Implementation of geolocator for location manipulation detection in GPS-based attendance application at watumas clinic

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Abstract. Geolocation-based attendance applications are widely used to enhance accuracy and efficiency in attendance management. However, Fake GPS applications pose challenges to data authenticity. This study developed a mobile attendance application using Geolocator to detect and prevent real-time location manipulation. By utilizing GPS, Wi-Fi, and accelerometer sensors, the system ensures accurate user location. The application was built using the Waterfall model, covering requirements analysis, system design, implementation, testing, and maintenance. Three testing methods were employed: Blackbox Testing for functionality verification, Whitebox Testing to assess the accuracy of the location detection algorithm and sensor integration, and User Acceptance Testing (UAT) to evaluate ease of use and effectiveness. Results show that the application accurately detects location manipulation, produces valid attendance data, and is well-received by users, with satisfaction rates of 90% for ease of use, 85% for response speed, 88% for detection accuracy, and 80% for the effectiveness of Fake GPS detection. This research contributes significantly to the development of safer and more efficient attendance systems, particularly in the Watumas Clinic.

1 Introduction

Geolocation-based attendance applications are increasingly being adopted in various institutions, including education, healthcare, and business sectors, to enhance the efficiency and accuracy of attendance management (1–4). A key technology supporting these systems is the Global Positioning System (GPS), which allows real-time monitoring of users' locations with high accuracy (5–8). However, the rise of Fake GPS applications, which enable location manipulation, poses a serious challenge to GPS-based attendance systems, particularly in ensuring the authenticity of location data (9–12).

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This challenge was also found at the Watumas Clinic. Previously, attendance recording at the Watumas Clinic was done manually using the WhatsApp application to send locations. This method is vulnerable to fraud, and in some cases, clinic employees have been proven to manipulate locations using the Fake GPS application. This incident shows that such manipulation practices are not only possible, but can also damage the integrity of attendance data and cause inaccuracies in the management of medical personnel attendance.

Cases of location manipulation of attendance have also been found in government circles. According to a report from the Baubau City Communication and Information Service in 2024, as many as 588 ASN (State Civil Apparatus) from 183 SKPD (Regional Work Units) in Baubau City, Southeast Sulawesi, Indonesia, were detected using Fake GPS to manipulate attendance data. The ASN involved came from various government agencies in Baubau City, including the Health Service, Education Service, and other agencies. One of the striking cases involved ASN from Bungi District who were recorded as present from 1,484 different coordinate points. The Baubau City Regional General Hospital (RSUD) had the highest percentage of involvement in this manipulation, reaching 6% (13,14). This finding further emphasizes the importance of implementing technology that is able to accurately detect location manipulation and prevent GPS-based attendance fraud.

To address this issue, this study developed a mobile attendance application based on Geolocator, a popular Flutter plugin, to accurately verify users' locations. With Geolocator, the application can ensure the validity of users' locations, improve attendance accuracy, and maintain system reliability. This system is also capable of detecting location manipulation attempts and rejecting invalid attendance submissions (15,16). This technology makes the application more effective in detecting location anomalies that may be manipulated by users (17,18). The mobile application is also designed to be user-friendly and responsive, making it easier for users to perform attendance in the field.

Previous research has attempted to use other technologies, such as Geofence and biometrics, but both have limitations. According to research conducted by D. Kumawat et al., Geofence only works effectively within fixed boundaries and is often inaccurate indoors. Meanwhile, biometric technologies, such as fingerprint or voice recognition, only prevent identity manipulation, not location manipulation (7). Additionally, research by Achmad Oky Efendi introduced Fake GPS detection using Mock Location and Device ID to prevent attendance account misuse across devices. However, the study developed an Android-based attendance app that uses face recognition and location-based services to detect Fake GPS manipulation but lacks a detailed discussion of the plugin used for this detection, an important aspect in ensuring location accuracy (18). As an alternative, Geolocator, supported by the available properties in Geolocator, offers a more flexible and accurate solution for detecting locations, even against manipulation by Fake GPS applications (19).

However, to ensure that this Geolocator system can be implemented with high accuracy and minimize the risk of manipulation, a structured and meticulous system development approach is required. Developing a location-based application, such as an attendance system that utilizes Geolocator, requires high data location integrity and the ability to verify locations in real-time (20,21). For this reason, the Waterfall model was chosen as the development approach, allowing each phase—such as requirements analysis, design, implementation, and testing—to be carried out systematically and comprehensively (15,22,23). With Waterfall, each phase must be fully completed before proceeding to the next, making it highly suitable for applications that demand precision in developing critical features such as location anomaly detection and attendance verification (24).

This study focuses on developing a mobile attendance application based on Geolocator at a clinic in Watumas, Purwokerto, Indonesia, with the primary goal of detecting and preventing location manipulation through Fake GPS. With this application, employee attendance is expected to be more accurate and valid, helping improve clinic management by reducing the risk of location fraud. This implementation is also expected to make a significant contribution to optimizing staff attendance and enhancing service efficiency at the clinic.

2 Methodology

This study employs the Waterfall development model, chosen for its structured and systematic approach. Each phase of development must be completed before moving on to the next phase, making it highly suitable for applications that require a high level of accuracy and validity, such as location-based attendance systems. The phases involved in the development of this system include requirements analysis, system design, implementation, testing, and maintenance.

2.1 Waterfall phases

The development of this application follows the Waterfall model, which consists of several sequential phases. The first phase is Requirements Analysis, where user and system requirements are analyzed to determine the features that the application must include, such as location validation, attendance, and leave requests. Next, during the System Design phase, the application's architecture is designed, including how the user's location data will be processed using Geolocator and a user-friendly interface. After the design is completed, the Implementation phase takes place, where the application is developed according to the design specifications, ensuring that each feature functions properly. The next phase is Testing, where the application is tested both functionally and logically through Blackbox and Whitebox Testing methods to ensure the system works as expected, especially in detecting location manipulation (25). Finally, the Maintenance phase is carried out after the application is deployed, where updates or fixes are made to maintain the performance and security of the application.

The implementation of the Waterfall method in the development of the GPS-based attendance application is illustrated in Figure 1.

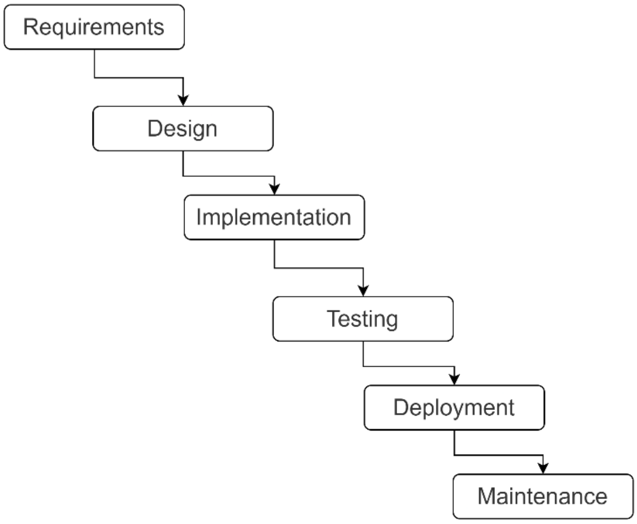

Fig. 1. Waterfall Model for Mobile Attendance Application Development

2.2 Geolocator model in application

This application uses the Geolocator plugin to detect the user's location in real-time. Geolocator allows the system to verify the user's location based on data collected from the mobile device. The system ensures that the location data sent is valid, allowing better verification of the user's attendance. The Geolocator model in the GPS-based attendance application is shown in Figure 2. This technology helps to ensure greater location accuracy, particularly in areas with weak GPS signals, without relying too heavily on a single data source.

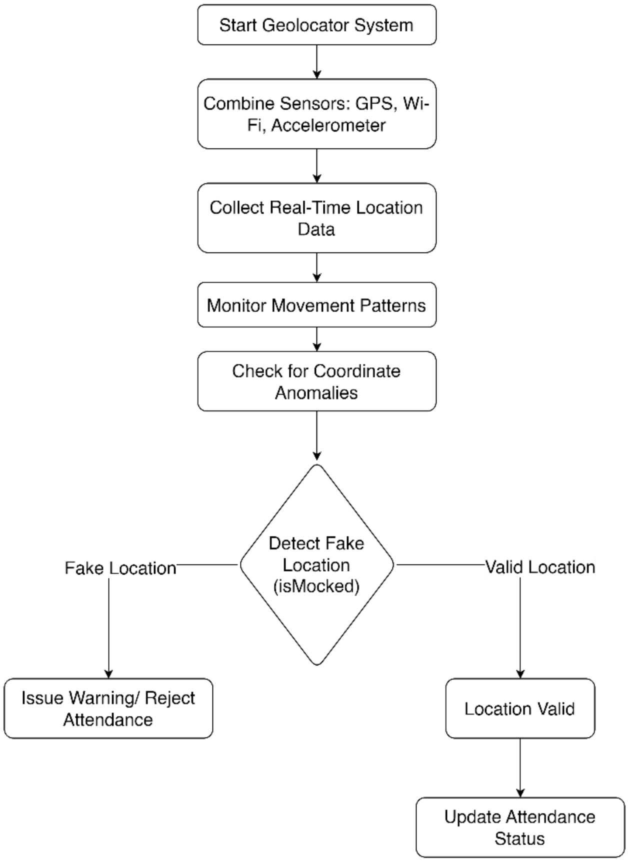

Fig. 2. Geolocator system with location detection and anomaly monitoring

In Figure 2, the system uses Geolocator to detect the user's location by combining data from multiple sensors such as GPS, Wi-Fi, and accelerometer. This process involves monitoring the user's movement patterns and detecting any anomalies in abnormal coordinate changes. The system periodically verifies the consistency and accuracy of the location data. If it detects that the user's location is inconsistent or identifies an anomaly indicating location manipulation (such as the use of Fake GPS), the user's attendance will be rejected or flagged. The system also utilizes the *is Mock*ed property to detect whether the location being used is falsified, in which case the application will reject the attendance.

2.3 Design systems

2.3.1 Use case diagram

The Use Case Diagram illustrates how users and administrators interact with the Geolocator-based attendance application. Users (employees) can perform several main functions, such as logging in, recording attendance (arrival and departure), and submitting leave requests. Administrators are responsible for managing attendance data and viewing attendance reports. Each time a user records attendance, the application sends location data collected by device sensors (GPS, Wi-Fi, accelerometer) to the server for verification. If the server validates the location, the attendance record is saved in the database. If the location is invalid, the server rejects the attendance and sends a notification to the user. Figure 3 below shows the interaction between users and the system, including the login process, attendance recording, and data management.

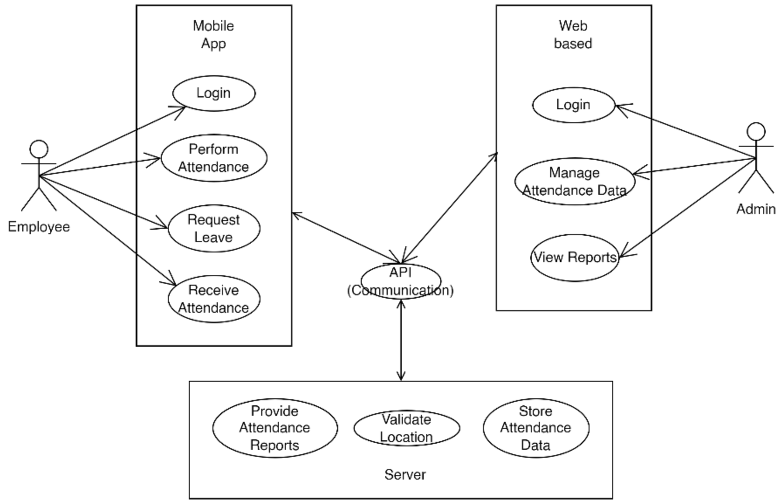

Fig. 3. Use Case Diagram for the Geolocator-based attendance application.

2.3.2 Data flow diagram (DFD)

DFD Level 0 (Context Diagram) illustrates the flow of data from the user to the server, which processes and stores attendance data. The system receives input from the user in the form of login information and location data. The location data is then sent to the server for verification. The server determines whether the location is valid or not. If valid, the data is stored in the database, and if invalid, the server sends an error notification to the user. Figure 4 below shows the data flow in Level 0, from user input to the storage of attendance data on the server or the sending of notifications if the attendance is rejected.

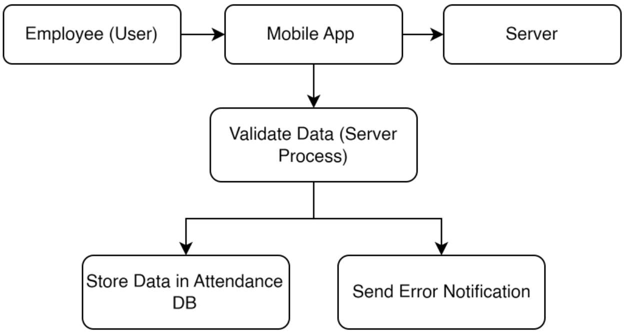

Fig. 4. Data Flow Diagram Level 0 for the attendance application.

DFD Level 1 provides a more detailed description of the system's processes. After the user submits location data, the server initiates the validation process. The server checks whether the user's location matches the designated attendance area. If the location is valid, the attendance data is stored in the database. If invalid, the server rejects the attendance and sends an error notification to the user. Figure 5 shows the data flow at Level 1, including the location validation process on the server and the transmission of attendance results to the user.

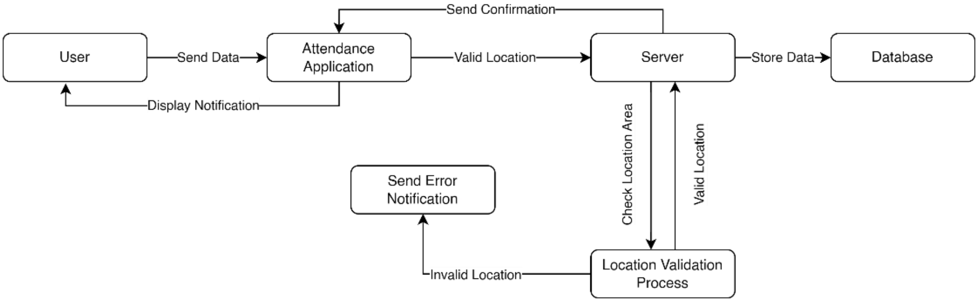

Fig. 5. Data Flow Diagram Level 1 for the Geolocator-based attendance application.

2.3.3 Database design

The database for this attendance application consists of three main tables, namely Companies, Users, and Attendance, which are interconnected to manage attendance data efficiently. The Company's table is related to Users through a One-to-Many relationship, so that one clinic (Watumas Clinic) can have many users, but each user is only registered at one clinic. Furthermore, the Users table is related to Attendance also through a One-to-Many relationship, allowing each user to have multiple attendance records that include time, status, and location information. This structure ensures that each attendance record is connected to the user and the Watumas Clinic concerned, facilitating the management of attendance data in one integrated system. Figure 6 below shows the relational structure between the tables, illustrating how Companies, Users, and Attendance are interconnected within one system.

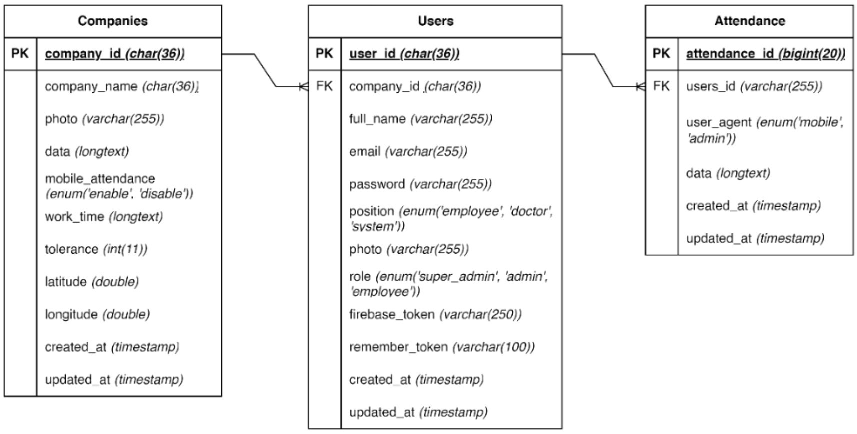

Fig. 6. Table relations in the database design of the GPS-based attendance application.

2.4 Model Testing

In this study, several types of testing were conducted to ensure that the Geolocator-based attendance application functions properly and is capable of accurately detecting location manipulation. Blackbox Testing, Whitebox Testing, and User Acceptance Testing (UAT) methods were chosen because each method thoroughly tests different aspects: functionality, internal logic, and user experience. Table 1 summarizes the types of testing, descriptions, testing focus, and expected results.

Table 1. Model Testing

Testing Type	Description	Testing Focus	Expected Results
Blackbox Testing	Functional testing focusing on input and output without inspecting the internal code.	Location permission functionality testing. Fake location detection testing. Fake attendance rejection.	The application can process location data and accurately detect location manipulation.
Whitebox Testing	Internal component testing to ensure the algorithm works as designed.	Location detection algorithm testing. *isMocked* property testing. Program logic testing.	The algorithm can detect fake locations and abnormal coordinate changes with high accuracy.
User Acceptance Testing (UAT)	Testing involving end users to assess ease of use and effectiveness of location detection.	User experience testing. Fake location detection in various conditions. User feedback.	The application is easy to use, fast in processing attendance, and effectively detects fake locations.

2.4.1 Blackbox testing

Blackbox Testing was conducted to test the functionality of the attendance application based on the received input and the produced output without inspecting the source code. The main focus of this test is to verify whether the application functions according to the specified requirements, such as location access permission, location data retrieval, and the detection of Fake GPS usage through the *isMock* property. Additionally, the system was tested to ensure that attendance is rejected if a fake location is detected. The expected outcome of Blackbox Testing is that the application can process the provided location data, detect location manipulation, and either accept or reject attendance based on location validation results.

2.4.2 Whitebox testing

Whitebox Testing focuses on testing the internal components of the application, particularly the algorithms used to detect location and location manipulation. The testing ensures that the location detection algorithm works as per the specified design, including the use of the *isMock*ed property to detect fake locations and anomaly detection algorithms to identify abnormal coordinate changes. Whitebox Testing also includes testing each logic branch used to process decisions based on the user's location status. The expected outcome is that the detection algorithm works with high accuracy and can quickly detect location manipulation.

2.4.3 User acceptance testing (UAT)

User Acceptance Testing (UAT) involves end users of the attendance application, such as clinic staff, to assess whether the application is easy to use and functions as required. Users are asked to use the application in real-world scenarios, both indoors and outdoors, to test the application's effectiveness in detecting fake locations and the accuracy of attendance records. During UAT, feedback from users is also collected to evaluate aspects such as ease of use, response speed, and the accuracy of the application in detecting fake locations. The expected outcome of UAT is that the application is well-received by end users, easy to use, and effectively detects location manipulation.

3 Results and discussion

3.1 Geolocator implementation in the application

The development of this Geolocator-based attendance application has been successfully implemented to meet the attendance management needs of the clinic, particularly in detecting and validating users' locations in real-time. This application integrates several key features designed to provide security, ease of use, and reliability in recording attendance and leave requests. The results of implementing these application features are as follows.

3.1.1 Login and biometric verification

The authentication process using a combination of username, password, and biometric verification (fingerprint or facial recognition) has been successfully implemented to ensure that only authorized users can access the main page of the application. This feature adds a crucial layer of security to prevent unauthorized access to the application. The Authentication screen can be seen in Figure 7.

Fig. 7. Authentication Page Interface

3.1.2 Main page and menu navigation

The main page, displaying various menus such as Check-in Attendance, Check-out Attendance, and Leave Request, has been successfully implemented with an intuitive interface. Each menu is easily accessible by users, with a clean design and simple navigation. Users can easily select the appropriate options to perform attendance or submit leave

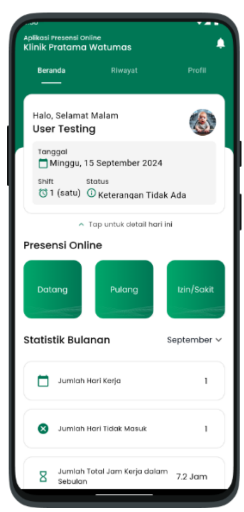

Fig. 8. Main Page Interface

requests. The interface of this application uses the Indonesian language, as shown in Figure 8, to ensure usability for local users. The main page interface can be seen in Figure 8.

3.1.3 Attendance page and location validation

The location validation feature using Geolocator has proven to be effective in detecting users' locations in real-time. After the user selects Check-in or Check-out Attendance, the system checks whether the user is in a valid location. If the location is valid, the Continue Attendance button will appear, allowing the user to send attendance data to the server. Conversely, if the location is invalid or the user is using a manipulation app like Fake GPS, the application displays an alert in Indonesian, notifying the user with a message such as *"Lokasi Palsu Terdeteksi"* to prevent them from proceeding with attendance until they are in an authorized location. Figures 9 and 10 show the attendance page interface and the location validation mechanism in the application, both when the user selects attendance and when the system detects valid or invalid locations, with all instructions presented in Indonesian to support local users.

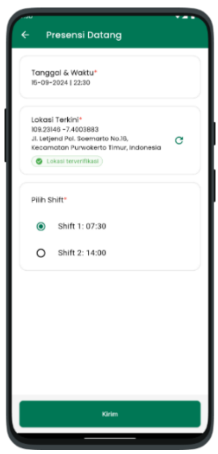

Fig. 10. Alert Display When a Fake Location is Detected

Fig. 9. Attendance Page Interface

3.1.4 Notifications

Notifications providing feedback to users after attendance or leave requests are successfully or unsuccessfully submitted have been well-implemented. The application uses Indonesian as the default language, so users will see notifications in Indonesian. For example, if attendance is successful, the user will receive a *"Sukses"* notification with the message *"Data berhasil disimpan",* which includes the time and location of the attendance. If attendance fails due to location validation, the user will receive a *"Gagal"* notification with a message indicating the failure reason. The same applies to leave requests, where the notification will indicate whether the request was successful or failed.

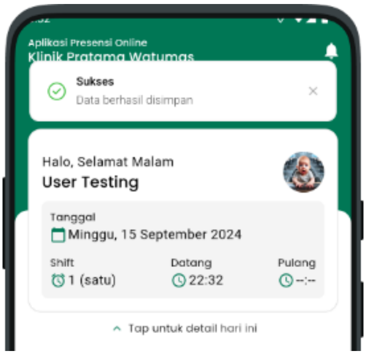

Fig. 11. Notification Interface

Figure 11 shows an example of the notification interface after a successful attendance, illustrating the clear presentation of information to users. In cases where attendance fails, the notification will appear in a similar format, but with a *"Gagal"* status and a failure message.

3.2 Testing results

To ensure that the Geolocator-based attendance application functions properly, various testing methods were conducted, including Blackbox Testing, Whitebox Testing, and User Acceptance Testing (UAT). Each testing method focused on different aspects: functionality, internal logic, and user experience, to ensure the application runs smoothly and accurately detects locations.

3.2.1 Blackbox testing

Blackbox Testing focused on testing the application's functionality by examining input and output without considering the internal code details. This testing covered the entire usage flow, from login, attendance, to leave requests, to ensure that the application produces the correct output based on user input.

Several testing scenarios were carried out. In the first scenario, Login and Biometric Verification, the system received input in the form of a username, password, and biometric verification (such as fingerprint or facial recognition), then verified their authenticity. If the user's input was valid, the application successfully directed the user to the main page. In the second scenario, Accessing the Attendance Page, the user selected Check-in Attendance, Check-out Attendance, or Leave, and the system displayed the attendance page showing the location, time, and appropriate attendance options. The third scenario involved Attendance with a Valid Location, where the user was in an authorized location. After selecting attendance, the Continue Attendance button appeared, and the attendance data was sent to the server. In the fourth scenario, Attendance with an Invalid Location, the user attempted to record attendance from an invalid location, such as using Fake GPS. In this case, the system displayed an alert warning that a fake location was detected, and the attendance process was halted with no data sent to the server. The results of the Blackbox Testing conducted on the application are summarized in Table 2 below.

Table 2. Blackbox Testing Results

Testing Scenario	Input	Output	Status
Login and Biometric Verification	Username, password, biometric verification	User successfully logged into the main page	Success
Accessing the Attendance Page	User selects Check-in/Check-out/Leave	Attendance page displayed, showing location, time, and attendance options	Success
Attendance with a Valid Location	User is in an authorized location and performs check-in/check-out/leave	Continue Attendance button appeared, data sent to the server	Success
Attendance with an Invalid Location	User attempts attendance using Fake GPS	Application displays "Fake Location Detected" alert, attendance process halted, no data sent to the server	Success
Successful Attendance Notification	Attendance accepted	"Attendance Successful" notification appeared	Success
Failed Attendance Notification	Attendance rejected	"Attendance Failed" notification appeared	Success

The results of this testing indicate that the application functions as expected. When valid input is received, the application produces the appropriate output, while invalid input is halted by the system, displaying a clear error message. The system is able to detect and prevent location manipulation and provide relevant feedback to users in the form of notifications.

3.2.2 Whitebox testing

Whitebox Testing aims to test the internal logic of the application, particularly in detecting location manipulation using the *isMock* property from Geolocator. The system verifies whether the received location data is authentic or manipulated. If *isMock* = true, the application blocks the attendance process and displays a warning; if *isMock* = false, the attendance proceeds, and the data is sent to the server. Figure 12 shows the pseudocode explaining the location detection logic.

```
BEGIN
 IF (Geolocator.isLocationServiceEnabled()) THEN
  locationData = Geolocator.getCurrentPosition()

  IF (locationData.isMock == TRUE) THEN
   DISPLAY "Alert: Lokasi palsu terdeteksi!"
   BLOCK presensi
  ELSE
   CONTINUE with presensi
   SEND locationData to server
  END IF

 ELSE
  DISPLAY "Alert: Layanan lokasi dinonaktifkan!"
  BLOCK presensi
 END IF
END
```

Fig. 12. Pseudocode of location detection logic

In addition to detecting fake locations, the system also checks whether location services are active. If location services are disabled, the application issues a warning and blocks attendance. The results of this testing are summarized in Table 3, which shows how the application responds to various scenarios tested, including detecting authentic locations, fake locations, and disabled location services.

Table 3. Whitebox Testing Results

Testing Scenario	Input	Output	Status
Authentic location (*isMock* = false)	Authentic location data	Attendance process proceeds, data sent to the server	Success
Fake location (*isMock* = true)	Manipulated location data	Attendance blocked, invalid location alert displayed	Success
Location services disabled	Location services turned off by user	Location services disabled alert, attendance process halted	Success

The test results show that the location detection algorithm works well, preventing location manipulation with Fake GPS and ensuring that attendance is only recorded from valid locations. The system also handles situations where location services are disabled, ensuring that unverifiable data is not accepted.

3.2.3 User Acceptance Testing (UAT)

User Acceptance Testing (UAT) was conducted by involving end users, such as clinic staff, to assess whether the Geolocator-based attendance application is easy to use and functions as required for day-to-day operations. Users were asked to use the application in various scenarios, including indoor and outdoor attendance, as well as under strong and weak GPS signal conditions. This test aimed to evaluate the effectiveness of the application in detecting users' locations and the overall user experience. The survey results from users regarding several important aspects of the application can be seen in Table 4.

Table 4. UAT Survey Results for Attendance Application

Testing Aspect	Very Satisfied (%)	Satisfied (%)	Unsatisfied (%)
Ease of Use	90%	10%	0%
Response Speed	85%	15%	0%
Location Detection Accuracy	88%	12%	0%
Notification Clarity	92%	8%	0%
Fake GPS Detection	80%	20%	0%

From the table above, we can see that the majority of users are very satisfied with the application's ease of use (90%) and response speed (85%). The location detection accuracy was appreciated by 88% of users as being very accurate, while 92% of users also reported that the application's notifications were always clear. The effectiveness of Fake GPS detection was rated positively by 80% of users, with 20% providing satisfied feedback.

The results from UAT show that the application was well-received by end users. The application is considered easy to use and responsive. Users also provided positive feedback on the accuracy of the application in detecting locations and the efficiency of the attendance process, even under weak GPS signal conditions. Some suggestions for improving the user interface were also noted for future development.

3.3 Discussion

The results of the GPS-based attendance application development using the Geolocator plugin show that the application is capable of effectively and accurately detecting location manipulation. Based on the testing conducted, the application can correctly identify the user's real location and detect any manipulation attempts through third-party applications such as Fake GPS. This is reinforced by the use of the *isMock* property in Geolocator, which successfully blocks attendance when the user's reported location is detected as manipulated.

In the Blackbox Testing, the application was tested from a functional perspective without inspecting the internal code. The results of this test showed that the application can process user input correctly, starting from the login process, biometric verification, to location validation during attendance. When the user is in a valid location, the application correctly displays the Continue Attendance option, and the attendance can be successfully recorded. On the other hand, if the user attempts to record attendance from an invalid location or uses Fake GPS, the system automatically rejects the attendance and notifies the user that the location is invalid.

In the Whitebox Testing, the internal logic of the application and the algorithms used were tested, particularly the use of the *isMock* property from Geolocator. The test results showed that the system could detect manipulated locations quickly and accurately. The application successfully differentiated between authentic and fake locations and blocked attendance from users attempting to manipulate their location. This demonstrates the superiority of the Geolocator-based system compared to other technologies, such as Geofence, which is less accurate in detecting location manipulation, especially indoors.

Furthermore, User Acceptance Testing (UAT) was conducted by involving clinic staff. This testing aimed to evaluate the user experience and satisfaction with the application. The UAT results showed that users found the application easy to use, particularly in navigating menus and completing the attendance process. The speed in detecting locations and delivering notifications was also rated positively by users. This indicates that the application not only functions well technically but also provide a good and intuitive user experience.

When compared to Geofence, this application offers a more flexible and accurate solution for detecting location manipulation. Geofence is limited to fixed areas and cannot detect location manipulation applications like Fake GPS (7,26,27). In contrast, this application provides a more comprehensive solution by ensuring that users are in the correct location when recording attendance.

4 Conclusion

This research has resulted in a GPS-based attendance application that uses the Geolocator plugin to detect users' locations in real-time with high accuracy. The application is designed to provide an effective solution for recording employee attendance, with a location validation feature to ensure the accuracy of attendance data. Testing through Blackbox Testing, Whitebox Testing, and User Acceptance Testing (UAT) showed that the application performs well in terms of functionality, internal logic performance, and ease of use.

The results of Blackbox Testing showed that the application can process user input and correctly detect location manipulation, rejecting attendance from fake locations generated by Fake GPS applications. Whitebox Testing assessed the internal algorithm of the application, particularly in detecting fake locations using the *isMocked* property. This algorithm has proven to be effective in detecting anomalies and unusual coordinate changes. User Acceptance Testing (UAT) involved end users to evaluate their experience with the application. The UAT results showed that the application was well-received, with a user satisfaction rate of 90% for ease of use, 85% for response speed, 88% for location detection accuracy, and 80% for the effectiveness of Fake GPS detection, even under weak GPS signal conditions.

Further development can focus on integrating Artificial Intelligence (AI) or Machine Learning technologies, allowing the application to learn from users' attendance patterns, optimize the attendance recording process, and provide deeper insights into employee attendance. Additionally, the integration of additional sensors or hybrid technologies can be considered to improve the application's performance under various environmental conditions.

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