GPS-Based Digital Business Technology Innovation in Community Health Centers: Application Development for Health Staff Performance Management

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ABSTRACT

Attendance management in community health centers (Puskesmas) often relies on manual procedures that are prone to inaccuracy, limited traceability, and weak verification mechanisms, particularly for staff performing field-based duties. These limitations hinder the effectiveness of performance monitoring and reduce administrative efficiency. This study aims to develop a GPS-based digital attendance system designed to enhance accuracy, accountability, and transparency in monitoring employee presence at Puskesmas Mantup. The research methodology comprises four stages: Observation to identify operational constraints; Planning and Analysis to formulate functional and non-functional requirements; System Design to model data structures, user interfaces, and workflow diagrams; and Implementation to develop the application using web technologies integrated with geolocation services. System functionality was validated through Blackbox Testing to ensure reliability across key processes, including login authentication, location validation, shift scheduling, and automated recording of attendance events. The results indicate that the system successfully performs real-time GPS verification, prevents false check-ins outside the designated radius, and supports both shift and non-shift attendance schemes. Additionally, the dashboard and reporting features provide comprehensive visibility for administrators in evaluating employee performance. Overall, the GPS-based attendance system substantially improves monitoring accuracy and operational efficiency, offering a scalable solution for adoption in primary healthcare settings.

1. Introduction

In the ongoing era of digital transformation, public service institutions are increasingly required to adopt technological innovations to enhance efficiency, transparency, and accountability. Attendance management represents a critical component of organizational governance, particularly within primary healthcare facilities such as community health centers (Puskesmas) [1]. The discipline and attendance of health personnel strongly influence service quality. Nevertheless, manual or signature-based attendance systems remain widely used, despite being vulnerable to manipulation, lacking transparency, and limiting real-time data processing capabilities [2]. At Puskesmas Mantup, the absence of an advanced attendance system hinders optimal staff performance, particularly in supporting data-driven reporting and evaluation. This condition highlights the need for a technology-based solution capable of delivering effective and sustainable improvements.

As service demands grow more complex and reporting requirements rely increasingly on performance indicators, conventional attendance mechanisms have become inadequate for modern healthcare management. Unmonitored absenteeism disrupts service continuity and reduces patient satisfaction, creating challenges for management in supervising staff discipline, especially for personnel with high mobility such as health promotion officers and field workers [3]. The implementation of a GPS-based digital attendance system via mobile devices offers a promising alternative. Such technology enables automatic attendance recording based on actual geolocation, thereby reducing opportunities for fraudulent reporting and providing valid, real-time data inputs [4].

Beyond attendance tracking, GPS-based digital systems can be integrated with performance management, workload analysis, and administrative reporting. This aligns with the broader development of e-Government and smart public services, in which digitalization functions not only as an efficiency driver but also as a foundation for data-driven policy development [5]. In the long term, GPS-based systems contribute both administrative and strategic value by supporting human resource planning and comprehensive quality assessments of healthcare services [6]. The development of a GPS-based digital attendance application for Puskesmas Mantup thus represents a strategic effort to modernize workforce management and strengthen transparent, accountable organizational governance [7].

Key issues identified include limited transparency in attendance data, challenges in monitoring field-based activities, and the absence of an integrated digital system supporting comprehensive performance management. However, the widespread use of smartphones among Puskesmas staff presents an opportunity to implement GPS-based attendance without requiring substantial investment in specialized hardware such as fingerprint scanners. Location-based digital attendance systems have demonstrated improved accuracy and significant reductions in fictitious attendance practices within various public service institutions, suggesting similar applicability at the community health center level [8].

From both theoretical and practical perspectives, the development of a GPS-enabled attendance information system is consistent with digitalization trends in public services and health management information systems (HMIS/SIMKES). Digital human resource management systems in healthcare organizations directly enhance operational efficiency and organizational effectiveness [9]. Within the broader context of digital business, such applications function not only as operational tools but also as components of analytical data systems that support evidence-based decision-making. Integration with performance evaluation mechanisms and Key Performance Indicators (KPIs) further reinforces the relevance of GPS-based attendance technology in health workforce management [10].

This study aims to design and develop a GPS-based digital attendance application tailored to the operational context of Puskesmas Mantup and intended to support the performance management of health personnel. The system will be evaluated in terms of functionality, security, usability, and its contribution to enhancing transparency and accountability in attendance reporting. The results are expected to serve as a reference model for implementing smart attendance systems in primary healthcare services, particularly in non-urban regions.

The novelty of this research lies in the development of a lightweight, mobile-based GPS attendance application specifically adapted to the operational characteristics of Puskesmas. The system can be further expanded to integrate performance management and healthcare service reporting. Unlike previous studies predominantly focused on educational or corporate environments [11], this research emphasizes real-world implementation within regional healthcare services, thereby contributing to the acceleration of digital transformation in public sector institutions that have traditionally been underserved by digital innovation initiatives.

2. Method

2.1. Observation

The research began with a direct observation of the attendance management practices at Puskesmas Mantup. This stage aimed to identify existing workflow patterns, challenges in the manual attendance process, and operational needs related to staff mobility. Observations focused on attendance recording methods, administrative procedures, and the limitations encountered in monitoring field personnel. The findings from this step served as the primary foundation for determining the system requirements of the GPS-based attendance website.

2.2. Planning and Analysis

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2.3. Planning and Design

This stage involved the architectural and interface design of the GPS-based attendance website. The researcher created system models such as use case diagrams, activity diagrams, flowcharts, and database schemas to outline system functionality and data flow. In addition, User Interface (UI) and User Experience (UX) prototypes were developed to provide a clear visualization of the website layout, navigation structure, and key features. The design process emphasized usability, mobile responsiveness, and integration with geolocation services to support field staff activities. All design outputs acted as blueprints for the implementation phase.

2.4. Implementation

The implementation phase consisted of building the GPS-based attendance website according to the approved system design. The development used web technologies (HTML, CSS, JavaScript) combined with a backend framework and GPS geolocation APIs to enable real-time location-based attendance submission. Features implemented included user login, geolocation-based attendance capture, attendance history display, and an admin dashboard for monitoring and reporting. System testing using Blackbox Testing was conducted to validate functional accuracy and ensure that the website operated reliably across various devices. After testing, the system was deployed for pilot use by Puskesmas Mantup staff to gather feedback for further refinement.

3. Results and Discussion

This section presents the findings obtained from each stage of the research process, which consisted of Observation, Planning and Analysis, Planning and Design, and Implementation [12]. The results illustrate how the system was conceptualized, developed, and evaluated based on empirical data collected from Puskesmas Mantup. Each stage contributes directly to the formulation of a GPS-based digital attendance website designed to address operational challenges related to staff mobility, attendance accuracy, and transparency. The discussion further elaborates on the significance of these findings by linking them to theoretical perspectives on digital transformation in public healthcare services and evaluating the system's effectiveness in improving attendance management. Through this integrated analysis, the Result and Discussion section provides a comprehensive explanation of how the proposed system meets user needs, resolves identified issues, and demonstrates potential for broader application within primary healthcare environments.

3.1 Observation

The observation phase revealed several critical issues in the existing attendance workflow at Puskesmas Mantup. Attendance was recorded manually using physical logbooks and signature-based verification. This method was prone to inaccuracies, manipulation, and time delays in administrative processing. Additionally, field staff such as health promotion officers and community outreach workers experienced difficulties in recording their attendance due to their mobility requirements. These findings confirmed the urgency of implementing a digital attendance system capable of real-time monitoring and location-based verification. This stage highlights that manual attendance mechanisms are no longer adequate for modern healthcare settings. They lack transparency, real-time reporting, and reliability issues commonly addressed through digital transformation initiatives in public service sectors. The identified problems justify the development of a GPS-based attendance website that offers automated, accurate, and location-validated attendance recording.

3.2 Planning and Analysis

In this stage, an analysis of user requirements was conducted based on the operational workflows at Puskesmas Mantup. The identified needs include: (1) Health staff must log in using their registered username and password to ensure secure access, (2) Staff members can record their attendance using GPS-based location validation and view their attendance history, (3) Administrators have full access rights to manage system data, including adding, updating, and deleting attendance records, user accounts, and location settings.

The software used in the development of the website includes Windows 10 as the operating system, XAMPP v3.2.3 as the local web server, a web browser such as Google Chrome or Microsoft Edge for interface testing, Microsoft Visio for system modeling, Sublime Text as the code editor, and a PHP framework such as CodeIgniter for backend development. The hardware specifications utilized in designing the website include a computer or laptop equipped with an Intel Core i5 processor and 2GB of RAM.

The primary system requirements consist of functional and informational components. Functional requirements encompass the features that must be present in the GPS-based attendance system for Puskesmas Mantup, such as login authentication, location-based attendance submission, and administrative monitoring. Meanwhile, informational requirements describe the necessary data elements that support system functionality, including user data, geolocation coordinates, attendance records, and reporting outputs.

Table 1. Functional Requirement

No	Functional Requirement	Description
1	Employee Data Management	Admin can add, edit, and delete employee data.
2	Shift & Non-Shift Scheduling	Admin can set attendance schedules for employees, including shift and non-shift arrangements.
3	GPS-Based Automatic Attendance	The system records employee attendance automatically based on GPS location.
4	Location Coordinate Validation	Attendance can only be submitted if the employee is within the coordinates specified by the admin.
5	Employee Attendance Reports	The app provides attendance reports that the admin can view.
6	User Authentication (Login)	Employees must log in before using the attendance features.
7	Attendance History	The app stores and displays the employee's attendance history.
8	Encrypted Data Transmission	Attendance data, including GPS location, is encrypted during transmission.

The non-functional requirements of the GPS-based attendance application emphasize security, stability, and user privacy. The system ensures that all transmitted data, including location information, is encrypted to protect user confidentiality. In line with its privacy policy, the application does not share any data with third parties and does not provide a mechanism for data deletion. To support accurate attendance validation, the application requires reliable GPS access and must consistently capture real-time location data. Additionally, the system is designed to run smoothly on Android devices, ensuring stable performance during location retrieval and attendance submission.

Table 2. Non-Functional Requirement

No	Non-Functional Requirement	Description
1	Data Privacy (No data shared)	The app does not share any user data with third parties.
2	Data Security (Encrypted in transit)	All transmitted data is encrypted to ensure security.
3	No Data Deletion Provided	The developer does not offer a data deletion mechanism.
4	Android Device Compatibility	The app operates on Android devices according to Play Store requirements.
5	Location Access	The app requires accurate GPS access for attendance functionality.
6	Real-Time Location Accuracy	The system must accurately capture real-time location for valid attendance.
7	Stable Performance	The app must be able to retrieve GPS data and submit attendance without delays.

3.3 Planning and Design

a. Use case

The image 1 above presents a *Use Case Diagram* of the GPS-Based Attendance Website**,** which is designed to support location-based attendance recording within the Puskesmas environment. This diagram illustrates the interactions between the two main actors, *Administrator* and *Staff,* and the various functions provided by the system. Through this model, it becomes clear how each role utilizes system features, starting from managing employee data, setting shift and non-shift schedules, defining GPS coordinates, to performing GPS-based attendance.

The diagram also provides a comprehensive overview of the system workflow, including user authentication, attendance submission by staff based on GPS location, and the administrator's ability to review attendance history and generate reports. By visualizing these relationships and processes, the system development becomes more structured, as user needs and system functionalities are clearly identified.

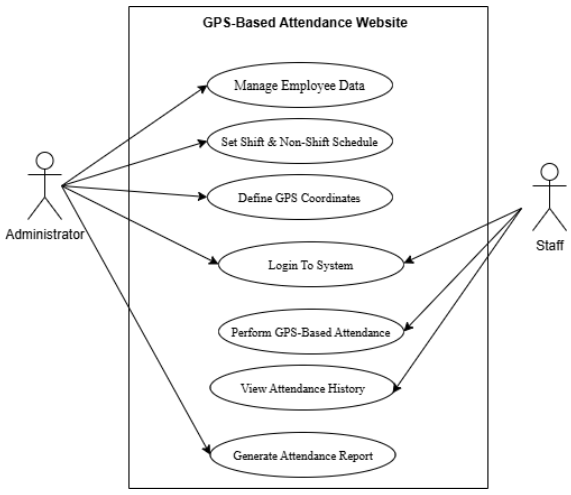

Fig 1. Use Case

Table 3. Use Case Description

No	Use Case	Actor	Goal	Description	Precondition	Postcondition
1	Manage Employee Data	Admin	To manage employee information	Admin adds, edits, or deletes employee data to ensure all staff are registered for GPS attendance.	Admin is logged in.	Employee data is updated in the system.
2	Set Shift & Non-Shift Schedule	Admin	To define working hours	Admin configures staff schedules to ensure attendance is recorded according to their assigned work periods.	Employee data exists.	The schedule is stored and applied during attendance validation.
3	Define GPS Coordinates	Admin	To set allowed attendance location	Admin sets the allowed GPS coordinate radius for validating staff attendance.	Admin is logged in.	GPS coordinate rules are saved for real-time validation.
4	Login to System	Staff dan Admin	To access the attendance system	Staff enter their username and password to authenticate before using the attendance features.	Staff has an active account.	Staff gains access to the system dashboard.
5	Perform GPS-Based Attendance	Staff	To record attendance based on location	Staff initiate attendance, system checks GPS location, and records check-in/out if within allowed area.	Staff is logged in and GPS is enabled.	Attendance is recorded with timestamp and location.
6	View Attendance History	Staff	To view past attendance	Staff view their recorded attendance data including check-in/out times and GPS validation.	Attendance data exists.	Attendance history is displayed.
7	Generate Attendance Report	Admin	To evaluate attendance	Admin views attendance reports for monitoring staff performance and discipline.	Attendance data exists.	Attendance reports are generated and displayed.

b. ERD

The diagram in Image 2 below presents the database schema designed to support the GPS-Based Attendance System implemented at Puskesmas Mantup. This schema illustrates the structure, relationships, and key attributes of all entities involved in managing employee attendance across shift, non-shift, and meeting (rapat) categories. Each table is organized to ensure accurate recording of check-in and check-out times, GPS-based location validation, token generation for different attendance types, and administrative management of employees, schedules, and attendance locations. The diagram also demonstrates how the system integrates various components such as employee data, attendance records, location settings, and scheduling rules into a cohesive and efficient data management framework essential for ensuring reliable and transparent digital attendance operations.

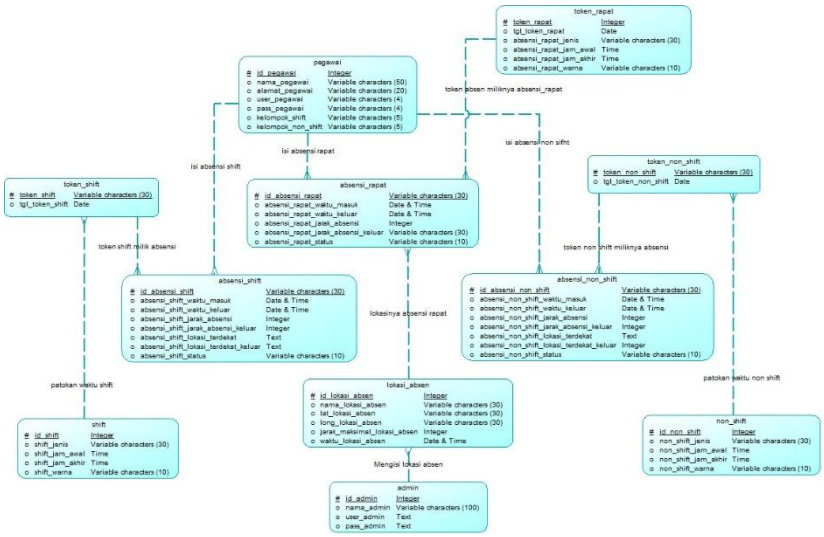

Fig 2. ERD

3.4 Implementation

The implementation phase involved the systematic realization of the system design into a functional GPS-based attendance application tailored for Puskesmas Mantup. This stage emphasized the integration of geolocation services, user authentication mechanisms, and attendance management features to ensure operational reliability and accuracy.

Fig 3. Login System

The first component implemented was the authentication module**,** which provides a secure login interface requiring staff to enter their registered username and password. This mechanism ensures controlled system access and establishes the initial validation layer for all subsequent attendance processes.

Fig 4. Dashboard

Upon successful authentication, users are directed to the main dashboard, which displays synchronized server time, the current date, and individualized attendance status. The dashboard also presents shift and non-shift scheduling information, enabling staff to identify their assigned working periods immediately. The system concurrently retrieves the user's geolocation data in real time and performs coordinate matching against predefined Puskesmas Mantup GPS points to validate eligibility for attendance recording.

Further implementation included the attendance recap module, where monthly attendance data are visualized in a calendar-based interface. This module presents detailed shift information, attendance logs, and automated indicators for late, absent, or invalid entries, facilitating transparent performance monitoring for both staff and administrators.

Fig 5. Attendance Recap

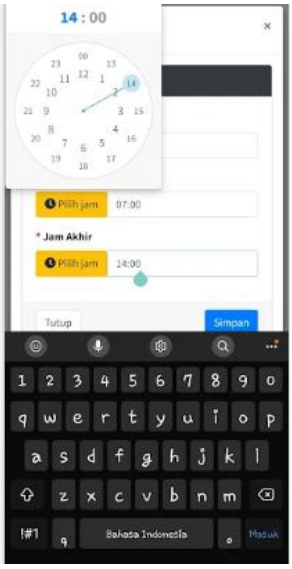

Fig 6. Time-selection Tool

The GPS update feature was also operationalized using Google Maps services, allowing users to request a real-time location refresh before performing check-in or check-out actions. This ensures that attendance data are recorded with optimal spatial accuracy, minimizing discrepancies due to delayed location retrieval.

Additionally, a time configuration interface was developed to support administrators in defining shift parameters. This interface includes an interactive time-selection tool that enables precise determination of start and end times for each shift category, thereby supporting accurate schedule enforcement within the system.

Overall, the implementation phase successfully translated the analytical and design specifications into a cohesive and reliable mobile application. The resulting system provides an efficient, accurate, and user-oriented platform for GPS-based attendance management at Puskesmas Mantup.

3.5 Black Box Testing

Blackbox Testing was performed to validate the functional accuracy and reliability of the GPS-based attendance system developed for Puskesmas Mantup. This testing method focuses on evaluating system outputs based on specific inputs without examining the internal code structure [13]. The goal is to ensure that every feature operates in accordance with predefined functional requirements and meets user expectations in real-world use [14]. The testing scenarios covered critical components of the system, including authentication, GPS validation, attendance submission, schedule recognition, and data visualization. Each test case was executed on multiple Android devices to evaluate system stability and responsiveness across different hardware specifications [15].

Table 4. Black Box Testing

No	Test Scenario	Test Steps	Expected Output	Actual Result	Status
1	Login Authentication	Enter valid username and password	User successfully logs in and enters dashboard	Successfully logged in	Passed
2	Login with invalid credentials	Enter incorrect username or password	System displays "Invalid Login" notification	Notification displayed	Passed
3	GPS Activation Check	Attempt to open attendance page with GPS disabled	System displays prompt "Enable GPS"	Prompt displayed	Passed
4	GPS Coordinate Validation	User attempts to check-in outside allowed radius	System rejects attendance and displays warning	Attendance rejected	Passed
5	GPS Coordinate Validation (Inside Radius)	User performs attendance within allowed coordinates	System records attendance with timestamp & live GPS	Successfully recorded	Passed
6	Check-in Submission	User taps "Check-in" button	System stores check-in time & GPS location	Data stored in database	Passed
7	Check-out Submission	User taps "Check-out" button	System stores check-out time & GPS location	Data stored in database	Passed
8	Shift Schedule Detection	User attempts attendance outside shift hours	System displays warning "Not within shift time"	Warning displayed	Passed
9	Attendance History Display	User opens monthly attendance recap	System loads calendar view and attendance logs	Logs displayed correctly	Passed
10	Admin – Employee Management	Admin adds, edits, deletes employee data	Changes saved in database	All functions work as expected	Passed
11	Admin – Schedule Management	Admin configures shift/non-shift schedules	Updated schedules applied to validation rules	Schedules updated	Passed
12	Admin – Attendance Report	Admin opens attendance report module	System generates daily/monthly reports	Reports load correctly	Passed
13	GPS Refresh Feature	User taps "Update Location" button	Google Maps retrieves latest coordinates	Location updated smoothly	Passed
14	Data Encryption Validation	Simulate data transmission	GPS & attendance data encrypted in transit	Encryption verified	Passed

4. Conclusion

The study demonstrated the successful design and implementation of a GPS-based attendance system to improve staff performance management at Puskesmas Mantup. By following systematic stages of observation, planning, analysis, and system development, the application effectively addressed problems in manual attendance recording, location validation, and shift scheduling.

The resulting system integrates secure authentication, real-time geolocation checks, automated attendance validation, and clear attendance history displays. GPS enforcement ensures staff can only check in within authorized coordinates, improving accuracy and preventing fraud. Overall, the system provides a reliable and efficient platform for monitoring staff attendance, with future potential for analytics, payroll integration, and expanded cross-platform support.

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