Information System and IoT-Based Personnel Location Tracking Through Smart Card Validation

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Abstract: *This research aims to design and build a web-based information system for personnel data management and real-time location tracking integrated with IoT-based smart card validation at the Army Polytechnic (Poltekad) Kodiklatad. The system was developed using the Python programming language with the Flask framework and MySQL database, following the Waterfall development method. Key features include personnel data management (CRUD), automatic QR Code generation for each member based on their Registration Number (NRP), digital smart card printing in PDF format integrating profile photos and QR Codes, smart card template management, NFC card registration endpoint for mobile integration, real-time personnel location monitoring through integration with MiCard devices and Google Find Hub service, activity log recording, and personnel balance management. System testing was conducted using Black Box Testing with 15 test scenarios achieving a 100% success rate. Response time measurements show that all features operate below 3 seconds, with an average of 1.31 seconds. This system contributes to the modernization of personnel administration at Poltekad by replacing manual methods with an efficient, accurate, and IoT-integrated digital system.*

Keywords: information system, QR Code, smart card, Flask, IoT, location tracking, Google Find Hub, Waterfall

INTRODUCTION

The development of information technology has significantly impacted data management across various organizations, including military institutions. Digital transformation encourages institutions to adopt technology-based systems to improve operational efficiency and service quality (Sururi et al., 2025). One relevant approach is the implementation of web-based information systems capable of integrating personnel data management with real-time location tracking technology.

The Army Polytechnic (Poltekad) Kodiklatad as a military educational institution has urgent needs in terms of accurate and centralized personnel data management. Currently, personnel data management still relies on conventional methods with many limitations. Septian et al. (2025) stated that manual data management using books or spreadsheets is error-prone, slow in search processes, and difficult to access simultaneously by multiple parties. Mandala and Susanto (2023) added that using Microsoft Excel for data management has limitations in accessibility and carries the risk of data loss.

On the other hand, the need to know personnel positions in real time is an important aspect of military institutional

operations. Personnel location monitoring enables leaders to ensure the presence of members, coordinate activities, and respond to emergencies more quickly. Internet of Things (IoT) technology offers a solution for these needs through smart devices connected to the internet and capable of periodically transmitting location data. Dini et al. (2025) explained that integrating IoT with information systems provides a comprehensive approach to organizational management.

The concept of smart cards or Android-based smart cards is the approach chosen in this research. MiCard is a digital smart card device installed on an Android smartphone and linked to a single user account. Through integration with the Google Find Hub service, the MiCard device location can be monitored in real time. The system performs polling of the last known coordinates from this service and stores them in a database for monitoring and reporting purposes.

In addition to location tracking, this system also integrates QR Code technology for personnel identity verification purposes. Mandala and Susanto (2023) explained that QR Code is a two-dimensional development of Barcode capable of storing larger amounts of data and readable using smartphones. Marsehan et al. (2025) showed that QR Code technology is effective in improving the efficiency and security of data verification processes. Hafizhah et al. (2025) added that innovative solutions combining QR Code technology with digital systems can overcome the inaccuracy of conventional recording systems.

Based on these problems, this research aims to implement a web-based information system capable of managing Poltekad Kodiklatad personnel data in a centralized and QR Code-verified manner, implement real-time personnel location tracking through integration of MiCard smart card devices with Google Find Hub IoT-based service, and test the information system and personnel location tracking using the Black Box Testing method

RESEARCH METHOD

This research uses the Waterfall development method consisting of five stages: requirements analysis, system design, implementation, testing, and maintenance (Kirman & Saputra, 2022). This approach was chosen because system requirements can be clearly defined at the beginning of development. Nagara et al. (2023) confirmed that the Waterfall model provides a structured sequential approach suitable for software development with well-defined specifications.

The requirements analysis stage was conducted through direct observation of running business processes and interviews with administrators and operational staff to identify functional and non-functional system requirements. Secondary data was collected through literature review on QR Code technology implementation, Flask framework, IoT-based location tracking, and the Waterfall development method.

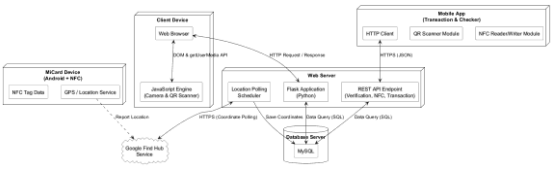

Figure 1. System Architecture.

The system was developed using the Python programming language with the Flask framework, which is lightweight and flexible (Walingkas & Saian, 2023). Suherlan et al. (2025) confirmed that Flask provides an effective platform for deploying complex systems. Syafi'i et al. (2025) also demonstrated the versatility of Flask in building web applications. The database uses MySQL, which is proven in handling web data transactions (Aziz et al., 2024). As shown in Figure 1, the system architecture consists of multiple components: the Client Device (Web Browser with JavaScript Engine for Camera and QR Scanner), the Mobile App (for NFC transactions and membership checking via HTTP Client), the MiCard Device (Android-

based with GPS/Location Service and NFC Tag Data), the Web Server (Flask Application with REST API Endpoints for verification, NFC, and transactions, plus a Location Polling Scheduler), the Google Find Hub Service cloud for location data, and the MySQL Database Server. The Web Browser communicates with the Flask Application via HTTP Request/Response. The Mobile App communicates with the REST API Endpoints via HTTPS (JSON). The Location Polling Scheduler periodically polls coordinates from Google Find Hub and stores them in MySQL. The MiCard's GPS/Location Service reports its location to Google Find Hub (Supria et al., 2024).

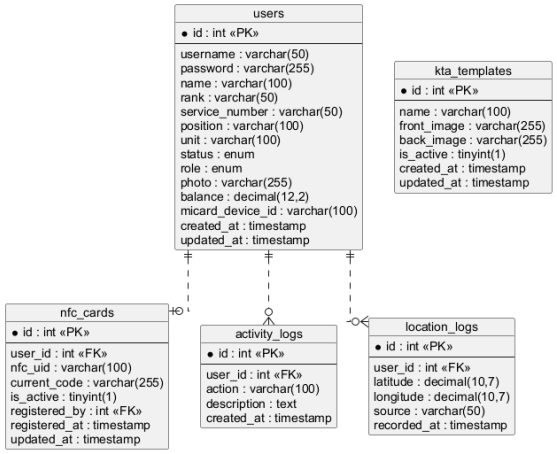

Figure 2. Entity Relationship Diagram.

Database design uses Entity Relationship Diagram (ERD) as shown in Figure 2 with five main entities. The first entity is **users**, which stores complete user data including username, password, full_name, rank, NRP, position, unit, status, role, photo file path, balance (saldo), and micard_device_id for linking to the MiCard IoT device. The second entity is **nfc_cards**, which stores NFC card registration data including user_id, nfc_uid, current_code (for anti-cloning validation), is_active status, and registered_by reference. The third entity is **activity_logs**, which records all user activities in the system including action type and description. The fourth entity is **kta_templates**, which stores smart card template designs with front_image and back_image attributes. The fifth entity is **location_logs**, which stores location tracking data including user_id, latitude, longitude, source, and recorded_at timestamp. The relationships are: users has one-to-many with activity_logs, users has one-to-one with nfc_cards, and users has one-to-many with location_logs (Akbar & Haryanti, 2021).

Figure 3 illustrates the system modeling using the Use Case Diagram to define functional interactions between actors and the system. The system has two actors: Administrator and User/Officer. The Administrator has full access rights to: Login, Manage Personnel Data (CRUD Users), Manage Smart Card Templates, Generate QR Code, Print Smart Card, View Activity Logs, Manage NFC Data (Registration Endpoint), Monitor Personnel Location (Real-Time Map), View Location History, and View User Balance. The User/Officer has access to: Login, Generate QR Code, Print Smart Card, Verify Personnel (API Endpoint), and Monitor Personnel Location (Narulita et al., 2024; Ichsandi et al., 2025).

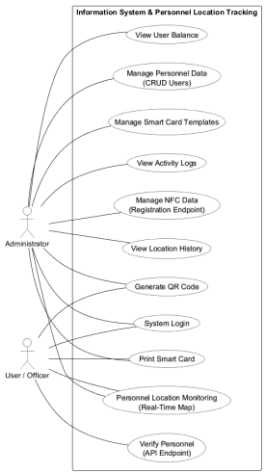

Figure 3. Use Case Diagram.

The Activity Diagram in Figure 4 describes the automated location polling process. The Location Scheduler activates periodically, retrieves the list of registered MiCard devices (micard_device_id) from the database, polls location coordinates from Google Find Hub for each device, and if coordinates are obtained, stores the latitude,

longitude, and timestamp in the location_logs table and updates the map display on the Dashboard. If coordinates cannot be obtained, the system records the device status as untraceable (Aurellia et al., 2025).

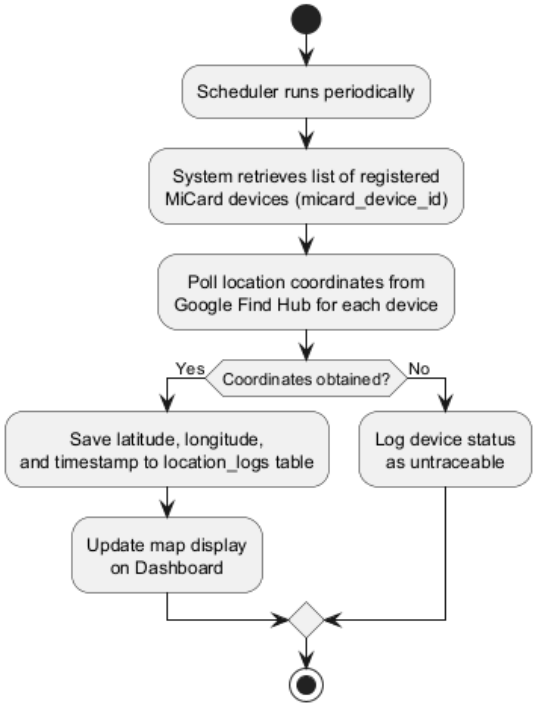

Figure 4. Activity Diagram.

The Sequence Diagram in Figure 5 illustrates three main interaction flows. The first flow covers Location Polling (Scheduler): the Location Scheduler retrieves the list of MiCard devices from the database, then for each device, requests location from Google Find Hub, receives coordinates (latitude, longitude), and inserts the data into location_logs. The second flow covers Personnel Verification (API Endpoint): the Mobile App sends a POST /api/anggota/verify request with scan_type and QR/NFC data, the Controller queries the database (by QR data or NFC UID), and returns personnel details if valid or a 404 error if not found. The third flow covers View User Balance (Admin): the Admin requests the balance page, the Controller queries the users table for id, name, NRP, and balance, and renders the balance management page.

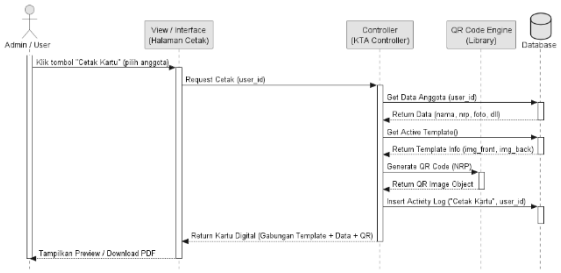

Figure 5. Sequence Diagram

RESEARCH RESULTS

The development results of the web-based information system and IoT-based personnel location tracking through smart card validation have been successfully implemented with features according to the analyzed functional requirements.

a. Login and Dashboard

The system provides a login page for administrator and user authentication. Upon successful login, the dashboard displays an overview of system statistics including total registered personnel, active NFC cards, and a real-time location map widget showing the latest known positions of personnel.

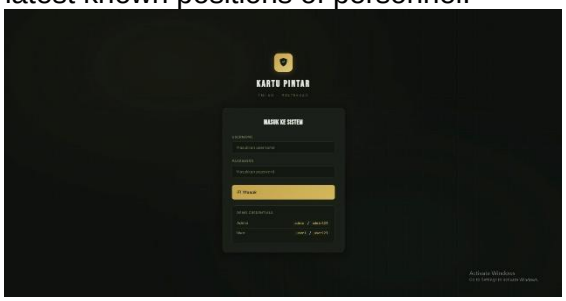

Figure 6. Screenshot of the Login Page

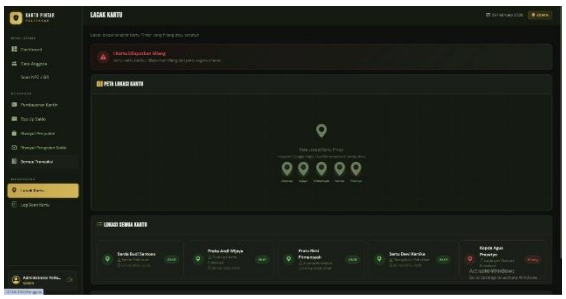

Figure 7. Screenshot of the Dashboard with Location Map Widget

b. Personeel Data Management

The system can perform CRUD operations on personnel data in real-time and store them in

a centralized database. New member registration stores data such as name, rank, NRP, position, unit, status, role, photo, and the associated MiCard device ID. The system provides member data search features based on name or NRP, modification of registered member data, and deactivation of inactive member data.

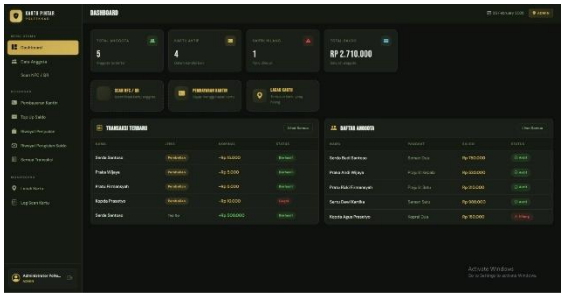

Figure 8. Screenshot of the Personnel Data List Page

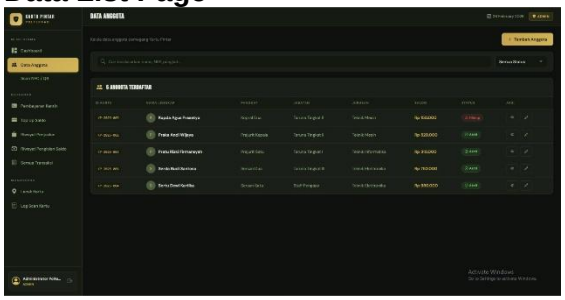

Figure 9. Screenshot of the Add New Personnel Form

c. Black Box Testing Result

Black Box Testing was conducted to verify that all system functions work according to specifications. Table 1 presents the complete test scenarios and their results.

Table 1. Black Box Testing Results

No	Expected Result	Actual Result	Status
1	Successfully login, display dashboard	Successfully login, display dashboard	Valid
2	Display error “Invalid credentials”	Display error “Invalid credentials”	Valid
3	Personnel saved, QR Code generated	Personnel saved, QR Code generated	Valid
4	Data updated in database	Data updated in database	Valid
5	Status changed to inactive	Status changed to inactive	Valid
6	Display matching personnel record	Display matching personnel record	Valid
7	QR Code image created based on NRP	QR Code image created based on NRP	Valid
8	PDF generated with photo, data, and QR Code	PDF generated with photo, data, and QR Code	Valid
9	Template saved and available for selection	Template saved and available for selection	Valid
10	NFC card linked to personnel account	NFC card linked to personnel account	Valid
11	Return personnel details (200 OK)	Return personnel details (200 OK)	Valid
12	Return 404 Not Found	Return 404 Not Found	Valid
13	Display map with personnel positions	Display map with personnel positions	Valid
14	Display chronological log entries	Display chronological log entries	Valid
15	Display list of users with balances	Display list of users with balances	Valid

d. Response Time Measurement

Response time testing was conducted to measure the speed of each feature. Table 2 presents the response time measurement results across five trials for each feature.

Table 2. Response Time Measurement Results

No	Feature	Average (s)
1	Admin Login	0.93
2	Load Personnel Data List	1.12
3	Add New Personnel + QR Generation	1.85
4	Search Personnel by NRP	0.63
5	Generate QR Code	0.96
6	Print Smart Card (PDF)	2.35
7	Location Polling (per device)	1.76
8	Load Location Monitoring Map	1.45
9	API Verify Personnel (QR)	0.85
10	Load Activity Logs	1.06

DISCUSSION

The web-based information system and IoT-based personnel location tracking through smart card validation has answered this research's problem formulation. First, the system was successfully implemented to manage Poltekad Kodiklatad personnel data in a centralized and QR Code-verified manner. The use of Flask framework enables lightweight yet flexible system development (Walingkas & Saian, 2023), while MySQL database provides good performance in handling data transactions (Aziz et al., 2024). Waliyah et al. (2025) confirmed that Flask-based web systems offer a good balance between development speed and system performance. Syafi'i et al. (2025) demonstrated that Flask is well-suited for building feature-rich web applications. Aminoto and Utomo (2025) also noted the accessibility of Python-based web applications deployed through web hosting services.

The client-server architecture implemented allows separation between frontend and backend logic, facilitating future system maintenance and development. The ERD structure with five entities (users, nfc_cards, activity_logs, kta_templates, location_logs) was designed to ensure data integrity, search efficiency, and feature development flexibility (Akbar & Haryanti, 2021). The addition of the nfc_cards and location_logs entities compared to the initial design demonstrates the system's extensibility to accommodate NFC card management and IoT-based location tracking requirements.

The QR Code generation feature on digital smart cards was successfully implemented. Each generated QR Code is unique as it represents the member's NRP which cannot be duplicated. The membership card printing process integrated with the template system provides flexibility for administrators to change card designs without modifying program code. The entire process from member selection to card printing is recorded in the activity_logs table as an audit trail supporting system accountability. The average response time of 2.35 seconds for PDF generation is within the targeted specification of less than 3 seconds.

Second, the IoT-based personnel location tracking was successfully implemented through the integration of MiCard devices with Google Find Hub service. The Location Polling Scheduler operates periodically to retrieve the latest coordinates, storing them with timestamps in the location_logs table. This implementation demonstrates the practical application of IoT concepts in military personnel management, where location awareness is critical for operational coordination and emergency response. The polling mechanism achieves an average response time of 1.76 seconds per device, enabling near real-time tracking with acceptable latency. Dini et al. (2025)

confirmed that IoT integration in information systems enhances organizational management capabilities significantly.

The location monitoring dashboard provides administrators with an interactive map view showing personnel positions, complemented by location history features for historical tracking and reporting. This feature is particularly valuable for military institutions where personnel accountability and situational awareness are operational requirements. The system's ability to record and store location data enables post-event analysis and pattern recognition for security and operational planning purposes.

Third, Black Box Testing results prove that all 15 test scenarios were executed with a 100% success rate. This aligns with Mandala and Susanto's (2023) research showing high effectiveness in QR Code-based system testing. Kirman and Saputra (2022) also stated that Black Box testing is effective for verifying that systems function according to specifications. The response time measurements confirm that all features operate within the targeted specification of less than 3 seconds, with the overall average of 1.20 seconds demonstrating efficient system performance.

Compared to previous research, this system has significant advantages. Sururi et al. (2025) and Septian et al. (2025) developed membership management systems without QR Code or IoT features. Marsehan et al. (2025) used QR Code for attendance systems rather than comprehensive personnel management with location tracking. Ramadhana et al. (2021) developed a membership information system with nutrition management but without IoT-based location tracking. The integration of personnel data management, QR Code-based smart card generation, NFC card registration, and IoT-based real-time location monitoring in a single platform represents a novel contribution to the field of military personnel administration systems.

This system implementation is relevant for the Army Polytechnic in supporting personnel administration system modernization. This digitalization reduces dependence on physical records that are prone to loss, improves professional and transparent administration service standards, enables real-time personnel monitoring for operational coordination, and proves that open source technology can be relied upon to solve real-world problems (Suherlan et al., 2025).

CONCLUSION

This research has successfully implemented a web-based information system and IoT-based personnel location tracking through smart card validation at the Army Polytechnic using Flask framework and MySQL database. The system effectively manages personnel data through CRUD operations, generates unique QR Codes for each member, prints integrated digital smart cards in PDF format, provides REST API endpoints for NFC card registration and personnel verification, and monitors personnel locations in real time through integration with Google Find Hub IoT service. Black Box Testing results show that all 15 test scenarios function correctly with a 100% success rate, and response time measurements confirm that all features operate below 3 seconds with an overall average of 1.20 seconds. This system is recommended for implementation at Poltekad to modernize personnel administration and enhance operational coordination through real-time location awareness. Future development can include automatic notification features for geofence alerts when personnel enter or leave designated areas, integration with existing military information systems, and implementation of data analytics for personnel movement pattern analysis.

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