1. Agile Process

Planning is the initial stage in system development involving the identification of needs and resources. This process entails project goals, risk analysis, and determination of management plans. It focuses on detailing the steps required to achieve project goals efficiently.

The design involves the development of a system blueprint to be constructed. The design process entails creating a comprehensive system blueprint for construction, incorporating architectural elements such as Use Case, Activity, Class, and Sequence diagrams, as well as user interface design. During the design phase, it is necessary to consider factors such as comfort, performance, and other aspects that may influence system implementation.The development of a system involves transitioning from design to actual code, which would be developed by a team with their respective roles. It is decisive to maintain an ethical code and implement appropriate procedural practices. System testing is necessary to ensure that the system functions properly and meets user expectations, and the results can identify and rectify system bugs.

Deployment involves implementing software into the production environment or targeted location. This process must be elaborated carefully to minimize service disruptions. A good understanding of the production environment is crucial for successful deployment. Maintenance is a stage involving routine system upkeep post-launch. This encompasses enhancing functionality and security updates. Maintenance is necessary to ensure the system continues to operate optimally over time.

The initial step in this research is a literature review. This review was to comprehend various literature from multiple sources and to understand better developments in attendance system development, referring to data collection, which is the process of gathering information or facts needed for specific purposes. Subsequently, problem formulation was carried out by examining the results obtained from the literature review. Problems can be identified based on their

relevance, urgency, and significance under investigation. Data collection in the research involves several stages, namely literature review, observation, interviews, and questionnaires. Observation and interviews identify issues in the system and attain a deep understanding of the desired user needs. The techniques and characteristics of the interviews involve extensive exploration and observation of behaviors that make the research object (Hansen, 2020). Whole research process can be seen in the Figure 2.

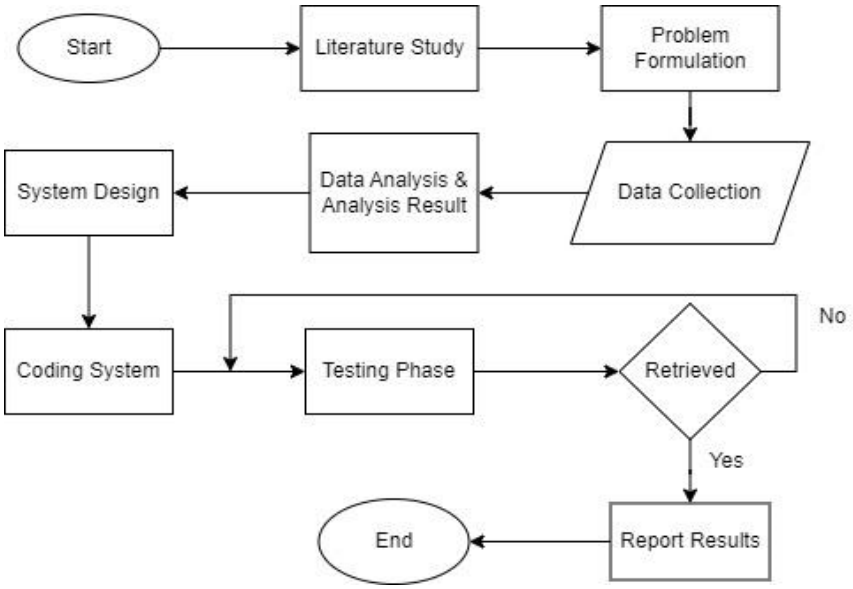

Figure 2. Research Process

A questionnaire collected several responses and feedback from users of the system. The measuring instrument used to gauge occurrences by the researchers is the purpose of the questionnaire (Dewi et al., 2020). This process is the initial stage in research towards the next stage. Data analysis and the quality of the data collected greatly influence the final outcome of the project or study. The data analysis is necessary for determining the next steps by companies or organizations (Al Ghivary et al., 2023). The process of gathering information or facts required for a specific purpose. The user interface serves as a bridge between the user and the system to communicate and understand issues that occur in the system. The goal of website interaction is to effectively operate and control heavy equipment for users, while the heavy equipment simultaneously provides feedback information that can help users make decisions (Raafi'udin et al., 2020).

RESULT

System analysis

The depiction of requirements analysis for an RFID-based attendance system utilizes the Unified Modeling Language (UML), a standardized language employed for modeling, specifying, and documenting software artifacts and information systems. In this context, UML is utilized to present in detail the requirements of the RFID-based attendance system, including functional and non-functional specifications, interactions between system entities, and the involved data structures. The analysis of the requirements for the RFID-based attendance system is depicted using UML as follows:

Use case

The attendance use case is explained in Figure 3, where the admin can manage attendance data. Within the attendance data, entries for presence, leaving, sick leave, and permission can be made. The admin can also generate attendance reports. Figure 4 explains the use case where each lab assistant taps the card to make entries for presence and leaving.

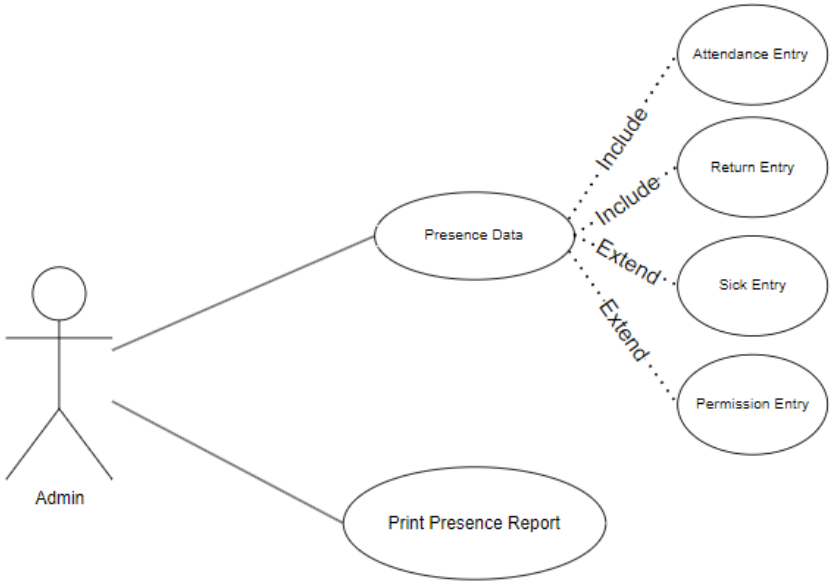

Figure 3. Admin usecase

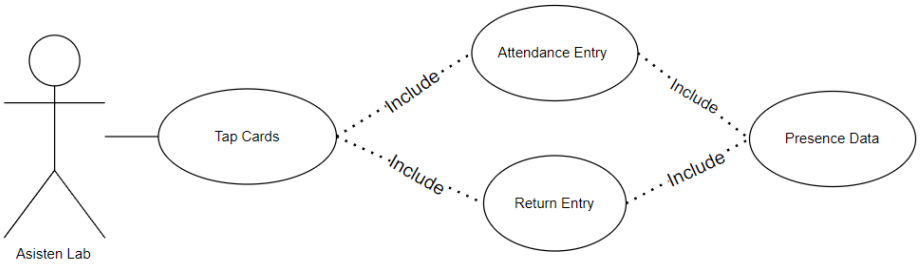

Figure 4. Attendance usecase

Activity Diagram

The activity diagram displays the admin activities within the system for accessing the dashboard, as explained in Figure 5. Admins must log in first to access the dashboard; if they cannot log in, they will not be able to access it. The requirement for accessing the dashboard is to have an account registered as a user role. Figure 6 explains that the attendance process can only be done if the Mifare card has been registered in the database. Card registration can only be done by admins or roles with access to the database. These registered cards will be used for future attendance.

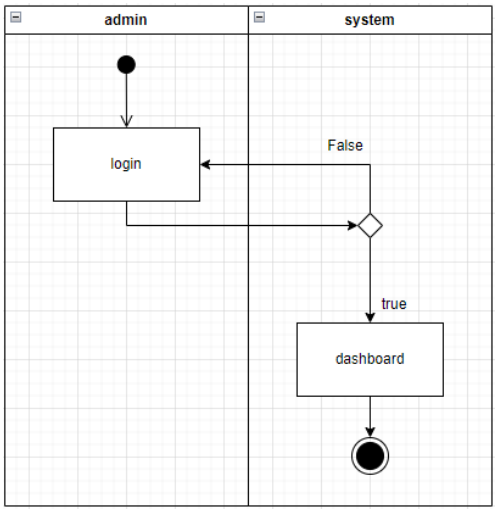

Figure 5. Admin

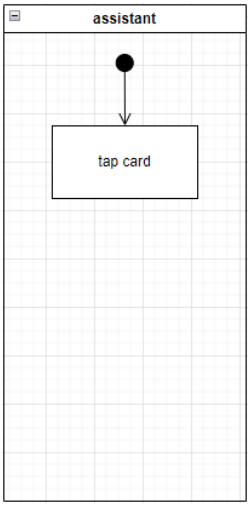

Figure 6. Lab assistant

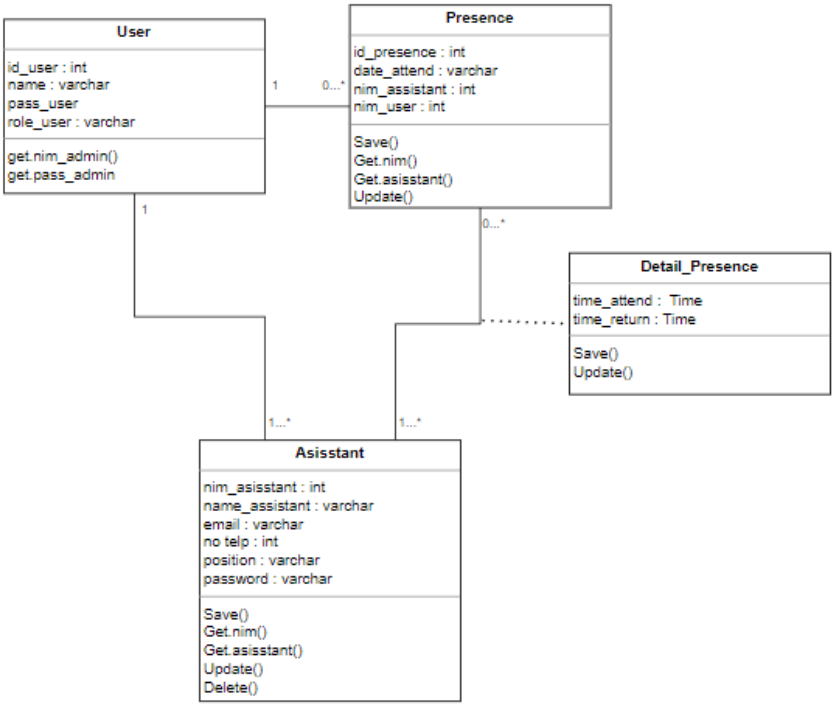

Figure 7. Class diagram attendance

Class Diagram

This Class Diagram depicts the classes of several database systems and the relationships between the classes. In Figure 7, each relationship between classes in the database is displayed to observe patterns of interconnection among entities in the designed database structure. The User class represents system users and their data. The Presence class represents user attendance data and stores user attendance dates. The Assistant class represents assistant data and stores assistant information.

Sequence Diagram

The Sequence diagram is used to sequence the system's steps in processing a command from the user. Using the UML Sequence diagram assists software engineers in understanding conceptual designs more effectively. This diagram is capable of assisting in understanding the concepts of software engineering (Karampure et al., 2021). Here is the proposed sequence diagram design. Figure 8 explains that the attendance process can only be carried out if the Mifare card has been registered in the database. Card registration can only be performed by an admin or a role with access to the database. These registered cards will aid future attendance.

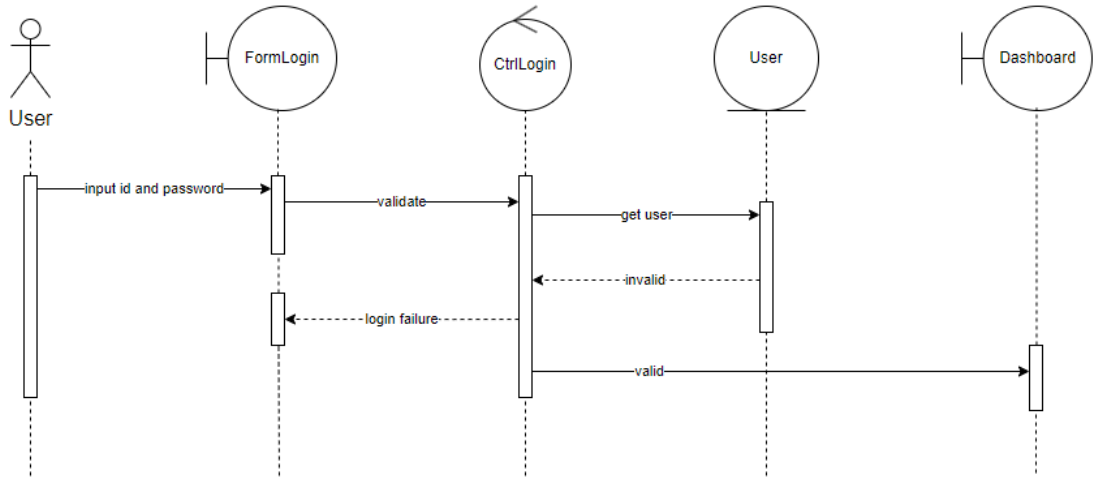

Figure 8. Admin Login

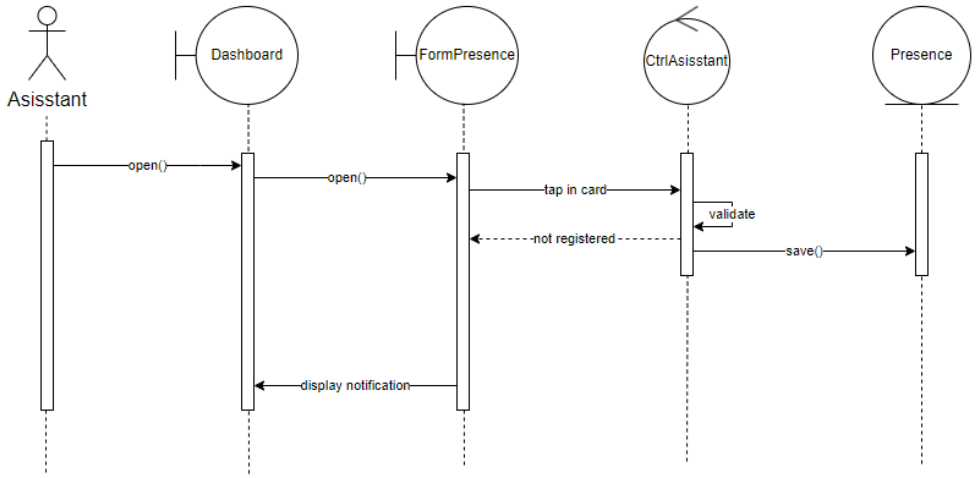

Figure 9. Process attendance

The process of recording attendance is contingent upon the Mifare card registration in the database, after which it is promptly stored therein, as illustrated in Figure 9. Notification will appear when the attendance is completed. Card registration can only be done by an admin or a role with access to the database. These registered cards will be helpful for future attendance. If not validated, the input will return to the attendance form. Figure 10 hints that the report can only be accessed by the admin. Before obtaining information about the report, the admin must enter the date, month, and year period. After that, the system will display the attendance obtained from the database, and the admin can print the report.

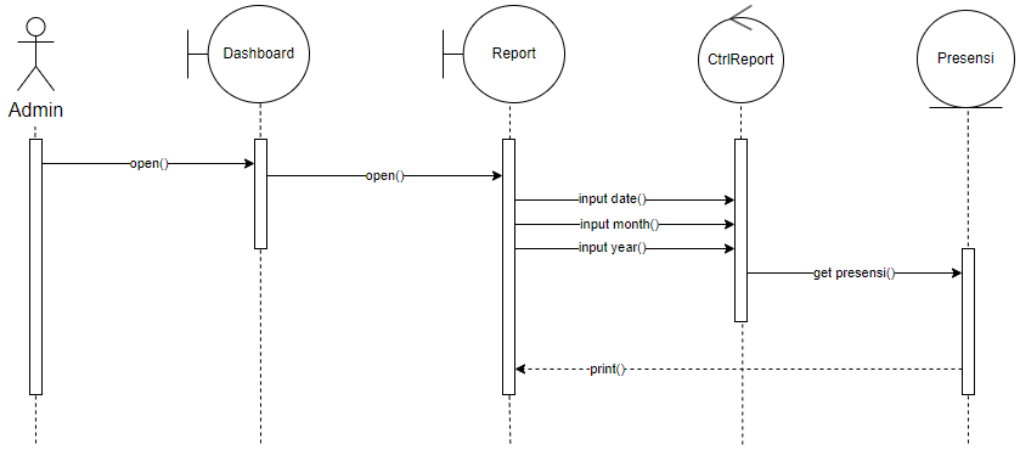

Figure 10. Report process

System design

The login page in Figure 11 is the process of accessing the dashboard. Admins must enter their email or username and password integrated into the database. Lab assistants without access will be immediately rejected, and the website will continue to display the login page. Figure 12 demonstrates the registration menu containing the user's email or username, user password, and admin or superuser password. An account cannot be created without entering the admin or superuser password. Figure 13 depicts the dashboard as the initial view after successful login. This initial view consists of a sidebar, navbar, and post body as the dashboard. Admins will obtain various information from the dashboard. Figure 14 explains that attendance notifications will change according to the system's reading; if no business processes are carried out by lab assistants, the notification will not change. Dashboard notifications change as the system reads Mifare cards. The figure above is an example of successful attendance or successful reading of Mifare cards by the system.

Figure 11. Login page

Figure 12. Register page

Figure 13. Dashboard page

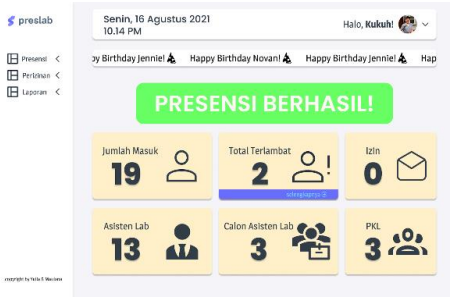

Figure 14. Success page

Figure 15. Notification of failure

The dashboard notification changes as the system reads the Mifare card. The Figure 15 is an example of an undetected card, indicating that the card has not been registered or integrated into the database. The dashboard notification displays a message like the one above, indicating a system failure when reading the Mifare card during the attendance process. This might happen when the card is tapped or pulled too quickly. In Figure 16, this attendance sidebar contains a table displaying the assistants who have clocked in, along with their arrival and departure times from the lab. Figure 17 is a summary of lab assistant attendance and absence, which can be accessed by the admin. The admin can print the attendance data of lab assistants who have logged their attendance during the specified period.

Figure 16. Attendance table

Figure 17. Report table

System testing

System testing was conducted by performing user trials on several features available in the system. The findings from the examination can be elucidated within the Table 1. After conducting analysis, system design, coding, and system testing, the next stage was to test the effectiveness, efficiency, security, and usability of the previous system and the system using RFID. This can be explained in the Table 2.

Table 1. Functional testing of the attendance system

Testing Scenario	The expected results	The trial results	Description
Login page for the admin.	If an admin wants to log in, they can validate their username/email and password on the login page. If successful, they will be directed to the dashboard menu immediately.	System at the login menu successfully validates the username/email and password, allowing access to the dashboard menu.	Success
Dashboard menu when the assistant's card tap-in is successful.	If the assistant successfully taps in with the lab assistant card, a success notification will appear.	Attendance web system successfully identifies the lab assistant card that is already registered, resulting in a successful notification.	Success
Dashboard menu when the assistant's card tap-in fails.	If the assistant fails to tap in with the lab assistant card, an unsuccessful notification will appear.	Attendance web system fails to identify the lab assistant card that is not yet registered, resulting in an unsuccessful notification.	Success
Admin menu for monitoring transaction data and manual attendance input.	Admin can manually input, edit, and delete attendance records on the web-based attendance system, while the user only needs to tap in for attendance.	Attendance web system successfully creates users, with admins having full access and lab assistants only being able to perform attendance.	Success
Lab Assistant attendance page menu to view the total attendance and when we are present.	User can monitor the display on the attendance tab after completing the tap-in to see the arrival time and the number of lab assistants present.	System can display the attendance tab when lab assistants tap in for attendance.	Success
report page menu to summarize the results of ICT Lab attendance transactions.	Admin can print reports of the attendance transaction results.	Admin successfully prints the report of the attendance transaction results.	Success

Table 2. The online attendance system website before using RFID

Criteria	Results	Percentage
Effectiveness	Good Enough	76%
Efficiency	Good	86%
Security	Good Enough	78%
Usability	Good	84%

Table 3. online attendance system website after implementing RFID

Criteria	Results	Percentage
Effectiveness	Very Good	90%
Efficiency	Very Good	92%
Security	Very Good	90%
Usability	Very Good	90%

The previous efficiency level in the attendance system was good at 86%. However, with several advancements, this efficiency level increased to excellent at 92%. This indicates that the attendance system can record automatically and minimize human errors in time recording. Security in the previous system showed a fairly good rating of 78%, although slightly vulnerable to human fraud. With RFID implementation, security improved significantly to an excellent category at 90%, thereby minimizing fraud during attendance data input. Usability also experienced a significant improvement from good at 84% to excellent at 90%, indicating an easier system operation and a better user experience after RFID adoption. This result demonstrates that integrating RFID into the attendance system yields favorable outcomes for its utilization within the ICT Lab.

DISCUSSION

Based on the comparison of the respondent tables above, the results indicate changes in several aspects. Prior to RFID implementation, the system's effectiveness was rated quite good at 76%, but it significantly increased to excellent, reaching 92% after the RFID implementation. This demonstrates that the attendance system has evolved with a high level of accurate output. The previous efficiency level in the attendance system was rated good at 86%. However, with several advancements, this efficiency level increased to excellent, reaching 92%. This data suggests that the attendance system can automatically record and minimize human errors in time recording. Security in the previous system was rated fairly good at 78%, although slightly vulnerable to human fraud. With RFID implementation, security significantly improved to excellent, reaching 90%, thereby minimizing fraud during attendance data input. Usability also experienced a significant improvement from good at 84% to excellent at 90%, indicating easier system operation and a better user experience after RFID adoption. The positive effects of implementing RFID technology in the attendance system are evident in its successful utilization within the ICT Lab.

Employing RFID cards for attendance and integrity significantly aids in the data collection process. RFID technology, which automatically assists computers in recording data, identifying objects, or tracking individuals through radio waves, greatly enhances efficiency (Putra et al., 2021). This technology is highly capable of reducing the incidence of lab assistant fraud and is more efficient than previous processes. The RFID attendance system can manage inputted data and generate comprehensive reports into the database efficiently, thus reducing potential fraud by lab assistants (Ula et al., 2021). RFID does not use batteries or chips, meaning it does not require sensor costs and has an unlimited lifespan (Costa et al., 2021).

One of the constraints of this study involves its concentration on developing a system for a particular case study, specifically the integration of RFID technology into a web-based attendance system at the Integrated ICT Lab, as discussed by Lee and Chen (2023). The unique characteristics and specific requirements in the Integrated ICT Lab environment may not fully reflect the challenges and dynamics might occur in other domains. Generalizing the findings becomes limited to usage scenarios outside of that environment. Therefore, periodic checks and supervision are also necessary to ensure the Web Attendance system runs smoothly. Criticisms and suggestions from users are crucial in the development of this project, considering the potential value that can still be further developed.

The researchers' contribution to this study encompasses several essential aspects. Practically, the researchers were involved in designing the system, coding, and testing. These steps were carried out sequentially to ensure that the built system met the desired functionality requirements. Empirically, the researchers applied black-box system testing techniques to evaluate the performance of the built system. Through black-box testing, potential weaknesses and deviations from the established specifications could be identified, thus ensuring optimal system performance quality. Supriyono (2020) defines black-box testing as a software evaluation technique that prioritizes software features or functional specifications. Methodologically, the researchers applied an agile development methodology approach in designing the implementation of new concepts by applying RFID technology outside of the ongoing business processes in the ICT Lab.

CONCLUSION

The researchers' contribution to this study encompasses several vital aspects. In practical terms, they were involved in designing the system, coding, and testing. These steps were carried out sequentially to ensure that the built system met the desired functionality requirements. From an empirical perspective, the researchers applied black-box system testing techniques to evaluate the performance of the built system. Through black-box testing, potential weaknesses and deviations from the established specifications could be identified, thus ensuring optimal system performance quality. Black-box testing is a software testing method that focuses on the features or functional specifications of the software. Methodologically, the researchers applied an agile development methodology approach in designing the implementation of new concepts by applying RFID technology outside of the ongoing business processes in the ICT Lab.

Author contributions

The authors made significant contributions to the study's conception and design. The authors was in charge of data analysis, interpretation, and discussion of results. The final manuscript was read and approved by the authors.

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Conflict of interest

The authors declare that there is no potential conflict of interest.

Data availability statement

All data are available from the authors.

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