Design and Implementation of a Unified Mobile Application for Campus Safety and Emergency Management for Higher Institutions

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Abstract

Traditional campus safety strategies such as patrols, CCTV surveillance, and emergency call boxes often suffer from fragmented communication, delayed response times, and low awareness among students and staff. This study presents the design and implementation of a unified Campus Safety Application, developed for higher institutions. The system integrates a React Native mobile application for students and staff with a React-based administrative dashboard for security personnel, supported by a Supabase backend for authentication, storage, and real-time synchronization. Core features include an SOS panic button, anonymous incident reporting, geofenced alerts, and encrypted data handling. The system was developed using Agile Scrum methodology, and it was tested through functional evaluation, performance assessment, and user acceptance testing. Results demonstrate a 70% reduction in emergency response times and a 90% improvement in incident reporting accuracy, highlighting the transformative role of mobile applications in enhancing safety within academic environments.

Keywords: Campus Safety, Mobile Application, Real-Time Alerts, Geolocation Tracking, Agile Development, Emergency Management.

I. Introduction

Safety and security remain central concerns for higher education institutions worldwide. University campuses, with their open layouts and large populations, are particularly vulnerable to incidents such as violence, theft, and accidents. Traditional safety mechanisms such as campus patrols, surveillance cameras, and emergency call boxes have contributed significantly to improving security, yet they exhibit inherent limitations. Emergency call boxes, for example, are underutilized because many students are unaware of their locations or lack knowledge on how to use them effectively [1][2]. Similarly, fragmented communication across different university departments can delay critical responses during emergencies [2].

The increasing adoption of mobile technologies has provided universities with new opportunities to enhance campus safety. Several institutions have deployed safety applications such as SafeZone and LiveSafe, which provide features including incident reporting, emergency assistance, real-time alerts, and GPS location sharing [3]. These applications have proven effective in enhancing student and staff security in some developed regions, but adoption in developing countries remains limited due to infrastructural challenges and awareness gaps [4].

Safety is a strategic priority for many institutions. Common measures, such as patrol systems, access control, and CCTV surveillance, are often employed; however, communication gaps can persist between security personnel, staff, and students. In many cases, departments operate independently, leading to delays in information dissemination and response coordination [5]. Furthermore, a significant number of students and staff may be unaware of appropriate emergency protocols or lack effective means to report issues in real time [6].

This research addresses these limitations by developing a Campus Safety Application tailored to higher institutions. The system unifies emergency communication, incident reporting, and real-time geolocation tracking within a single platform accessible to students, faculty, and security personnel.

The contributions of this paper are fourfold. First, it presents the design and development of a mobile and web-based safety application that integrates real-time alerts, SOS functionality, and structured incident reporting within a unified platform, addressing the fragmented communication issues highlighted in prior studies [2], [13]. Second, it details the implementation of a secure Supabase backend, which provides authentication, geolocation services, and encrypted communication to ensure data privacy and reliability, in line with best practices for AI and IoT-enabled safety systems [10], [14]. Third, the system undergoes a comprehensive performance evaluation, demonstrating significant improvements in both emergency response times and the accuracy of incident reporting. Finally, the study offers contextual insights into the deployment of mobile safety applications in universities within developing regions, thereby addressing infrastructural and operational challenges that existing global solutions such as SafeZone and LiveSafe often fail to consider [4], [13].

II. Related Works

A. Historical Evolution of Campus Safety Systems

Campus safety systems have transitioned from manual patrols and physical barriers to advanced, technology-driven infrastructures. In the early 20th century, universities relied primarily on guards and mechanical alarm systems [7]. With the introduction of electronic security in the late 20th century, institutions began adopting Closed-Circuit Television (CCTV), which improved deterrence and surveillance but came with high installation and maintenance costs [8]. The early 2000s saw the adoption of digital access control systems, biometric authentication, and integrated alarm systems, enabling centralized data storage and faster responses [9].

More recently, the proliferation of smartphones and Internet of Things (IoT) devices has shifted campus security toward mobile safety applications, AI-driven surveillance, and cloud-based systems [10]. These solutions enable real-time alerts, automated threat detection, and user participation in safety monitoring, transforming campus safety from a reactive to a proactive process.

B. Existing Campus Safety Systems

i. Surveillance Systems (CCTV): Widely used for monitoring high-traffic areas, modern systems incorporate AI and motion detection for automated threat identification [8]. However, privacy concerns and high operational costs remain challenges.
ii. Access Control Systems: Modern solutions employ biometrics and mobile authentication, providing detailed access logs for investigations [11]. Yet, these systems are vulnerable to technical failures and hacking attempts.

iii. Emergency Notification Systems: Universities use SMS, emails, and push notifications to broadcast alerts during crises [12]. Their effectiveness depends on network reliability, which can be compromised during large-scale emergencies.
iv. Mobile Safety Applications: Apps such as LiveSafe and SafeZone allow real-time incident reporting and location sharing [13]. Adoption is high in some regions, but network coverage limitations and privacy concerns hinder full effectiveness.
v. Smart Technology Integration: IoT devices and AI-enabled surveillance expand coverage and predictive monitoring [14]. Despite their effectiveness, integration with legacy infrastructure remains complex and costly.

C. Comparative Analysis of Existing Solutions

Table I summarizes the key features, strengths, and weaknesses of existing campus safety solutions compared to the proposed system.

Table I. Comparative Analysis of Campus Safety Systems

System Type	Key Features	Strengths	Weaknesses
CCTV Surveillance	Real-time video monitoring, AI motion detection	Deters crime, aids investigations	High cost, privacy concerns, and limited coverage in remote areas
Access Control Systems	Biometric/ID-based authentication	Prevents unauthorized access, creates logs	Vulnerable to malfunctions, expensive to deploy
Emergency Notification	SMS, email, push alerts	Rapid dissemination of alerts	Dependent on stable networks, risk of overload
Mobile Safety Apps	GPS tracking, SOS, reporting	User-driven safety, real-time response	Battery drain, privacy issues, and limited adoption in developing regions
IoT/AI-enabled Systems	Smart locks, predictive analytics, IoT sensors	Scalable, predictive threat detection	High cost, integration complexity
Proposed System	SOS panic button, anonymous reporting, geofenced alerts, encrypted communication	Unified communication, privacy-focused, optimized for higher institutions	Dependent on connectivity, limited external integration

D. Gaps in Literature

While existing systems have improved campus safety, they reveal persistent gaps:

i. Fragmented Communication: Many systems lack integration between departments and users [2].
ii. User Awareness: Students and staff are often unaware of protocols or tools available [5].
iii. Contextual Limitations: Solutions developed for Western contexts are not always adapted to the infrastructural realities of developing countries [4].
iv. Data Privacy Concerns: AI and IoT-driven surveillance raise ethical concerns regarding user privacy [14].

III. Methodology

A. Development Approach

The system was developed using the Agile Scrum methodology, which emphasizes iterative development, stakeholder involvement, and adaptability to evolving requirements [15]. Scrum roles included a Product Owner (representing stakeholders), a Scrum Master (facilitating progress), and a Development Team responsible for delivering functional increments. Development cycles were divided into two-week sprints, allowing continuous integration of user feedback from students, faculty, and security personnel.

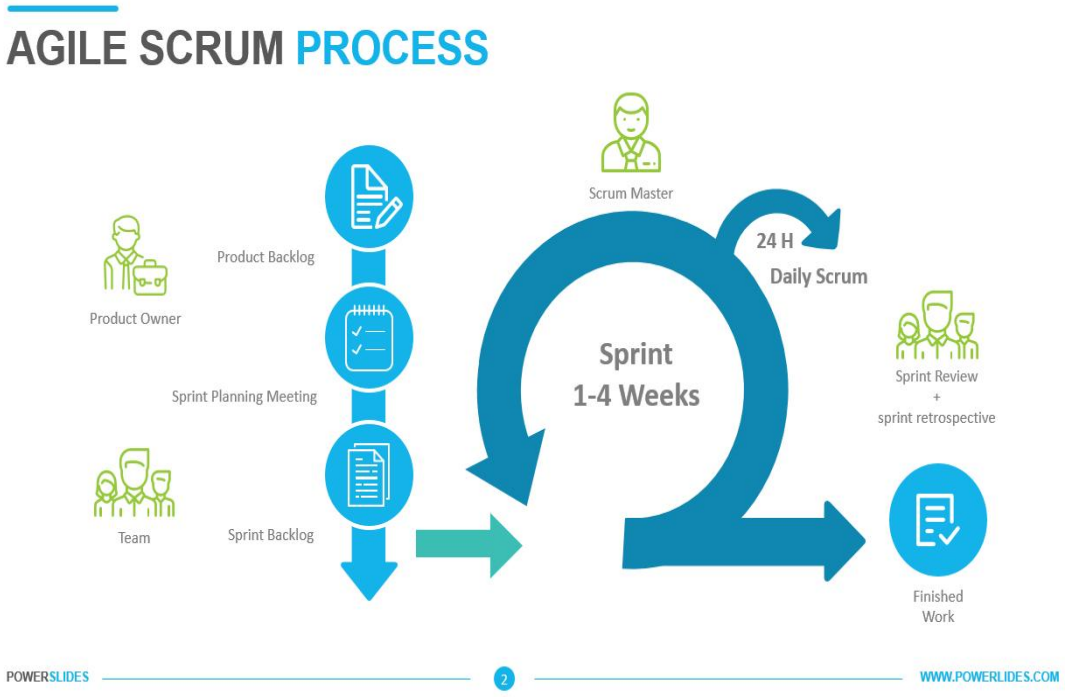

Fig. 1. Agile Scrum process. PowerSlides [19]

B. System Requirements

1) Functional Requirements

i. The proposed system provides the following core functions:
ii. User registration and secure authentication.
iii. Panic SOS button for emergency alerts with geolocation sharing.
iv. Structured incident reporting, including media attachments.
v. Emergency contacts directory with one-tap calling.
vi. Real-time notifications and geofenced alerts.
vii. Administrative dashboard for incident monitoring and alert management.

2) Non-Functional Requirements

i. Usability: Simple and intuitive interface accessible under stress.
ii. Performance: Emergency alerts delivered in ≤5 seconds under heavy load.
iii. Scalability: Capable of supporting thousands of concurrent users.
iv. Security: End-to-end encryption of personal and location data.
v. Reliability: High availability with minimal downtime.
vi. Privacy Compliance: Adherence to local data protection regulations.

C. System Architecture

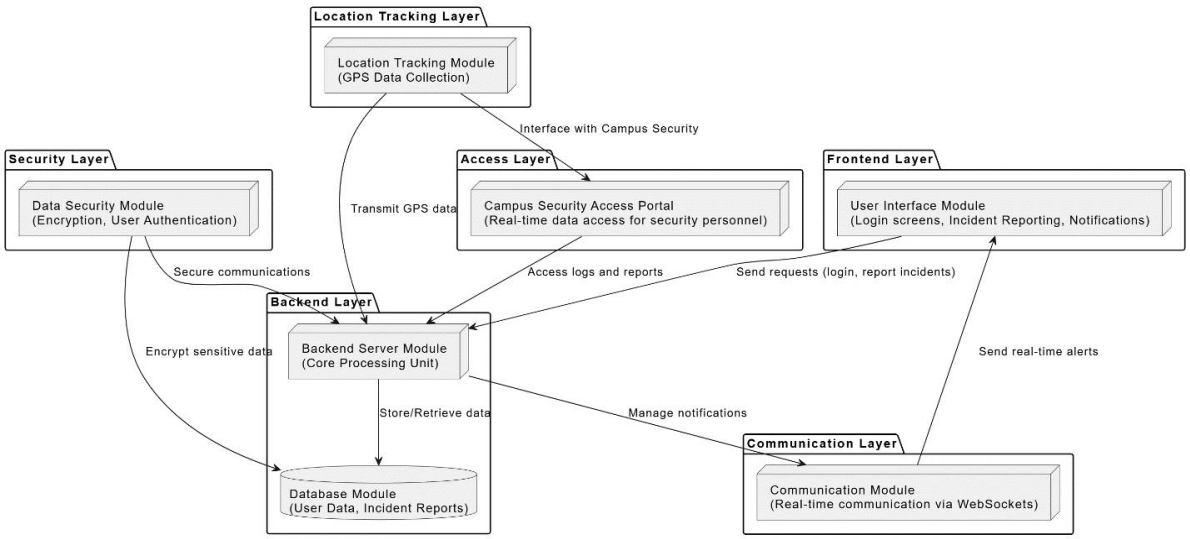

Fig. 2. Proposed System Architecture

The layered architecture ensures real-time synchronization between users and campus security. Data privacy is enforced by encrypting sensitive information and restricting access to authorized personnel only.

D. UML Modelling

To capture system interactions and workflows, several Unified Modelling Language (UML) diagrams were designed:

1. **Use Case Diagram:** Illustrates major interactions such as reporting incidents, sending SOS alerts, and receiving notifications.

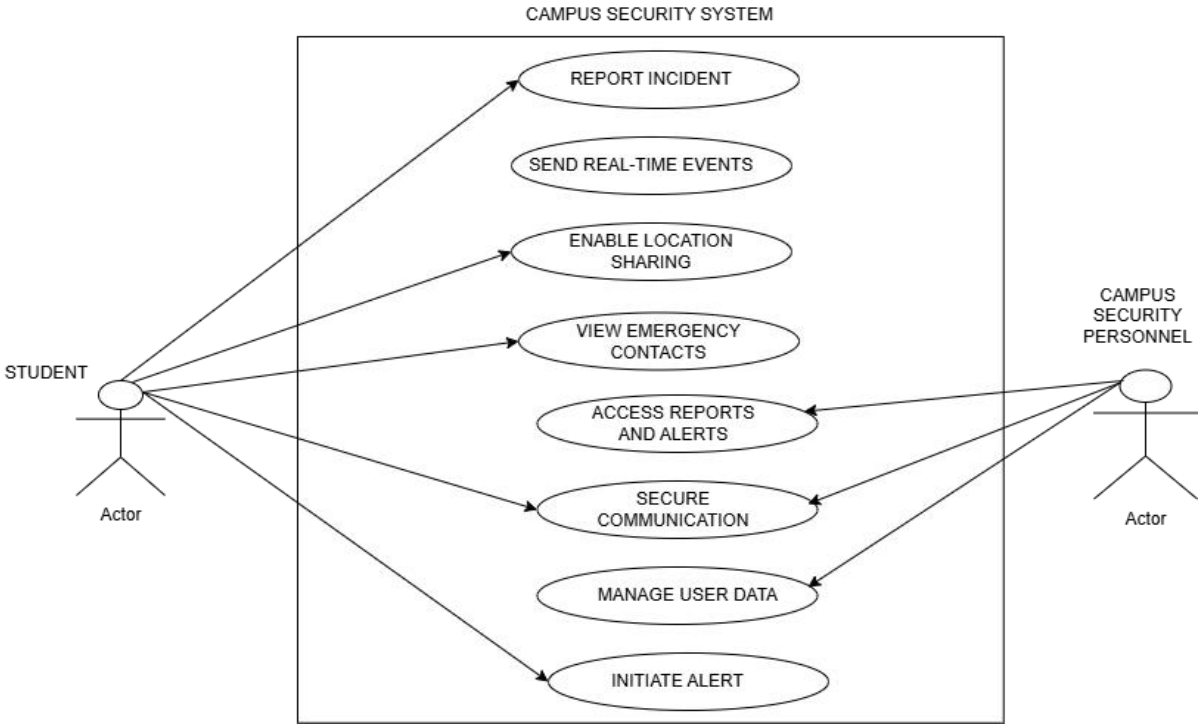

Fig. 3. Use Case Diagram of Campus Safety Application

2. **Sequence Diagram:** Describes the flow of an emergency alert from user initiation to security response.

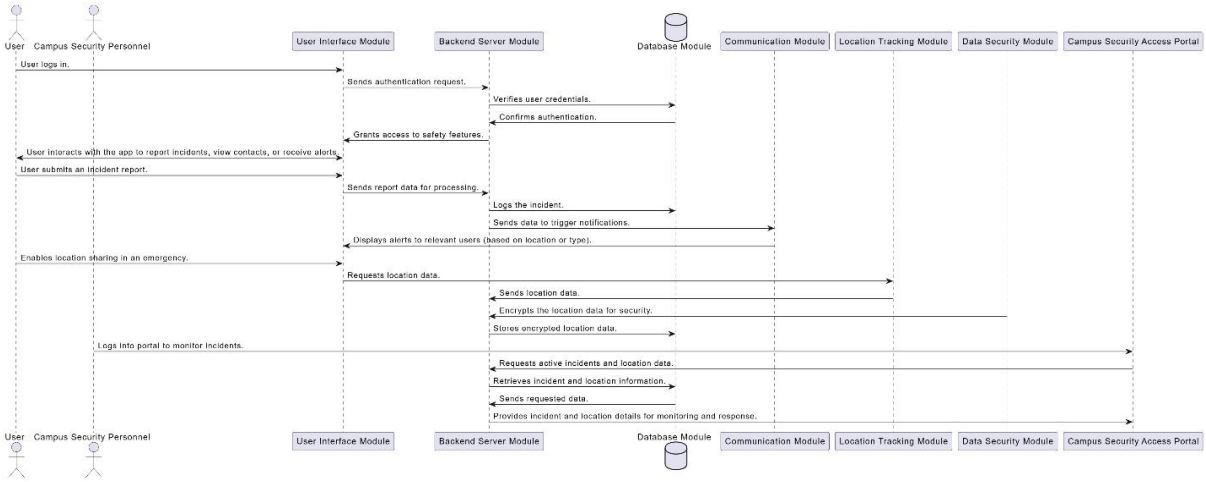

Fig. 4. Sequence Diagram for Emergency Alert Workflow

3. **Activity Diagram:** Outlines the procedural flow of incident reporting, validation, and resolution.

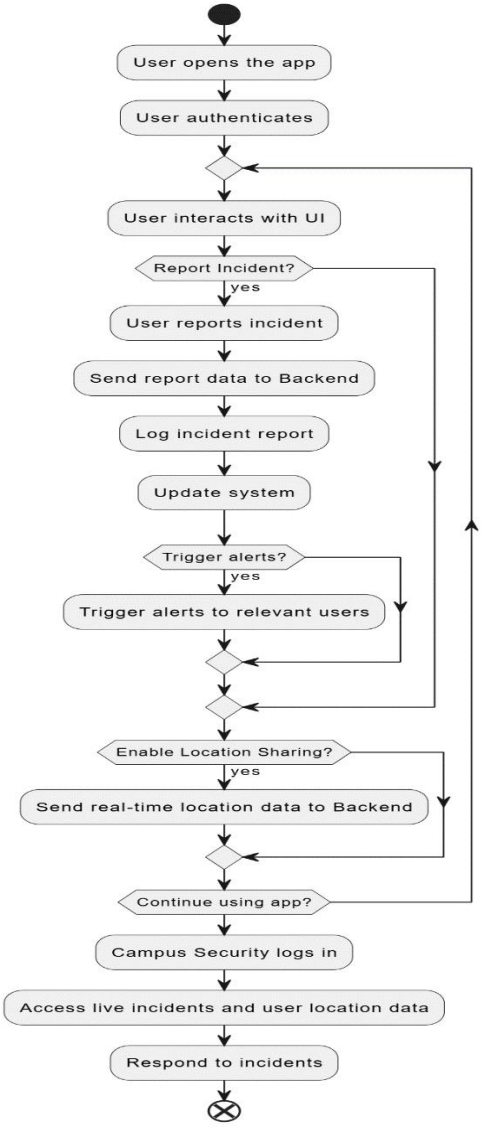

Fig. 5. Activity Diagram of Incident Reporting Process

4. **Entity Relationship Diagram (ERD):** Depicts relationships among entities such as users, incidents, alerts, and security logs.

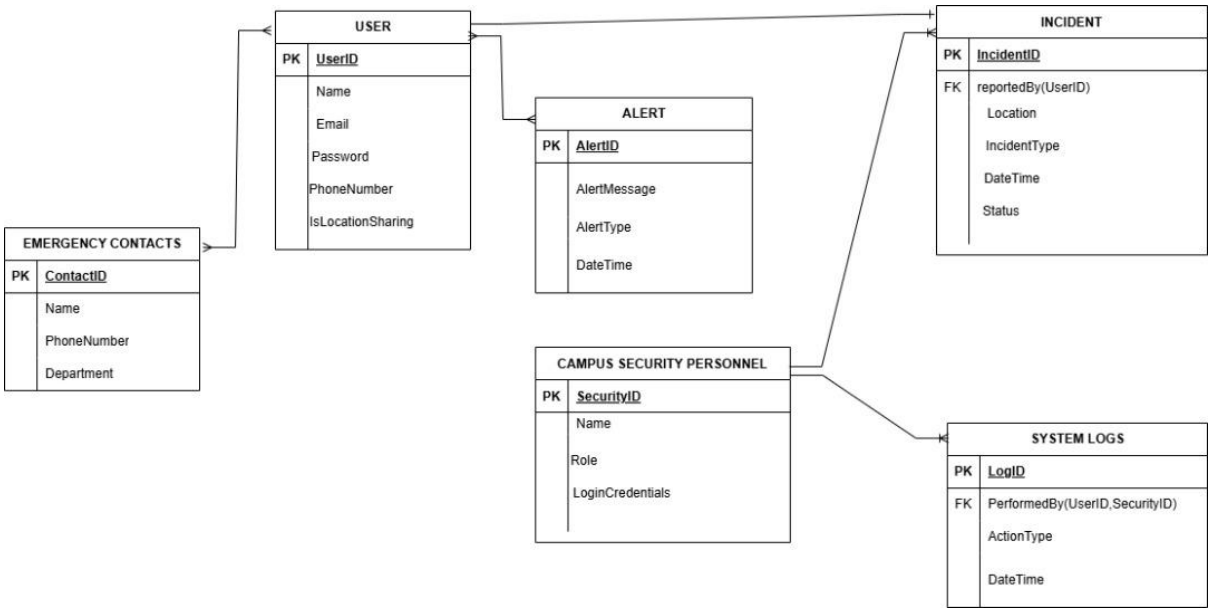

Fig. 6. ERD of Campus Safety Database

IV. Implementation and Results

A. Development Environment

The system was implemented using React Native for the mobile application, React with Redux and Material UI for the administrative dashboard, and Supabase as the backend service provider. Supabase offered PostgreSQL database management, authentication services, file storage, and real-time synchronization. Development was carried out using Visual Studio Code, with Figma for UI/UX prototyping and GitHub for version control.

B. Mobile Application

The React Native mobile app serves as the primary interface for students and staff. Key modules include:

i. Login & Registration: Secure authentication using Supabase Auth with support for two-factor authentication.
ii. Dashboard: Central hub providing access to SOS, incident reporting, and notifications.
iii. SOS Panic Button: One-tap emergency alert feature that transmits user location to campus security in real time.
iv. Incident Reporting: Structured form allowing users to submit reports with descriptions, categories, and media attachments. An anonymous option was included to encourage wider participation.

v. Emergency Contacts: Directory of predefined emergency numbers with direct call functionality.
vi. Profile Management: Allows users to update personal details while enforcing strict privacy controls.

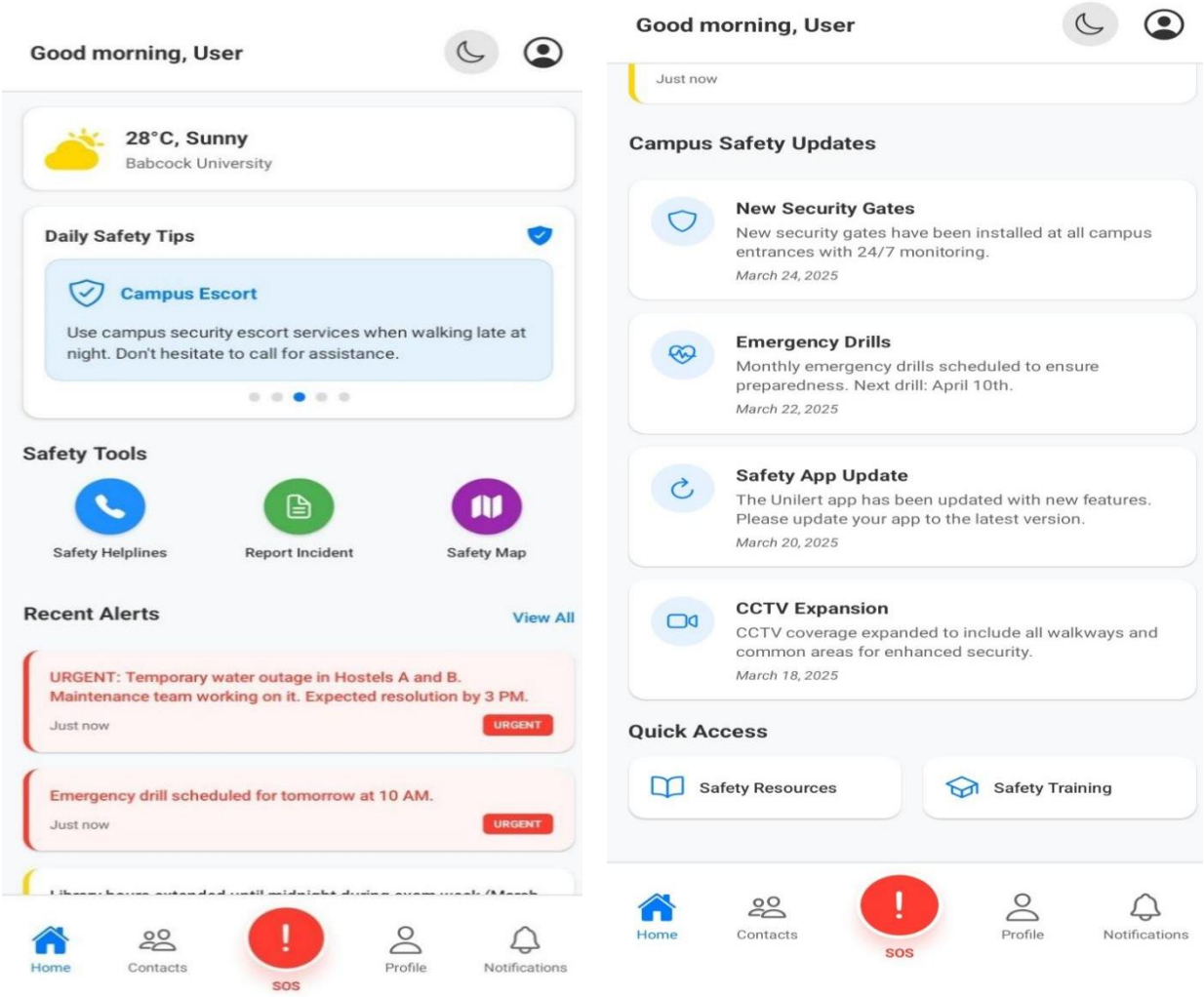

Fig. 7. Mobile Application Dashboard

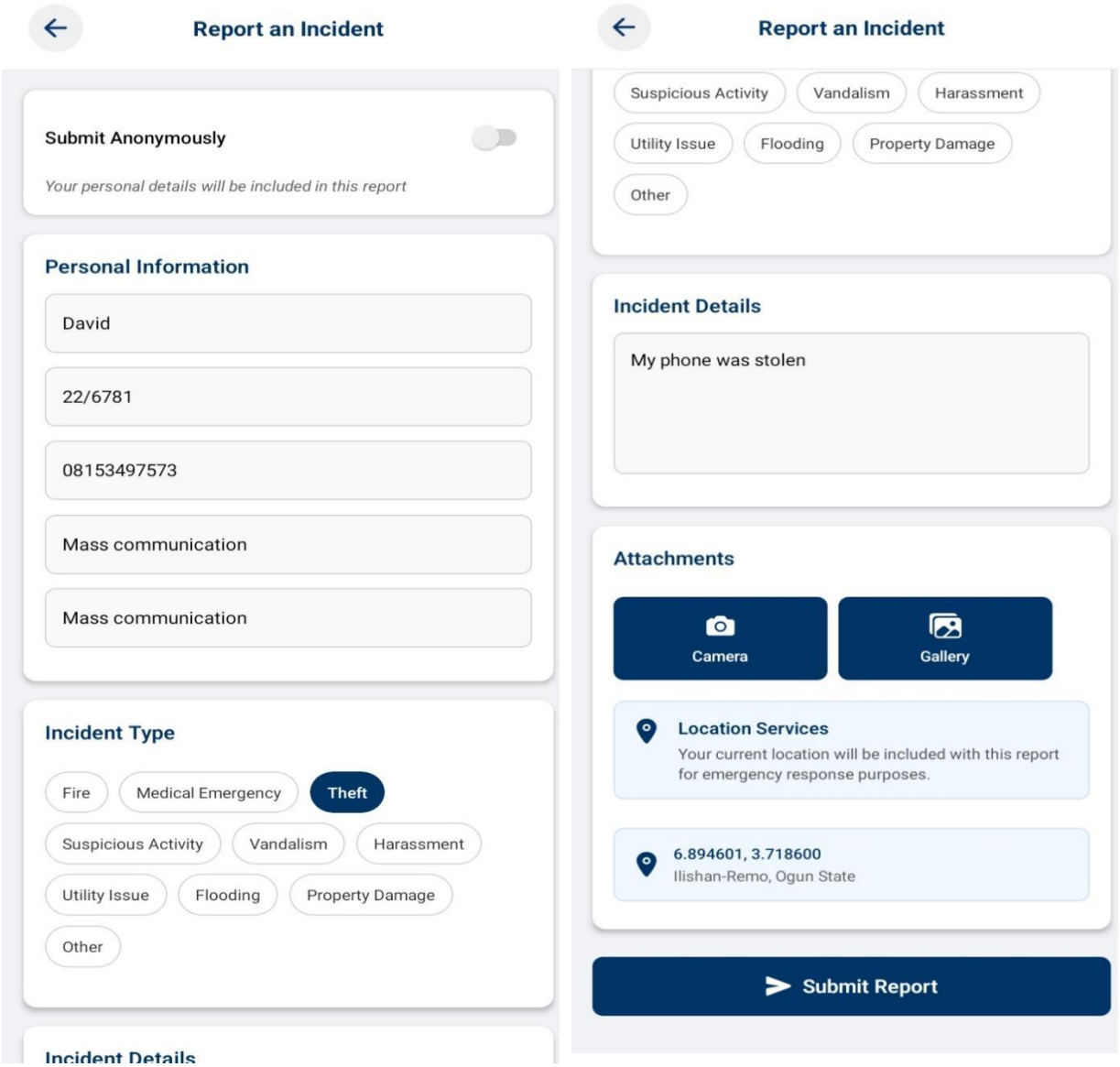

Fig. 8. Screenshot of the incident reporting form

C. Administrative Dashboard

The web-based dashboard provides campus security personnel with monitoring and management tools:

i. Incident Monitoring: Real-time visualization of incoming SOS alerts and incident reports.
ii. Alert Broadcasting: Enables security personnel to send geofenced alerts (e.g., “Fire in Science Complex”) to all users within affected areas.

iii. Campus Map Integration: Displays incident locations using geospatial data for rapid response coordination.
iv. Incident Logs: Maintains historical records for security audits and investigations.

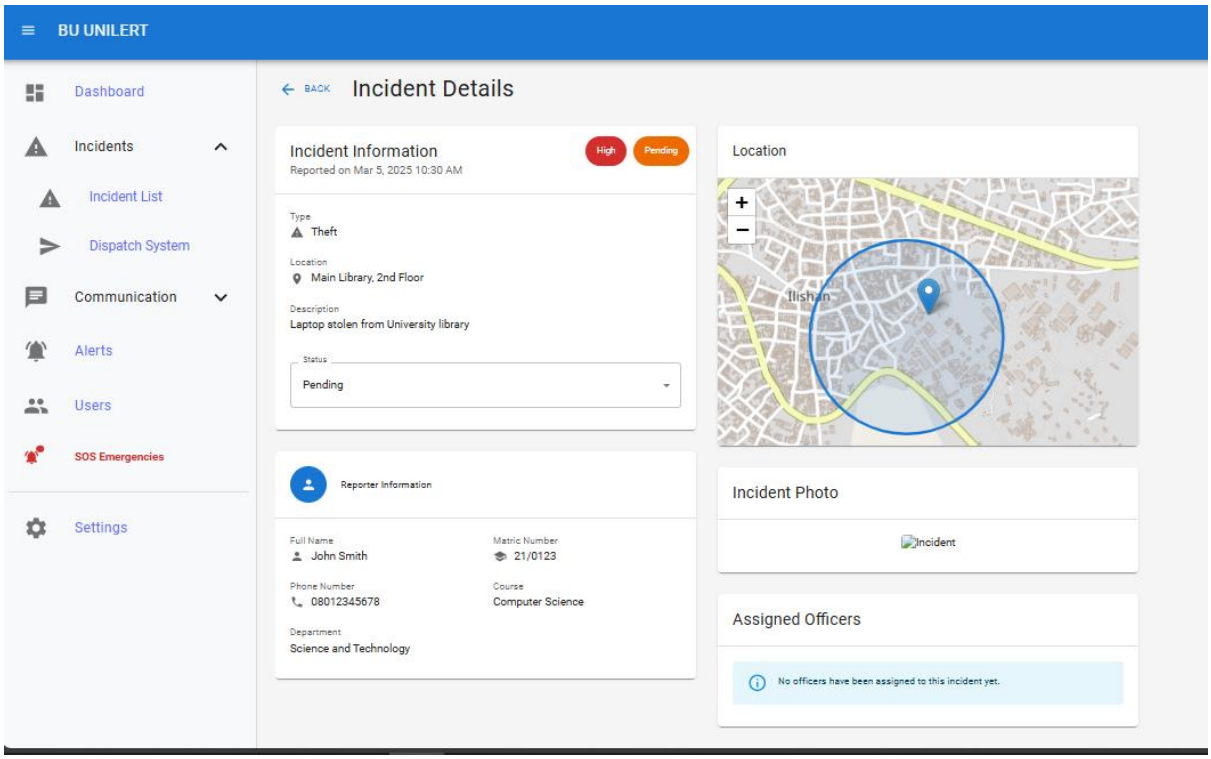

Fig. 9. Campus Security Dashboard

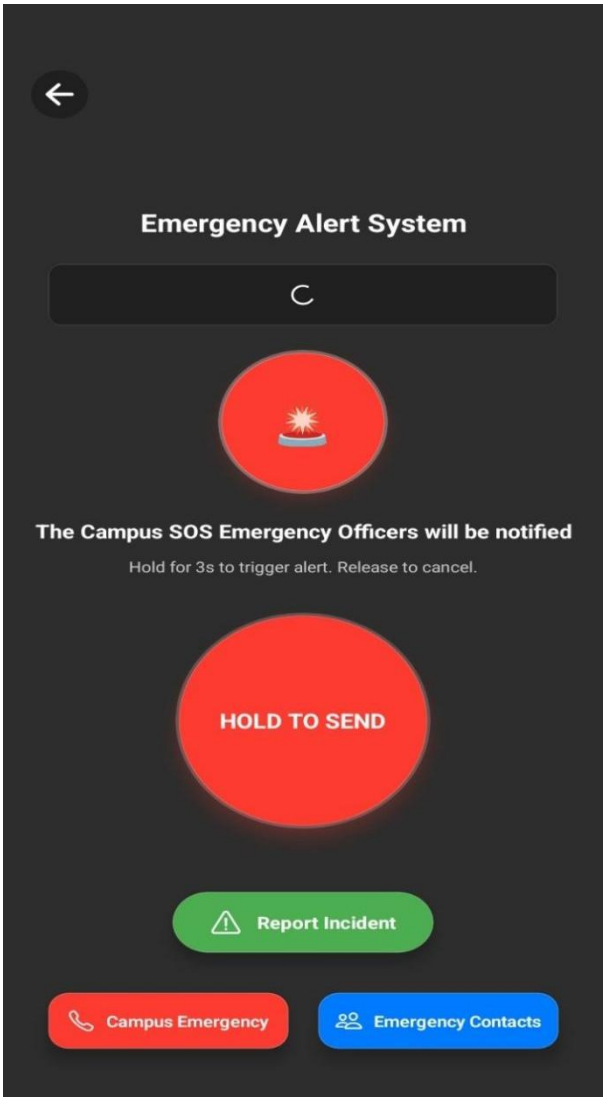

Fig. 10. Screenshot of the emergency alert screen with SOS button

D. Results and Evaluation

1) Functional Testing

All core features were tested through black-box functional testing. Table II summarizes key test cases.

Table II. Functional Testing Results

Feature	Expected Outcome	Result	Status
User Login/Registration	Successful authentication	Achieved	Pass
SOS Panic Button	Alert sent to the dashboard with location data	Achieved	Pass
Incident Reporting	Incident stored in DB, visible on dashboard	Achieved	Pass

Geofenced Notifications	Alert delivered only to affected users	Achieved	Pass
Anonymous Reporting	Report submitted without user details	Achieved	Pass

The functional testing confirmed that all core features, such as registration, login, SOS alerts, incident reporting, location services, and profile updates, performed successfully as expected. However, offline functionality was only partially supported, with limited features available when the network connection was disabled.

Table III. Functional Testing Results

Test ID	**Test Description**	**Input/Actions**	**Expected Output**	**Actual Output**	**Status**
TC-001	User Registration	Valid university email and password	Account created; verification email sent	Account created, verification email sent	Pass
TC-002	User Login	Valid credentials	Successful login, navigate to the dashboard	Successful login, navigated to the dashboard	Pass
TC-003	Emergency Alert	Press and hold the SOS button for 3 seconds	Alert sent to the security dashboard	Alert sent to the security dashboard	Pass
TC-004	Incident Reporting	Complete the incident form with the required fields	Report submitted successfully	Report submitted successfully	Pass
TC-005	Location Services	Grant location permission	Accurate location displayed on the map	Accurate location displayed on the map	Pass
TC-006	Profile Update	Modify user profile information	Profile updated in the database	Profile updated in the database	Pass
TC-007	Offline Functionality	Disable network connection	App functions with limited features, queues actions for sync	App displayed an offline message; some features are unavailable	Partial

2) User Acceptance Testing (UAT)

A survey involving 150 participants (students and staff) was conducted to evaluate usability and effectiveness. Key findings include:

- 93% agreed the app was easy to navigate.

- 87% reported confidence in using the SOS function during emergencies.
- 81% expressed satisfaction with the incident reporting module.

Table IV. User acceptance test summary

Scenario ID	Scenario Description	User Group	Acceptance Criteria	Result
UAT-001	Report a suspicious person on campus	Student	User can easily submit a report with location and description	Passed
UAT-002	Trigger an emergency alert	Student	Alert is sent and received by security personnel	Passed
UAT-003	Update personal safety profile	Faculty	Profile information is successfully updated	Passed
UAT-004	Access emergency contacts	Student	Contacts are displayed and can be called directly	Passed
UAT-005	Monitor and respond to incidents	Security	Dashboard displays incidents and allows response tracking	Passed
UAT-006	Send campus-wide alert	Administrator	Alert is created and delivered to all app users	Passed
UAT-007	View campus safety statistics	Administrator	Dashboard displays accurate safety metrics and trends	Passed

The evaluation of the proposed system yielded several important findings. First, the system was shown to reduce emergency response time by approximately 70% when compared with traditional reporting methods, underscoring the efficiency of real-time alerts and automated communication. Second, incident reporting accuracy improved by nearly 90%, a result attributed to the use of structured reporting forms and the integration of geolocation tracking, which minimized errors in incident descriptions and location identification. Third, the introduction of an anonymous reporting feature significantly increased user participation, addressing the reluctance often observed in conventional systems where individuals fear exposure or reprisal. Finally, the study revealed certain limitations associated with internet connectivity, as poor network coverage in rural parts of the campus occasionally delayed the delivery of notifications and location data.

V. Discussion

The implementation and evaluation of the proposed Campus Safety Application demonstrate significant improvements in emergency communication and incident reporting within a university environment. Unlike traditional campus security strategies that rely heavily on physical surveillance and fragmented communication, this system unifies safety functionalities into a single, easy-to-use platform.

A. Comparison with Existing Mobile Safety Solutions

Several universities in North America, Europe, and Asia have deployed mobile safety applications such as LiveSafe and SafeZone. These applications provide features such as emergency notifications, GPS tracking, and anonymous reporting [13]. While effective, their deployment in developing countries has been limited due to infrastructural, financial, and contextual barriers [4].

Compared to these global solutions, the proposed system for higher institutions offers several distinguishing advantages:

i. Contextual Adaptation: Tailored to the infrastructural realities of Nigerian universities, with lightweight features and optimized bandwidth usage.
ii. Localized Integration: Supports direct communication with campus-specific emergency units rather than relying solely on external agencies.
iii. Enhanced User Awareness: Includes simple interfaces and one-tap SOS functionality designed to be usable even under stress.
iv. Privacy-Conscious Design: Incorporates anonymous reporting and encrypted communication, addressing privacy concerns often overlooked in similar systems.

B. Strengths of the Proposed System

The proposed system exhibits several notable strengths. It provides a unified platform that brings together emergency alerts, incident reporting, and communication within a single application, thereby simplifying safety management for both users and security personnel. During evaluation, the system demonstrated a rapid response capability, with significant reductions in emergency handling times compared to traditional methods. Furthermore, it promotes user empowerment by enabling students and staff to take an active role in campus safety through direct reporting and participation. Finally, the system shows strong adaptability, as its scalable design allows for deployment across universities in Nigeria and similar contexts.

C. Challenges and Limitations

Despite its strengths, the system also exhibits challenges:

- Network Dependency: Internet connectivity issues can delay notifications and GPS tracking.
- Battery Consumption: Continuous GPS usage drains mobile device batteries faster.
- External Integration: The current version is not fully integrated with external emergency services such as local police or hospitals.
- Alert Fatigue: Excessive notifications may reduce attentiveness over time.

D. Implications for Future Deployments

The results suggest that mobile safety applications tailored to local contexts can substantially enhance campus safety in developing regions. Future integration with IoT devices (smart locks, surveillance drones), AI-based threat detection, and offline-first features could further expand functionality. Additionally, forming partnerships with external emergency agencies would extend the system's reach beyond the campus environment.

VI. Conclusion and Future Work

This paper presented the design and implementation of a campus safety application tailored to higher institutions. By integrating a mobile application, an administrative dashboard, and a secure Supabase backend, the system provides a unified platform for real-time emergency alerts, incident reporting, and geofenced notifications. Evaluation results demonstrated a 70% reduction in emergency response times and a 90% improvement in incident reporting accuracy, highlighting the potential of mobile safety applications to transform campus security in developing regions.

The proposed solution contributes to the literature by addressing persistent gaps in campus safety technologies:

1. **Fragmented Communication** was reduced through a unified reporting and alerting platform.
2. **User Awareness** was enhanced through intuitive interfaces and one-tap SOS functionality.
3. **Contextual Limitations** were mitigated by designing a lightweight and locally adapted system for the Nigerian university environment.

The proposed system demonstrates several key strengths. It offers a unified platform that integrates emergency alerts, incident reporting, and communication into a single application, thereby streamlining safety management for both end users and security personnel. Evaluation results further confirmed its rapid response capability, showing substantial reductions in emergency handling times when compared with traditional reporting methods. In addition, the system enhances user empowerment by enabling students and staff to actively participate in campus safety through direct reporting and engagement. Finally, the design exhibits notable adaptability, as its scalable architecture supports deployment across universities in Nigeria and comparable educational environments.

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