

Development of a GPS-Based Digital Attendance System with Attendance Validation in a Learning Management System using the Rapid Application Development Method (Case Study: Digitech University)

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Abstract

Digital attendance systems that still rely on manual confirmation have the potential to cause inaccuracies in attendance data and open the door to fraud. This study aims to develop a GPS geofencing-based digital attendance system using the Rapid Application Development (RAD) method within the Digitech University Learning Management System (LMS). The research method used is descriptive, with a system development approach following the RAD stages. The system was developed as a web-based prototype with a multi-factor validation mechanism to verify student attendance based on location and time. Test results show that the digital attendance system improves the accuracy of attendance records, reduces the potential for fraud, and enhances the efficiency of the attendance process for both faculty and students.

Keywords: Digital Attendance, GPS Geofencing, RAD, LMS.

1. Introduction

Advances in information technology have driven digital transformation across various sectors, including higher education. One example of this is the use of Learning Management Systems (LMS), which support the learning process, assignment management, and digital tracking of student attendance. The use of LMS simplifies the management of academic activities because all processes can be carried out in an integrated manner on a single platform. Digitech University has implemented an LMS to support academic activities, including a student attendance feature. However, the attendance system currently in use relies solely on attendance confirmation without a mechanism to validate the user's location. This situation allows students to check in even when they are outside the campus area, which could lead to inaccuracies in attendance data and attendance fraud. In addition to lacking location validation, the current system does not yet provide a feature for uploading proof of leave or sick status, nor does it fully support optimal attendance monitoring by instructors. These issues highlight the need to develop an attendance system capable of verifying student attendance more accurately and in an integrated manner. One technology that can be applied to address this issue is GPS geofencing. This technology enables the system to validate a user's location based on their geographic coordinates relative to a predetermined area. In this study, location validation was performed using the user's device GPS, and distance was calculated using the Haversine algorithm to ensure that students were within the campus radius when checking in. Based on these issues, this study aims to develop a GPS geofencing-based digital attendance system integrated with a Learning Management System using the Rapid Application Development (RAD) method. The developed system includes location validation, attendance status management, the ability to upload proof of leave and sick leave, and a faculty monitoring dashboard. The results of this study are expected to improve the accuracy of student attendance data and reduce the potential for fraud in the attendance process.

2. Theoretical Review

2.1. Digital Attendance System

A digital attendance system is a system used to electronically record user attendance using information technology. The implementation of a digital attendance system aims to improve the efficiency of the attendance recording process, reduce errors in manual recording, and simplify the management and reporting of attendance data. In an educational setting, a digital attendance system allows instructors and students to take attendance more quickly and in a way that is integrated with the academic system in use.

2.2. Learning Management System

A Learning Management System (LMS) is a technology-based platform used to manage the online learning process. An LMS provides various features that support academic activities, such as the distribution of learning materials, assignment collection, discussion forums, learning assessments, and student attendance tracking. The use of an LMS makes the learning process more flexible and ensures it is well-documented within a single, integrated system.

2.3. GPS Geofencing

GPS geofencing is a technology that uses geographic coordinates to establish virtual boundaries around a specific area. The system can determine whether a user is inside or outside a designated area based on location data obtained from the user's device. In an attendance system, GPS geofencing technology can be used as a location validation mechanism to ensure that users are in the appropriate area when checking in.

2.4. Haversine Algorithm

The Haversine algorithm is a method used to calculate the distance between two coordinate points based on their latitude and longitude values on the Earth's surface. This algorithm is widely used in location-based applications because it can produce fairly accurate distance calculations. In this study, the Haversine algorithm was used to calculate the distance between students' locations and the center of the campus as a basis for validating GPS geofencing-based attendance.

$$\begin{aligned}x &= (\text{lon}2 - \text{lon}1) \cos\left(\frac{\text{lat}1 + \text{lat}2}{2}\right); \\y &= (\text{lat}2 - \text{lat}1); \\d &= \sqrt{(x^2 + y^2)R}\end{aligned}\tag{1}$$

2.5. Rapid Application Development

Rapid Application Development (RAD) is a software development method that emphasizes the speed of system development through a prototyping approach and active user involvement in every stage of development. This method was chosen because it can produce systems in a relatively short time while still addressing user needs. The stages of RAD consist of Requirements Planning, User Design Workshop, Construction, and Cutover.

3. Research Methods

3.1. Research Method

This study employs a descriptive method with a system development approach. The descriptive method is used to describe the current state of the attendance system and to analyze the problems identified prior to developing the new system. This approach was chosen because the study focuses on the design and implementation of a GPS geofencing-based digital attendance system integrated with a Learning Management System (LMS). The research subjects consisted of faculty members and students at Digitech University, who are the primary users of the system. The results of the analysis of the current system were used as the basis for designing a solution tailored to the users' needs.

3.2. Data Collection

Data collection was conducted using two main techniques: direct observation and a documentary study. Observations were made of the attendance process on the Learning Management System (LMS) to understand the system's workflow, the attendance confirmation mechanism, and the weaknesses of the system currently in use. In addition to observation, the study also utilized a documentary approach by collecting data in the form of system screenshots, attendance logs, academic guidelines, and references to previous research related to digital attendance systems. The data obtained was used as the basis for needs analysis and system development.

3.3. System Development Method (RAD)

The system development method used in this study is Rapid Application Development (RAD). This method was chosen because it supports the system development process in a relatively short time through a prototyping approach and actively involves users at every stage of development. RAD is considered suitable for developing a digital attendance system that requires rapid validation and immediate feedback from users. The system development process using the RAD method consists of the following four phases.

3.3.1 Requirements Planning

At this stage, user needs are identified, the weaknesses of the current attendance system are analyzed, and information is gathered through observation and a review of documentation. The results of this stage are used to determine the functional and non-functional requirements of the system to be developed.

3.3.2 User Design Wrokshop

This phase focuses on the system design process using the Unified Modeling Language (UML), which includes Use Case Diagrams, Activity Diagrams, Sequence Diagrams, and Entity-Relationship Diagrams (ERDs). In addition, an interface prototype is created using Figma to gather user feedback before the system is developed.

3.3.3 Contruction

During the development phase, the system was implemented using the Laravel framework for the backend, MySQL as the database, and Tailwind CSS for the frontend. The key features developed include GPS-based geofencing for location validation, attendance status management, uploading proof of permits and sick leave, and a faculty monitoring dashboard.

3.3.4 Cutover

The final stage is system testing and evaluation. Testing is conducted using the black-box testing method to ensure that all features function according to the functional requirements. In addition, the results of the system implementation are evaluated to ensure that the system is capable of supporting the student attendance process more effectively and in an integrated manner.

4. System Design

4.1. Current System Analysis

Based on observations of the attendance system in the Learning Management System (LMS) used at Digitech University, the student attendance process is still conducted through an attendance confirmation mechanism without location validation. Students can check in online as long as the attendance session is open by the instructor, without any verification that they are at the intended class location. In addition, the current system does not yet provide a feature for uploading supporting documentation for leave or sick status. Faculty members also do not yet have access to real-time attendance data that could be used to monitor student attendance more effectively. These conditions could potentially lead to inaccuracies in attendance data and increase the likelihood of attendance fraud. To address these issues, it is necessary to develop an attendance system capable of validating locations, supporting the management of various attendance statuses, and providing an integrated monitoring dashboard.

4.2. Proposed System Analysis

The proposed system is a GPS geofencing-based digital attendance system integrated with a Learning Management System (LMS). This system uses GPS technology to obtain the user's location coordinates and the Haversine algorithm to calculate the user's distance from the center of the campus area. In the developed system, instructors can schedule attendance sessions, set the learning mode (online or offline), and monitor student attendance data through the monitoring dashboard. Students can mark their attendance according to their selected status: present, excused, sick, or late. For excused and sick statuses, the system provides a feature to upload supporting documentation that can be verified by the instructor.

Table 1: shows a comparison between the current system and the proposed system.

Aspek Perbandingan	Sistem Absensi Lama	Sistem Absensi Usulan
Metode Absensi	Konfirmasi manual melalui LMS	Validasi multi-faktor (GPS Geofencing)
Validasi Lokasi	Tidak tersedia	Menggunakan GPS Geofencing untuk memastikan lokasi mahasiswa
Potensi Kecurangan	Tinggi (titip absen, absen dari luar kelas)	Lebih rendah karena membutuhkan lokasi dan validasi bukti
Akurasi Data Kehadiran Dosen	Relatif rendah Dosen perlu verifikasi ulang secara manual	Lebih akurat dan dapat dipertanggungjawabkan Tugas dosen berkurang karena validasi otomatis
Pencatatan Log	Hanya status hadir/tidak hadir	Mencatat waktu, lokasi, bukti dan identitas pengguna
Integrasi Sistem	Terintegrasi dengan LMS	Dirancang untuk terintegrasi dengan LMS

4.3. Use Case Diagram

A Use Case Diagram is used to illustrate the interactions between users and the system. The system involves two main actors: students and faculty members. Students can check in, upload proof of leave or sick leave, and view their attendance history. Instructors can manage attendance sessions, set the learning mode, monitor student attendance data, and view supporting documents uploaded by students.

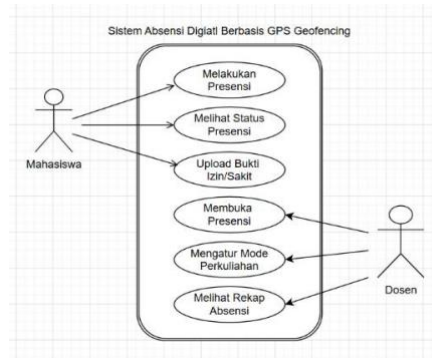


Fig. 1: Use Case Diagram of Attendance System

4.4. Activity Diagram

An activity diagram is used to illustrate the flow of the student attendance process in the developed system. The process begins when a student selects a currently in-progress course; the system then checks the status of the attendance session opened by the instructor.

If the selected learning mode is offline, the system will retrieve the user's GPS coordinates and validate their location by calculating the distance to the campus area. If the location meets the requirements, the attendance data will be saved to the database. Conversely, if the user is outside the specified radius, the system will reject the attendance request.

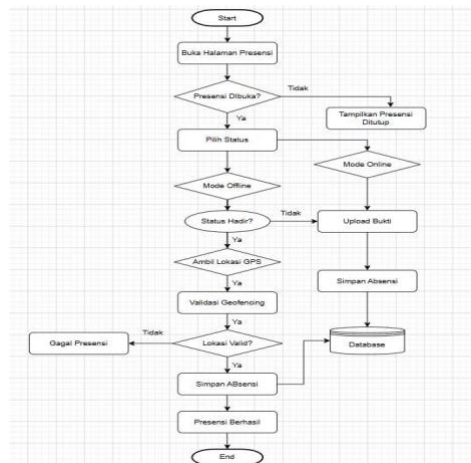


Fig. 2: Attendance Activity Diagram

4.5. Sequence Diagram

The sequence diagram illustrates the interactions between system components during the attendance process. The interaction begins when a student submits an attendance request through the system interface. The system then retrieves the user's location data and sends that information to the server for validation.

The server then calculates the distance using the Haversine algorithm and determines whether the check-in should be accepted or rejected. The validation results are sent back to the user and stored in the database if they meet the specified criteria.

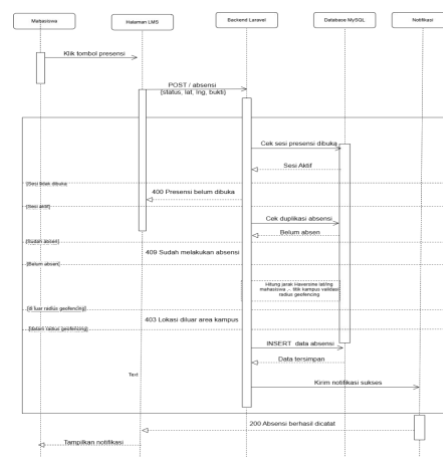


Fig. 3: Attendance Sequence Diagram

4.6. Entity Relationship Diagram (ERD)

An Entity-Relationship Diagram (ERD) is used to depict the database structure used in a system. The database consists of several main entities that are interconnected, namely students, instructors, courses, class sessions, attendance records, and attendance settings. The relationships between entities are designed to support the processes of attendance data management, attendance validation, storage of supporting documents, and monitoring by instructors.

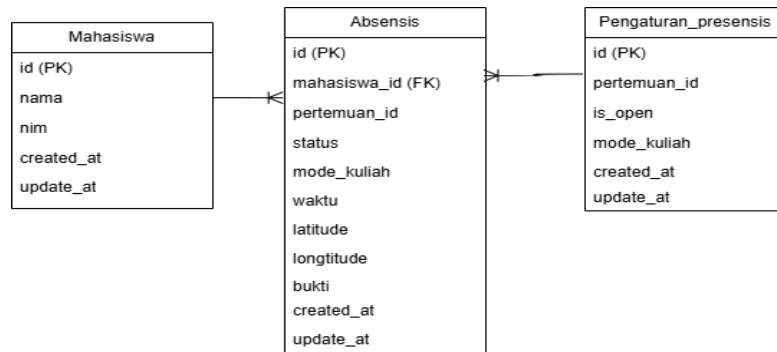


Fig. 4: Entity Relationship Diagram

5. System Implementation

5.1. Lecturer Dashboard

The instructor dashboard serves as a central hub for managing and monitoring student attendance. Through this page, instructors can view a list of the courses they teach, the number of students enrolled in each course, and a summary of student attendance data. The dashboard also provides access to attendance settings and attendance reports, making it easier for instructors to monitor attendance centrally.

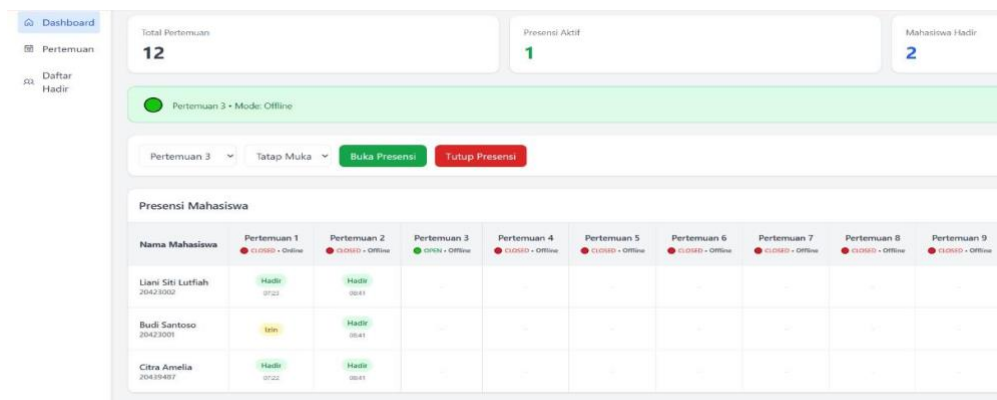


Fig. 5: Lecturer Dashboard

5.2. Attendance Settings

The attendance settings feature is used by instructors to manage attendance for each class session. Through this page, instructors can open or close the attendance session, specify the type of class being held, and configure the validation mechanism used during the attendance process. For in-person (offline) classes, the system will enable GPS geofencing validation to ensure that students are within the designated area. Meanwhile, for online classes, students can check in without going through the location validation process.

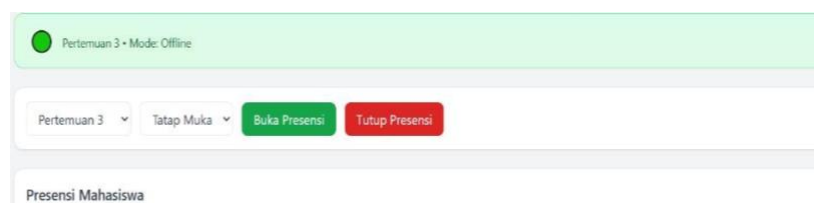


Fig. 6: Attendance Settings

5.3. Student Attendance Page

The student attendance page is used to record attendance for each class session. The system provides several attendance status options, including present, late, excused, and sick. Students can select the appropriate status before submitting their attendance data to the system. Information regarding meetings, courses, and attendance status is displayed in real time, allowing students to ensure that the data they submit corresponds to the class session currently in progress.

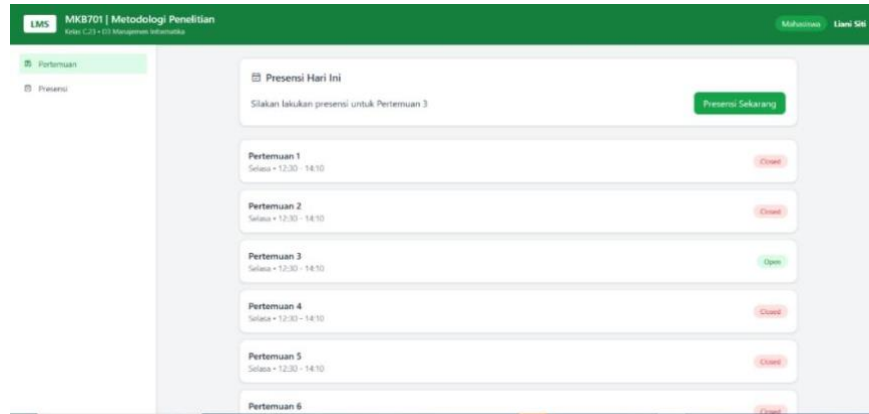


Fig. 7: Student Attendance Page

5.4. GPS Validation Process

Location validation is the main feature developed in this study. When students check in during in-person classes, the system retrieves the user's location coordinates via the GPS service on their device. These coordinates are then sent to the server to calculate the distance using the Haversine algorithm relative to the previously defined center point of the campus area. If the calculated distance falls within the specified geofencing radius, the system will accept the attendance data. Conversely, if the user is outside the permitted area, the system will reject the attendance request and display a notification to the user. The implementation of this mechanism aims to improve the accuracy of attendance data while reducing the potential for attendance fraud.

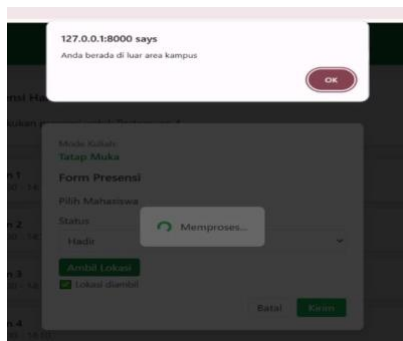


Fig. 8: GPS Validation Process 2

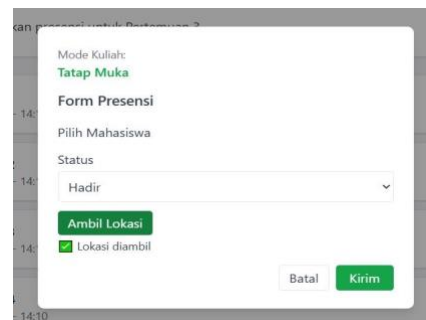


Fig. 9: GPS Validation Process

5.5. Permission/Sick Evidence Upload

To support more flexible attendance management, the system provides a feature that allows students who select “leave of absence” or “sick leave” to upload supporting documents. Through this feature, students can upload documents in the specified format as proof of their absence. Documents that are successfully uploaded will be saved in the system and can be accessed by instructors through the monitoring dashboard. With this feature, the process of verifying student absences can be carried out in a more structured and documented manner.

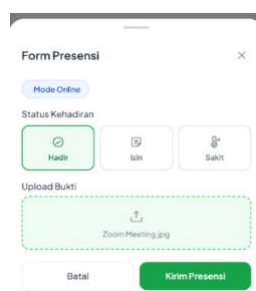


Fig. 10: Permission/Sick Evidence Upload

5.6. Attendance Recapitulation

The attendance summary feature is used to display all student attendance data stored in the system. The data is displayed by course and session, making it easier for instructors to evaluate student attendance throughout the learning process. In addition to displaying students' attendance status, the system also provides information on the time of attendance, the type of attendance, and any supporting documents that have been uploaded. As a result, instructors can monitor and verify attendance data more effectively than with the previous system.

MAHASISWA	P1 ● OPEN Online	P2 ● OPEN Online	P3 ✖ CLOSED Offline	P4 ✖ CLOSED Offline	P5 ✖ CLOSED Offline	P6 ✖ CLOSED Offline
Liani Siti Lutfiah 20423002	Hadir 20:45	Hadir 20:43	---	---	---	---
Budi Santoso 20423001	Hadir 20:44	Sakit Bukti	---	---	---	---
Citra Amelia 20439487	Hadir 20:45	Izin Bukti	---	---	---	---

Fig. 11: Attendance Recapitulation

6. Testing and Discussion

6.1. Blackbox Testing

System testing was conducted using the black-box testing method. This method is used to evaluate system functions based on input and output, without considering the structure of the program code. Testing was conducted on all major features of the developed system, including attendance session management, GPS-based geofencing location validation, uploading of supporting documents, attendance data storage, and monitoring of attendance data by instructors.

Tabel 2: Blackbox Testing Results

No	Fitur yang Diuji	Skenario Pengujian	Hasil yang diharapkan	Hasil Pegujian	Status
1	Membuka Presensi	Membuka Presensi	Membuka Presensi	Membuka Presensi	Membuka Presensi
2	Menutup Presensi	Menutup Presensi	Menutup Presensi	Menutup Presensi	Menutup Presensi
3	Presensi Offline	Presensi Offline	Presensi Offline	Presensi Offline	Presensi Offline
4	Validasi GPS	Validasi GPS	Validasi GPS	Validasi GPS	Validasi GPS
5	Presensi Online	Presensi Online	Presensi Online	Presensi Online	Presensi Online
6	Upload Bukti Izin	Upload Bukti Izin	Upload Bukti Izin	Upload Bukti Izin	Upload Bukti Izin
7	Upload Bukti Sakit	Upload Bukti Sakit	Upload Bukti Sakit	Upload Bukti Sakit	Upload Bukti Sakit
8	Penyimpanan Data	Penyimpanan Data	Penyimpanan Data	Penyimpanan Data	Penyimpanan Data
9	Dashboard Dosen	Dashboard Dosen	Dashboard Dosen	Dashboard Dosen	Dashboard Dosen
10	Status Sudah Absen	Status Sudah Absen	Status Sudah Absen	Status Sudah Absen	Status Sudah Absen

6.2. Testing Results

Based on the results of the testing conducted, all of the system's key features functioned as intended in accordance with the specified functional requirements. The system is capable of managing attendance sessions, validating student locations, storing attendance data, and displaying attendance information in real time on the instructor's dashboard. The GPS geofencing feature successfully restricts attendance checks to designated areas, so students outside the campus radius cannot check in during in-person classes. Additionally, the feature for uploading supporting documents for leave and sick leave requests functions as required by the system.

6.3. Discussion

The results of the implementation show that the GPS geofencing-based digital attendance system is able to improve the student attendance validation process compared to the previous system, which relied solely on attendance confirmation without location verification. The integration of GPS and the Haversine algorithm enables the system to automatically check locations before attendance data is stored in the database.

In addition to improving the accuracy of attendance data, the system also supports the management of various attendance statuses, such as present, late, excused, and sick. The feature for uploading supporting documents helps instructors verify student absences in a more structured manner. The monitoring dashboard also makes it easier for instructors to track student attendance during each session.

However, the system still has some limitations. The accuracy of location validation depends heavily on the quality of the device's GPS and the network conditions used by the user. In addition, the system is still being implemented in a test environment and has not yet been fully integrated with the main academic system. Therefore, further development is needed to improve the system's stability and expand its implementation to a production environment.

7. Conclusion

This study successfully developed a GPS geofencing-based digital attendance system integrated with a Learning Management System (LMS) using the Rapid Application Development (RAD) method. The developed system is capable of validating students' locations using GPS and the Haversine algorithm, enabling more accurate attendance tracking compared to previous systems. In addition, the system also provides features for managing attendance status, uploading supporting documents for leave and sick leave, and a monitoring dashboard that helps instructors manage student attendance data.

Based on the results of black-box testing, all major system features are functioning in accordance with the established functional requirements. The system's implementation demonstrates that the use of GPS geofencing can help reduce potential attendance fraud and improve the validity of student attendance data. For future development, the system can be integrated with the main academic system and enhanced through the implementation of additional validation methods to improve the accuracy and reliability of the attendance process.

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