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Implementation of Global Positioning System (GPS) Technology in Employee Presence Mobile Applications to Improve the Accuracy of Attendance Verification in Solar Power Generation Companies

ABSTRACT

This study investigates the use of Global Positioning System (GPS) technology in a mobile attendance application for employees at a solar power-producing firm. The current attendance system is constrained and inflexible in accommodating employee mobility, as the company previously used a fingerprint-based approach and now uses the parent company's attendance program, both of which limit customization to meet specific requirements. A GPS-based attendance application was created to improve attendance verification precision, provide flexible access for field employees, and enhance human resource management by enabling more accountable attendance recording. This study employs a mixed-methods approach, incorporating data collection methods such as literature reviews, interviews, and observations to achieve a thorough understanding of user requirements and the shortcomings of the prior system. The system development method adheres to the Rapid Application Development (RAD) model, prioritizing swift prototype cycles and active user involvement. Testing is performed using black-box testing to confirm that the system's functionality meets the requirements, with white-box testing on the Clock-in page to validate the program's internal logic. The research findings demonstrate that the developed GPS-based attendance application markedly improves attendance record precision, facilitates employee mobility across diverse project locations, and reduces the likelihood of attendance fraud. The solution also provides real-time monitoring of attendance data for HR, enhances internal data integration, and enables more thorough analysis of attendance patterns. The GPS-based attendance application automates attendance recording and verification, enhancing the efficiency and accountability of the attendance management system in alignment with the digital transformation of the solar power generation company.

Keywords: Employee Attendance, Global Positioning System, Rapid Application System (RAD), Black box Testing, White box Testing.

INTRODUCTION

Digital transformation has significantly altered human resource management, particularly in employee attendance and performance monitoring. Attendance systems that previously served only to record working hours have transformed into essential instruments for performance assessment, compensation allocation, and the cultivation of a disciplinary culture within enterprises. Nonetheless, the deployment of traditional attendance methods, such as fingerprint recognition, encounters constraints in the current era of flexible work that necessitates significant mobility. These technologies cannot confirm the attendance of

personnel working remotely, underscoring the need for a more adaptable, accurate, technology-driven attendance system that delivers real-time data.

A solar power-producing company encounters similar difficulties in managing staff attendance. The project's operations across Indonesia require a flexible attendance system that accommodates field staff mobility. The fingerprint system has demonstrated inefficiency, whilst the parent company's attendance application provides restricted flexibility and control over internal data. This scenario necessitates the creation of an autonomous attendance system customized to the requirements and operational attributes of the solar power generation company as a strategic measure for efficient human resource management. This research addresses the topic by proposing solutions that include Global Positioning System (GPS) technology within a mobile attendance application and a web-based attendance data management system on an HR Management website, utilizing the Rapid Application Development (RAD) methodology. GPS technology is used to ensure precise location verification of attendance in real time. Furthermore, to ensure data integrity against fraudulent activities, the mobile attendance application incorporates a Device Binding mechanism that permanently associates each user account with a single registered mobile device ID, thereby preventing unauthorized access or attendance by third parties. The RAD technique enables a more rapid, flexible development process through prototyping and ongoing user feedback.

Information System, an information system has multiple information technology components that collaboratively produce information, hence establishing a communication channel within an organization or group (Aguda, 2024). This project employs a system to develop a mobile attendance application enhanced by GPS, designed to deliver precise, real-time attendance data to facilitate human resource management in the solar power generation sector.

Attendance Framework, (Chauhan et al., 2024) define attendance as an individual's presence at a location, signifying that certain individuals anticipate this presence for a particular reason. This research primarily focuses on developing an attendance system with GPS-based technology. This advancement will facilitate more efficient, transparent, and contextually relevant documentation of employee attendance at the solar power-producing firm.

Mobile Application, a mobile application is software explicitly developed for operation on mobile devices, including smartphones and tablets (Mary Nkechinyere Nwakamma et al., 2024). This research indicates that the mobile application serves as the primary platform for employee attendance, enabling flexible, precise tracking from any location and meeting users' mobility requirements.

Human Resources Management Website, (Hope, 2024) assert that HRM is intended to consolidate many human resource management tasks, including personnel data management, attendance tracking, and centralized digital reporting. Furthermore, it offers functionalities for leave requests, KPI (Key Performance Indicators)-driven performance assessments, and self-service access for employees to oversee their own information. Consequently, the notion of the HR Management Website corresponds with this research, since both emphasize the digital transformation of HR management procedures. This

research enhances functionality by connecting the HR Management Website system to a real-time, GPS-based mobile attendance application to facilitate employee mobility and ensure the accuracy of field attendance data.

⁷ Global Positioning System (GPS), the Global Positioning System (GPS) provides information about an individual's position on Earth's surface (Harshini et al., 2025). This research uses GPS as the primary method to improve the precision of employee attendance verification in mobile positions, especially within the dynamic operating environment of PT Surya Energi Indotama.

Flutter and Laravel Frameworks, (Prasada & Ikrimach, 2024) assert that Flutter is an open-source framework developed by Google for developing mobile applications compatible with mobile operating systems. This project involves developing a mobile attendance application using Flutter to ensure consistent performance and an intuitive user experience. (Murali et al., 2024) characterize Laravel as a PHP-based MVC web development framework designed to enhance product quality and minimize maintenance costs. This research utilizes Laravel to develop the Application Programming Interface (API) that oversees attendance data and interfaces directly with the Flutter-based mobile application. Furthermore, Laravel is used to build the HR Management Website, which serves as the hub for managing and monitoring employee attendance, with features for employee data administration, attendance reporting, and real-time oversight of work activities via a responsive, organized web interface.

⁴ Rapid Application Development (RAD) Methodology, (Kosa & Saurina, 2026) assert that Rapid Application Development (RAD) is a linear, sequential software development methodology that prioritizes short development cycles. This research employs Rapid Application Development (RAD) because it meets specialized application development requirements, especially in dynamic work settings such as PT Surya Energi Indotama.

The subsequent development stages corresponding to each RAD phase, as delineated by Kendall in the article by (Rizky Prasetyo & Ikrimach, 2025): ² Requirements Planning: During this phase, users and analysts convene to delineate the objectives of the application or system and ascertain the information requirements stemming from these objectives. RAD Design Workshop: ² This phase emphasizes the design and refinement process, characterized as a workshop. In the RAD design workshop, users evaluate the current prototypes, and analysts ² enhance the modules according to user feedback. Implementation: During the implementation phase, analysts collaborate closely with users in workshops to create both the business and non-technical facets of the organization. ⁹ Upon approval of the elements and completion of the system construction and filtration, the new systems or components are tested and subsequently integrated into the organization.

⁵ Black-box and White-box Testing, black-box testing is a software evaluation technique performed without regard to the system's internal structure or logic (Nazara & Nasien, 2024). This research employs this method to evaluate essential aspects, including login, attendance, and location validation, to confirm that the system operates in accordance with user requirements.

White-box testing involves evaluating software at the code level to ensure that inputs and outputs conform to specified requirements (Patel, 2026). This research employs this strategy to verify that all functions, conditions, and logical flows perform as anticipated.

This project seeks to develop and implement a GPS-based attendance application integrated with a web system to improve accuracy, flexibility, and efficiency in managing staff attendance at the solar power generation company. The final results are anticipated to serve as a reference for implementing digital attendance systems in the renewable energy sector and to enhance data-driven human resource management.

METHOD

The author employs Mixed Methods in this research, integrating qualitative and quantitative methodologies for a more thorough examination. The qualitative technique is employed to comprehend user requirements, assess the current attendance system, and investigate employees' perspectives regarding the deployment of the new system. Simultaneously, the quantitative method is used to evaluate technological factors, including GPS position precision, temporal efficiency of the attendance procedure, and the reliability of the system's data.

Data collection transpires through multiple phases. A literature review is conducted to analyze theories and prior research on mobile applications integrating GPS technology with human resource management systems. Subsequently, the researcher performs interviews with project personnel and application users to obtain direct feedback from field operators. Third, observing attendance activities at the solar power-producing company promotes comprehension of the actual workflow. System testing is ultimately conducted with end users to assess the dependability, accuracy, and functionality of the developed system.

This research employs the Rapid Application Development (RAD) methodology, which is considered effective for expediting system development while maintaining quality and addressing user requirements. This methodology emphasizes the iterative development of prototypes and engages consumers at each phase of the process.

The RAD technique comprises three primary parts. The initial phase is Requirement Planning, which entails assessing requirements to develop GPS-based attendance functionality, user authentication mechanisms, and connectivity to the Laravel API backend and the HR Management website. The second component is the RAD Design Workshop, in which developers and users jointly create the application interface using Flutter while concurrently building the backend with Laravel and a MySQL database. The third phase is the Implementation Phase, which entails deploying and testing the system through Black-box and White-box Testing methodologies to verify that all functionalities perform as anticipated. The RAD approach is selected for its ability to create an expedited, more efficient, and aligned attendance system with the operational requirements of the solar power generation company within a brief development period.

RESULTS AND DISCUSSION

This attendance system is designed to help the solar power generation company precisely record, verify, and track staff attendance using Global Positioning System (GPS) technology. The objective of this technology is to verify location accuracy during employee check-ins and to facilitate a flexible work system that encompasses field activities.

The mobile attendance tool is intended for diverse work environments, including Work from Office (WFO), Work from Home (WFH), project workers (PRY), and personnel on business travel. To maintain data integrity and prevent attendance fraud, a security system is implemented using a Device Binding mechanism that associates each user account with a single registered mobile device. This system also interfaces with the HR Management Website built on the Laravel framework, which presents and manages staff attendance data in real-time, as well as personal employee information and leave request data.

The main objectives in building this system are to improve user-friendliness, ensure precision in time and location tracking, and optimize data integration between the mobile application and the HR online system. This interface enables centralized management of all attendance operations, enabling the company to monitor and assess employee attendance.

The findings from the system needs analysis reveal that delineating the roles and tasks of each user is essential to ensure that the GPS-based attendance application can efficiently and accurately fulfill the firm's operational requirements.

Table 1. User Functional Requirements

Actor	Description
Employee	Actors who play a role in using mobile applications that are built to take attendance, obtain permission, and find out information about attendance history.
Admin	The actor who plays a role in controlling the website as a whole as a control center for managing employee information.
General Manager	The actor who plays a role in controlling the attendance page website to see employee attendance, and the permission page as approval for permit/leave applications submitted by employees.

System Design, UML-Based System Modeling, Figure 1 below illustrates the use case diagram, designating the employee as the user who uses the mobile attendance application to check in and out, manage personal data, process leave requests, and access attendance history. The Administrator functions as the server with access privileges, serving as the control center to oversee attendance statistics, process leave requests, and manage employee information on the HR Management Website. The General Manager is the only individual authorized to review attendance and approve staff leave requests on the HR Management Web.

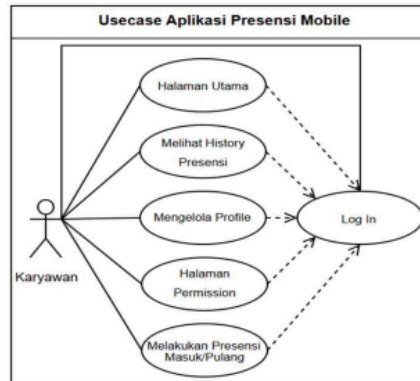


Figure 1. Usecase Diagram of Mobile Attendance Application

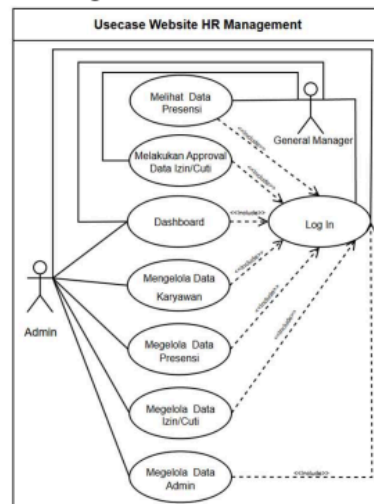


Figure 2. Usecase Diagram of HR Management Website

The activity diagram for the attendance page streamlines the check-in and check-out process by leveraging GPS (Global Positioning System) technology to authenticate employee locations. This enables the organization to verify that personnel are reporting to the designated places. Figure 3 depicts the check-in or check-out procedure, encompassing automatic location verification, selection of task type, completion of notes, selfie capture, and time recording.

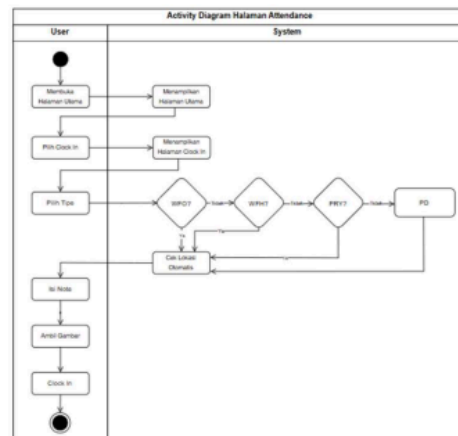


Figure 3. Activity Diagram of the Mobile Application Attendance Page

The sequence diagram depicts the procedure for documenting employee clock-ins and clock-outs. Figure 4 delineates the procedures, commencing with the employee's decision to clock in or clock out. The system promptly authenticates the GPS location, after which the employee selects the type (WFO, WFH, PRY, PD), captures a selfie, and optionally includes a remark before storing the data in the database. This procedure aims to ensure that attendance is documented accurately and in accordance with field conditions.

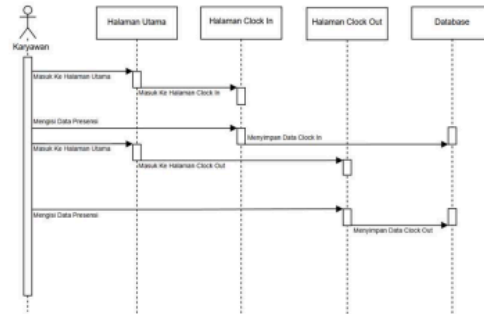


Figure 4. Sequence Diagram of Mobile Attendance Application

The class diagram illustrates the relationships among the classes used in the application's website development process. The attendance application/website's database, presensiapp, uses MySQL and comprises four tables: attendances, users, permissions, and admins. These tables are interrelated to facilitate user authentication, attendance tracking, and leave administration.

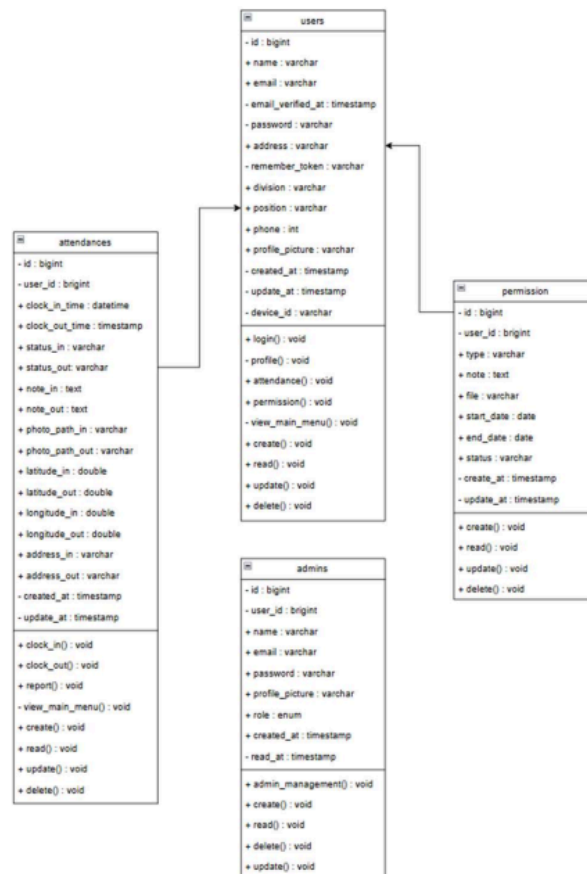


Figure 5. Class Diagram

Flowchart Sistem, the flowchart for the Clock In page delineates the logical progression of the Clock In procedure from initiation to completion. Figure 6 depicts the procedure, which commences with the presentation of the attendance page, accompanied by real-time date and time data, followed by location verification. Should the location remain undetected, the system displays an error message and prompts the user to repeat the validation procedure. Upon successful confirmation, the system logs the location, and the user then designates their attendance status (WFO, WFH, PRY, PD) and captures a photograph. Upon failure to capture an image, the system displays an error message, prompting the user to try again. Upon successful completion, the system archives the photograph. The user may include an optional note and submit the data for verification. The validation outcome determines whether the data will be stored in the database or returned as an error due to incomplete required fields.

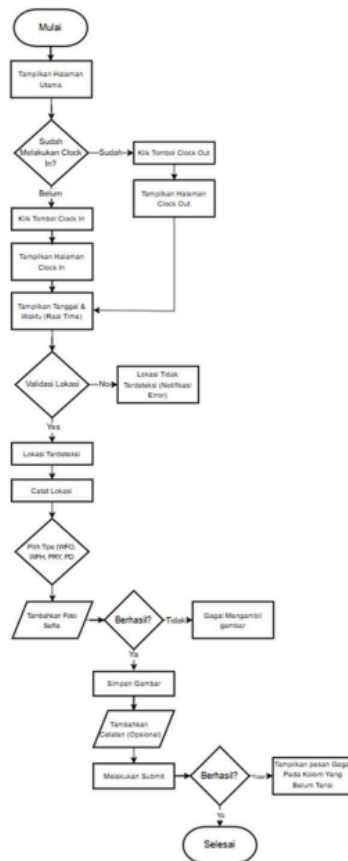


Figure 6. Clock In Page Flowchart

System Implementation, Database Implementation, the presence database table illustrated in Figure 7 is structured and established within this system, comprising multiple interrelated tables to oversee user data, attendance, and permissions. Each table is organized with designated columns to maintain data integrity and efficiency.

Tabel	Struktur	Baris	Jenis	Penyortiran	Urutan	Beban
attendance	id, nama, divisi, posisi, email, no_ktp, alamat, gender, password, foto	0	INT(11)	asc	1	0

Figure 7. The Presence Database Table

Implementation of the Mobile Attendance Application User Interface

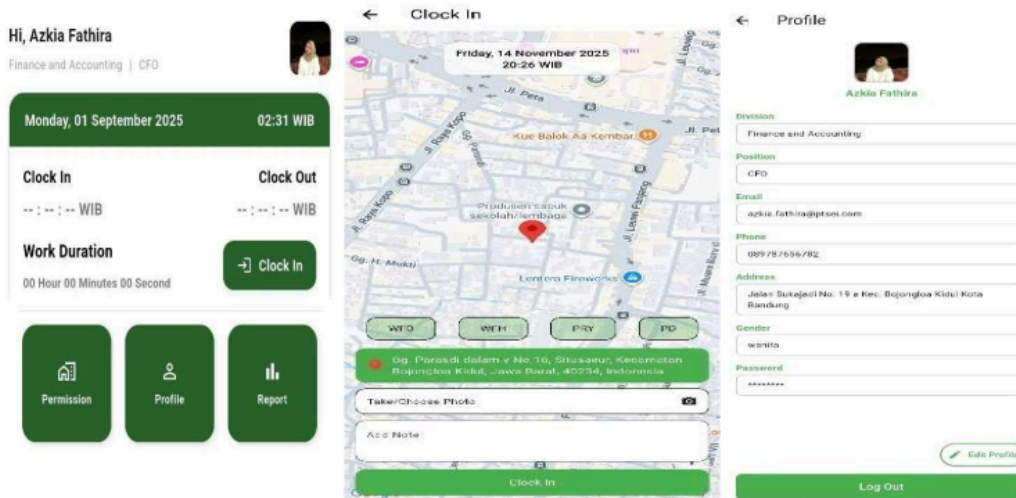


Figure 8. Main Menu Page, Clock in Page and Profile Page

Figure 8 illustrates the application's primary menu available to employees. This page provides access to the clock-in procedure, clock-out process, profile page, authorization page, and report page. This primary page provides employees with quick access to all application functionality via a single portal.

Employees use the clock-in page shown in Figure 8 to record their arrival times at work. This attendance approach incorporates an automatic location-monitoring component, a vital aspect of this research. Employees may choose the attendance location and capture a photograph as evidence of attendance, which requires facial recognition; if the face is not recognized, the photograph will not be retained. Furthermore, there exists a note space for employees to record any messages they would like to include.

Figure 8 illustrates the profile page containing the employee's personal information recorded within the system. The information provided includes identifying characteristics such as name, division, position, email, phone number, address, gender, and a concealed password. The clock-out sheet depicted in Figure 11 records the time employees exit after completing their tasks. The recording mechanism functions akin to the clock-in page by employing automatic location tracking, designating the attendance location type, and incorporating remarks and photographic evidence.

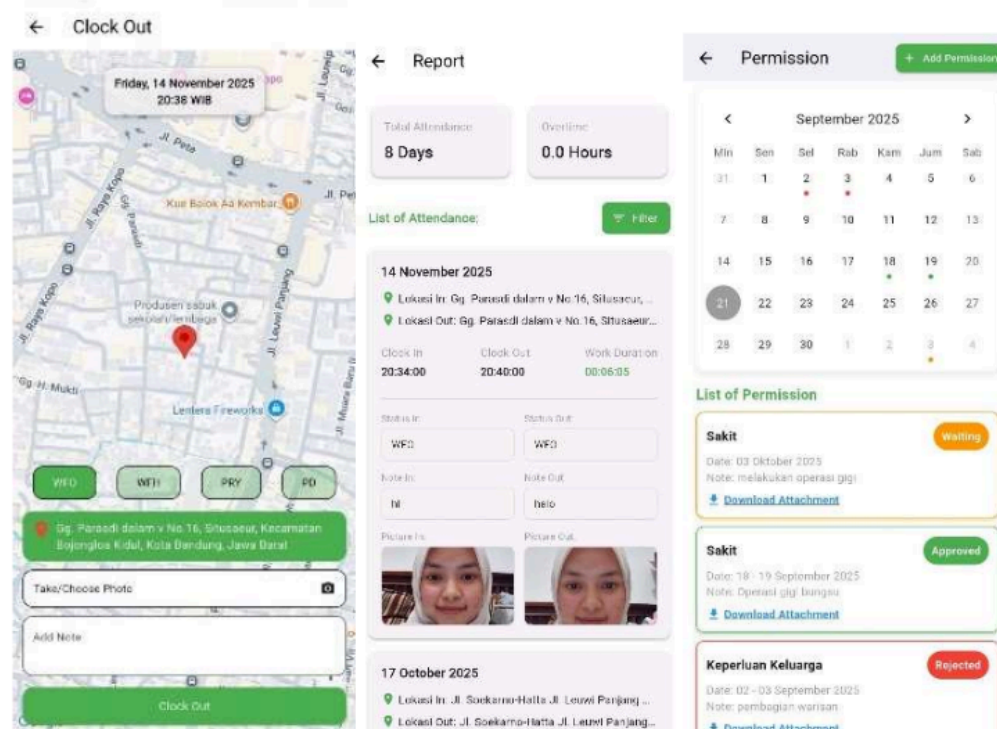


Figure 9. Clock Out Page, Report Page and Permission Page

Figure 9 displays a summary of employee attendance data for a designated timeframe. This information is presented in a clear, comprehensible list. The permission page shown in Figure 9 allows employees to view the status of their submitted leave requests. The documented leave data may encompass remote work, corporate travel, medical leave, family obligations, and diverse leave categories.

Implementation of the HR Management Website User Interface, Figure 14 shows the dashboard page, which serves as the system's homepage and provides a detailed overview of attendance statistics. This page presents numerous essential indicators, including the total personnel count, today's cumulative attendance, and information on absenteeism or leave requests, displayed numerically and graphically.

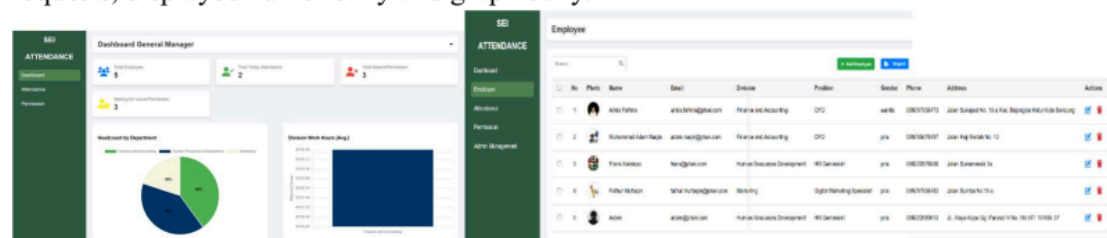


Figure 10. Dashboard page and Employee Page

The Employee page shown in Figure 10 serves as the primary module for managing employee information. This page displays a table containing a comprehensive list of employees, including name, email, division, position, and additional contact details. Figure 11 presents an attendance page with a comprehensive data table listing employee names, check-in and check-out times, work duration, image views, and attendance status.

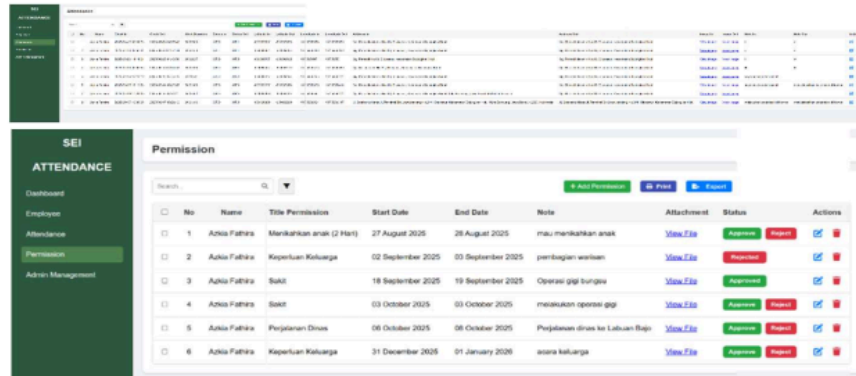


Figure 11. Attendance Page, Permission Page and Admin Management Page

The Permission page depicted in Figure 11 facilitates the management and processing of employee leave requests. The Administrator can access the submission list, review the details, and approve or reject submissions. The Admin Management page shown in Figure 11 is specifically designed for administering Administrator accounts and their associated access levels within the system. This site enables the primary Administrator to create, alter, and remove other Administrator accounts, in addition to overseeing their duties and access permissions.

Test Results, System Testing Using White-box, this research employs the basic path testing technique to verify that every statement, condition, and procedure inside the Clock In feature of the employee attendance system operates in accordance with the defined criteria and specifications.

Clock In Page Program Listing, this research employs the basic path testing technique to verify that every statement, condition, and procedure inside the Clock In feature of the employee attendance system operates in accordance with the defined criteria and specifications.

```
public function clockIn(Request $request)
{
    $request->validate([
        'status_in' => 'required|string',
        'latitude_in' => 'required',
        'longitude_in' => 'required',
        'address_in' => 'required|string',
        'photo_in' => 'required|image|max:2048',
    ]);
    $path = $request->file('photo_in')->store('attendance_photos', 'public');
    $fullUrl = asset('storage/' . $path);

    $attendance = Attendance::create([
        'user_id' => Auth::id(),
        'clock_in_time' => now(),
        'status_in' => $request->status_in,
        'note_in' => $request->note_in,
        'latitude_in' => $request->latitude_in,
        'longitude_in' => $request->longitude_in,
        'address_in' => $request->address_in,
        'photo_in' => $fullUrl,
    ]);

    return response()->json([
        'message' => 'Clock-in berhasil',
        'data' => [
            'id' => $attendance->id,
            'status_in' => $attendance->status_in,
            'note_in' => $attendance->note_in,
            'latitude_in' => $attendance->latitude_in,
            'longitude_in' => $attendance->longitude_in,
            'address_in' => $attendance->address_in,
            'clock_in_time' => $attendance->clock_in_time,
            'photo_in' => $attendance->photo_in ?
                asset('storage/' . $attendance->photo_in) : null,
        ]
    ]);
}
```

The aforementioned source code aligns with the business process flow depicted in flowcharts and flowgraphs, particularly for data validation, photo storage, and attendance outcome documentation.

Clock In Page Program Flowchart, the Clock In page flowchart depicts the logical flow of the Clock In process from start to finish.

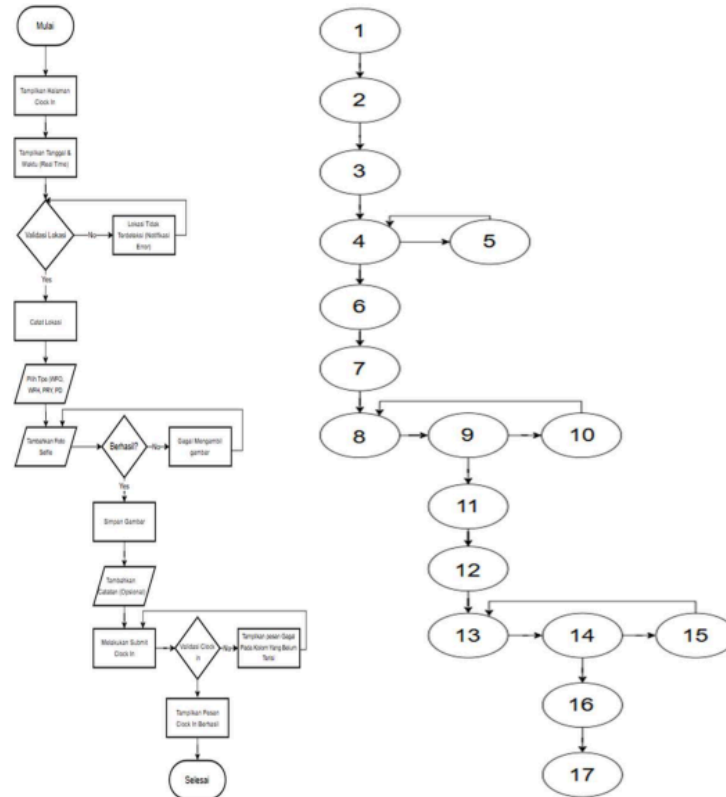


Figure 12. Clock In Page Flowchart and Clock In Page Flowgraph

The validation outcomes depicted in Figure 18 indicate whether the data will be stored in the database or returned as an error due to incomplete required fields. Clock In Page Program Flowgraph, Flowgraphs are constructed from flowcharts by delineating nodes and edges that signify the program's execution flow.

System Testing Using Black-box, this methodology emphasizes evaluating inputs and outputs to verify that the software functions in accordance with the defined specifications. This research employs Black-Box Testing across multiple components of the Employee Attendance Application and the HR Management Website.

Black-box Testing on Employee Mobile Attendance Application, the methodology, illustrated in Table 2, focuses on verifying the software's external behavior to confirm that each function, including recording clock-in and clock-out times and ascertaining locations, performs in accordance with the functional requirements, without requiring an examination of the internal architecture or source code.

Table 2. Black-box Testing on the Employee Mobile Attendance Application

Test Components	Testing Scenario	Expected results	Results
Log In Page	Enter a valid email and password then click the login button	The system successfully redirects the user to the login page.	In accordance
	Entering wrong email or password/empty input	The system rejects authentication and displays an incorrect email/password message. It also displays that the email and password fields are required.	In accordance
	Performing the First Login on Device A (user device)	The system successfully redirects to the main page and records the Device ID of device A into the database.	In accordance
	Try logging in on Device B (different device) using an account already registered on Device A.	The system rejects the login attempt by displaying the message “This account is already bound to another device”	In accordance
Main Menu Page	User successfully logged in and the main page opens.	Displays the main page according to user data	In accordance
	Select the navigation menu	The system will open the selected page without any error.	In accordance
Profile Page	Select edit profile	Opens the edit page so the user can update the data.	In accordance
	Change profile data then save	Updating data in the database and displaying a success notification	In accordance
	Clear the required fields and save	Displays a validation message that the field is required.	In accordance
	Select logout	Ends the user session and redirects to the login page	In accordance
Clock In and Clock Out Pages	Clock in with valid	Save attendance data and display the main page	In accordance
	Perform valid clock out	Save attendance data and display the main page	In accordance

Test Components	Testing Scenario	Expected results	Results
	Location not detected or error	Displays message failed to fetch location	3 In accordance
	Can't take selfie	Displays message failed to take picture	In accordance
	Upload photos without any faces detected	Displays face not detected message	In accordance
	Clearing required fields	Displays a validation message that a mandatory field must be filled in.	In accordance
Report Page	Selecting a date period	Displays attendance reports according to the selected period	In accordance
	Compare report results with database	Data in the application is consistent with data in the database	In accordance
Permission Page	Adding new permissions	Saving new permit/leave data	In accordance
	Checking permit/leave details	Displays data according to what was requested when adding permission and also sees the status according to the data: waiting, approved, rejected	In accordance

Black-box Testing on HR Management Website, the methodology presented in Table 3 emphasizes evaluating the software's external functionality, encompassing workflow verification, module integration, and output data precision. This guarantees that the system functions properly and meets the organization's managerial requirements.

Table 3. Black-box Testing on the HR Management Website

Test Components	Testing Scenario	Expected results	Results
Log In Page	Enter a valid email and password then click the login button	Displaying the dashboard page	In accordance
	Enter wrong email/password then click login	Displays validation error message	In accordance
	Did not fill in one of the required fields	Reject and display validation error message	In accordance

Test Components	Testing Scenario	Expected results	Results
Dashboard Page	Check the data displayed on the summary chart and graph.	Displays appropriate data and displays correct proportions	In accordance
	Access the navigation menu on the left side	Each menu successfully redirects to the appropriate page without any errors.	In accordance
Employee Page	Enter keywords into the search bar	Displays employee data from search results that match keywords	In accordance
	Access add employee and fill out all forms with valid data	New employee data has been successfully added to the table and database.	In accordance
	Make edits to one of the employee data	Data changes are successfully saved and the table is updated.	In accordance
	Perform deletion on one of the employee data	Data successfully deleted from table and database	In accordance
	Export employee data selected in the checkbox column	Generate employee data export file	In accordance
Attendance Page	Enter keywords into the search bar and filter	Displays employee attendance data from search results that match keywords and match filter selection.	In accordance
	Access add attendance and fill out all forms with valid data.	Employee attendance data has been successfully added to the table and database.	In accordance
	Make edits to one of the employee attendance data	Data changes were successfully saved and the table was updated.	In accordance
	Deleting one of the employee attendance data	Data successfully deleted from table and database	In accordance
	Export and Print employee attendance data selected in the checkbox column	Generate employee attendance data export file	In accordance
Permission Page	Enter keywords into the search bar and filter	Displays employee leave/permit application data based on search results that match keywords and filter selection.	In accordance
	Access add permission and fill all forms with valid data	Employee leave/permit application data has been successfully added to the table and database.	In accordance
	Make edits to one of the employee's leave/permit application data	Data changes were successfully saved and the table was updated.	In accordance
	Deleting one of the employee's leave/permit application data	Data successfully deleted from table and database	In accordance
	Export and Print employee leave/permit application	Generate employee attendance data export file	In accordance

Test Components	Testing Scenario	Expected results	6 Results
Admin Management Page	data selected in the checkbox column Selecting the approval status for one of the employee's leave/permit application data	The status changes according to the choice	In accordance
	Enter keywords into the search bar	Displays Admin data search results that match keywords	In accordance
	Access add Admin and fill all forms with valid data	Admin data successfully added into table and database	In accordance
	Make edits to one of the admin data	Data changes were successfully saved and the table was updated.	In accordance
	Perform deletion on one of the admin data	Data successfully deleted from table and database	In accordance

CONCLUSION AND RECOMMENDATION

This study effectively developed and implemented a GPS-based employee attendance system at a solar power production company to address the shortcomings of the previously used traditional attendance systems. The development process employed a Rapid Application Development (RAD) methodology, enabling rapid, adaptable development of the system to meet user requirements in the field. This program enables real-time attendance recording with automatic location verification, hence improving accuracy and reducing the risk of attendance data fraud.

A device-binding feature has been developed to maintain layered data integrity by associating users with their registered devices, effectively preventing proxy attendance. The integration of the mobile application with the HR Management Website enhances the efficiency of employee data management, streamlines monitoring processes. It facilitates digital transformation in human resource management, particularly for employees with significant mobility across diverse project locations.

To ensure the system remains relevant to the company's future requirements, ongoing upgrades and enhancements are essential, encompassing interface changes to improve responsiveness and security, as well as the integration of additional functionalities such as task management, payroll, and automated user notifications. In the long term, development may focus on applying machine learning to analyze attendance trends, integrating systems with other business units within PT Len Industri, and evaluating scalability to ensure the system's performance remains consistent as data volumes increase. This GPS-based attendance system aims to lay a robust foundation for a more efficient, transparent, and sustainable digital HR ecosystem within the solar power generation company.

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