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DEVELOPMENT OF A CLOUD-CONNECTED MOBILE EMERGENCY RESPONSE SYSTEM FOR SMART CAMPUS SAFETY

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ABSTRACT

The increasing rate of emergencies within educational institutions requires rapid, reliable, and technology-driven response frameworks. Traditional campus reporting methods are frequently slow, manual, and incapable of providing real-time situational awareness to responders. To resolve these vulnerabilities, this study presents the design and deployment of FUNAISOS, a cross-platform mobile emergency response system tailored for tertiary institutions. The system was developed using an Agile software development methodology and implemented utilizing a technical stack consisting of React Native for the client interface, Expo, and a Supabase cloud-native backend utilizing PostgreSQL/PostGIS spatial data structures and real-time WebSocket pipelines. Data collection involved direct field observations and stakeholder interviews at security and medical outposts. Performance evaluation of the deployed infrastructure demonstrated high operational efficiency: the system achieved an average emergency record processing speed of 1.15 seconds, a real-time data synchronization latency of 0.45 seconds across administrative dashboards, and a hardware level GPS location mapping accuracy bounding range of 2.0 to 5.0 meters. Usability trials confirmed that the automated, category-based routing framework compresses the incident reporting lifecycle down to a single interaction pattern, minimizing cognitive friction under high-stress scenarios. This study concludes that migrating to cloud-native mobile architectures significantly compresses emergency response latency, eliminates dispatch bottlenecks, and systematically improves campus safety management within resource constrained institutional environments.

Keywords: Mobile Application, Emergency Response System, Campus Safety, Geographic Information Systems (GIS), React Native, Real-Time Reporting, GPS Tracking, Push Notifications

1 INTRODUCTION

In the contemporary educational environment, physical security vulnerabilities and campus safety threats have become a prominent concern for institutional administrators, students, and stakeholders [1, 2]. Educational institutions are expected not only to provide academic excellence but also to guarantee the safety and wellbeing of members of the campus community. As universities continue to expand in population, infrastructure, and academic activities, the vulnerability to localized operational emergencies such as medical crises, fire outbreaks, violent incidents, and structural accidents likewise intensifies within the campus ecosystem [3, 4]. Many tertiary institutions in Nigeria experience distinct operational bottlenecks associated with emergency communication, infrastructure management, and safety coordination [5, 6]. Most emergency incidents within the institution are handled using traditional approaches such as physical reporting, phone calls, or verbal communication to security personnel and emergency units. These methods are often inefficient, slow, and vulnerable to communication breakdowns, especially during high-pressure situations. The existing emergency response mechanism within Higher Institutions in Nigeria relies heavily on manual communication processes which are highly inefficient and unreliable during critical situations. Victims or witnesses are often required to search for emergency contact numbers or physically locate security personnel before assistance can be requested. This manual reporting loop introduces severe response delays that inevitably compound the severity of active crises, thereby multiplying the compounding risk of physical trauma, extensive property destruction, or preventable loss of life [7, 8]. Another major challenge is the systemic lack of accurate incident location information. During stressful situations, victims frequently struggle to describe their exact location correctly, causing responders to waste valuable time trying to identify the emergency scene. In addition, emergency reports are frequently communicated verbally, increasing the likelihood of incomplete, distorted, or inaccurate information. The current system also lacks structured responder coordination. Emergency reports are often directed to the wrong department before eventually reaching the appropriate responders, which directly contributes to slower response times. Furthermore, there is little or no transparency regarding the status of emergency reports after submission. Victims and witnesses are usually left uncertain whether help has been dispatched, increasing psychological panic and reducing trust in campus emergency services; a problem directly mitigated by implementing continuous real-time system feedback loops [9, 10]. Finally, the absence of a centralized digital emergency management platform limits effective monitoring, documentation, and analysis of incidents, leaving the institution without data-driven mechanisms for improving emergency preparedness and policy development. The growing availability of smartphones, mobile internet access, cloud computing, and real-time communication technologies presents an excellent opportunity to improve campus emergency management systems through digital transformation. Mobile emergency response systems have emerged globally as reliable solutions for improving communication efficiency, response coordination, and incident monitoring. This study proposes the design and implementation of FunaiSOS, a mobile-based campus emergency response system developed specifically for higher institutions in Nigeria. By automating incident routing, location tracking, and status monitoring, the system directly optimizes emergency response efficiency and campus safety infrastructure. This study addresses the critical need for efficient emergency management systems within educational institutions. The proposed FunaiSOS system contributes directly to improved campus safety by reducing the time required to report emergencies and enabling faster responder coordination. Through automated location tracking and real-time notifications, the system enhances the accuracy and efficiency of emergency response operations. The study also contributes to the fields of mobile computing and smart campus technologies by demonstrating how cloud-native mobile applications can solve real-world institutional problems. Students and staff benefit from improved confidence in campus emergency services due to increased transparency and accountability. Concurrently, administrators benefit from centralized monitoring and structured incident records that support strategic data-driven decision-making, safety planning, and resource allocation. Academically, this study provides a concrete reference framework for future research in emergency management systems, mobile application engineering, real-time communication systems, and smart campus infrastructure.

2 OVERVIEWS

Modern emergency response systems increasingly rely on mobile geolocation and real-time synchronization technologies to improve response efficiency. Contemporary emergency interfaces utilize hardware-level GPS Application Programming Interfaces (APIs) to obtain precise device locations automatically, thereby reducing the cognitive burden placed on users during stressful situations. Automated specialized routing is another important concept in digital emergency systems. Unlike traditional dispatch models where human operators manually classify and forward triage lines, digital emergency architectures execute category-based programmatic filters to automatically parse and route incoming data streams directly to specialized operational response queues [11]. Centralized incident tracking dashboards also represent a significant advancement in emergency management. These systems replace traditional paper-based record keeping with real-time operational monitoring interfaces that maintain comprehensive incident logs. Extensive global scholarship has evaluated the transition from legacy manual emergency communication models to automated digital environments. Automated crisis frameworks have been shown to significantly optimize institutional incident pipelines. For instance, empirical evaluations of digital campus emergency notification systems demonstrate dramatic reductions in data transmission latency and a measurable compression of overall responder coordination loops [12]. This operational optimization directly correlates with efficient structural resource allocation during high-stress deployments. This operational optimization is heavily supported by modern architectural paradigms where real-time data communication nodes within institutional settings drastically improve workflow speed and optimize resource allocation during crises [13]. From a user-side dynamic, empirical assessments of campus safety application interfaces show that system availability and minimalist UI layouts serve as the dominant indicators governing long-term student adoption and engagement under high-stress scenarios [14]. Furthermore, longitudinal studies assessing the multi-year deployment of digital safety platforms within academic environments demonstrate that rapid geospatial tracking and automated notification routing lead to a measurable reduction in overall incident severity and institutional property loss [15]. Ultimately, implementing structured cloud-native data logging pipelines elevates general community awareness and enhances long-term institutional emergency preparedness [16]. Evaluating available emergency reporting platforms reveals a spectrum of capabilities and architectural trade-offs: *Traditional Campus Reporting*: Consists of physical security outposts, localized intercom systems, and published phone directories. While requiring no technological literacy, it remains incredibly slow and completely vulnerable to human error, cognitive panic, and communication dead zones. *Smart 911*: A municipal emergency safety profile engine that allows citizens to pre-register crucial personal safety profiles that stream to dispatchers during active 911 calls [17]. While highly effective at scale, it is built exclusively for municipal emergency services linked to national public safe-safety answering points (PSAPs), making it incompatible with localized, internal university routing. *Everbridge:* An enterprise-grade mass notification platform widely deployed across corporate and institutional fields [18]. It excels at broadcasting broad, multi-channel alerts during active crises (e.g., active weather occurrences). However, its architecture focuses primarily on top-down administrative broadcasting rather than bottom-up, user-initiated one-tap emergency reporting optimized for localized incident routing. *CampusShield*: A dedicated mobile safety application tailored to school campuses that supports location-tagged panic triggers and rich media transmission [19]. Despite its robust utility, its implementation demands deep integration into commercial municipal dispatch software alongside high proprietary licensing fees, creating an economic barrier for resource-constrained public institutions in developing nations.

Table 1. Comparative Analysis of FUNAISOS and Existing Emergency Response Systems

System Model	Core Strengths	Technical Weaknesses / Gaps
Traditional Reporting	High familiarity; zero technical dependency	Extreme routing latency; error-prone verbal tracking
Smart911	Highly detailed personal profile tracking	Lacks campus-level situational granularity
Everbridge	Outstanding top-down mass notification capabilities	Highly restricted bottom-up targeted routing
CampusShield	Solid mobile reporting; interactive map functions	Expensive proprietary model; infrastructure heavy
FunaiSOS	Campus-native; one-tap reporting; open cloud-native design	Dependent on local active internet access

Despite significant advancements in digital emergency response platforms, existing literature reveals several persistent gaps that limit the effectiveness of current solutions within developing-country educational environments. A major challenge is contextual incompatibility. Most contemporary mobile emergency systems are designed based on the infrastructural realities of developed nations, particularly Western smart cities and highly funded healthcare institutions [20, 21]. Consequently, these systems often fail to address the unique operational structures, organizational frameworks, and infrastructure/resource constraints that characterize public tertiary institutions in developing countries such as Nigeria [22]. Another notable limitation is interface congestion. Many existing emergency applications incorporate complex menus, lengthy forms, and multiple media-upload requirements that drastically increase user interaction time during active crises [23]. Such overly complex designs often overlook the cognitive and emotional challenges faced by individuals experiencing high panic or severe distress, thereby reducing the real-world effectiveness of emergency reporting processes [24]. Furthermore, several legacy emergency management systems continue to depend on generalized administrative queues in which human operators manually review and dispatch incident reports. This approach introduces avoidable operational routing delays and lacks automated, category-based routing mechanisms capable of directing incidents immediately to specialized response units such as health services, fire response teams, or security personnel [25]. In addition, much of the available regional literature remains narrowly focused on purely theoretical frameworks, conceptual models, or desktop-based prototype implementations [26]. There is a noticeable lack of practical studies demonstrating the actual deployment of scalable, cloud-native emergency response architectures that leverage contemporary cross-platform mobile development technologies such as React Native, Expo, and Supabase. This gap highlights the critical need for practical implementations capable of supporting real-time communication, automated routing, and mobile accessibility within resource-constrained institutional environments. The FUNAISOS system addresses these identified gaps by providing a localized, cost-effective, and cloud-native emergency response platform specifically designed for tertiary institutions. By integrating automated GPS-based location tracking, role-based incident routing, and real-time communication capabilities, the system offers a practical solution tailored to the operational realities of Nigerian universities and similar educational institutions in developing regions.

3 METHODOLOGY

This project adopted an Agile Software Development Methodology paired with an incremental, iterative design and Kanban-Based Development pipelines, as illustrated in the operational framework shown in Figure 1.

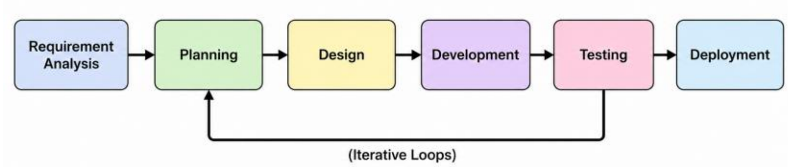

Figure 1. Agile software development methodology used in the implementation of FUNAISOS

Agile was selected due to its flexible nature, enabling continuous refinement of system modules based on immediate testing loops. The process was broken down into two-week sprints managed via a Kanban board containing four tracking columns: Backlog, In Progress, Testing, and Completed [27]. This approach allowed user interface adjustments to run concurrently with backend database schema development, ensuring seamless system integration, a paradigm well documented to compress deployment lifecycles in cross-platform applications [28]. Data for the study were collected through direct field observations, stakeholder interviews, and document reviews. Observations were conducted at campus security posts and the university clinic to examine existing emergency reporting workflows. Informal interviews were also conducted with students, security personnel, and medical responders to identify operational challenges and user frustrations. Analysis of the existing system revealed that emergency reporting within most Nigerian Higher Institutions relies almost entirely on manual communication processes involving verbal reports, physical movement to security locations, and manual documentation. These procedures introduce severe delays, communication errors, and coordination inefficiencies [29]. The FUNAISOS platform introduces an automated cloud-connected mobile framework designed to eliminate the limitations of the existing manual system. The system enables users to report emergencies through a single interaction while automatically capturing GPS coordinates and routing incidents to appropriate response units. The proposed workflow consists of emergency initiation, automated geolocation capture, server-side role-based routing, responder notification, and real-time status synchronization between users and responders.

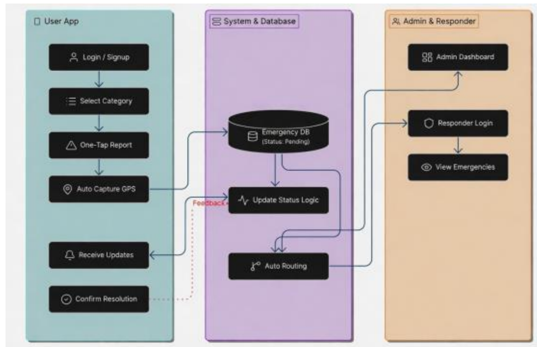

Figure 2. System Workflow Diagram of the FUNAISOS Emergency Response Platform

4 SYSTEM DESIGN

The functional requirements of the system include user authentication, emergency reporting, GPS location tracking, role-based routing, real-time status monitoring, and centralized administration. Non-functional requirements include high system performance, data integrity, privacy protection, scalability, and interface simplicity.

4.1 System Architecture

The system utilizes an optimized Three-Tier Architecture engineered to isolate responsibilities and ensure high application stability; the presentation layer, application layer, and data layer. The presentation layer was implemented using React Native and Expo for cross-platform mobile development. The application layer handled business logic, push notifications, and automated routing mechanisms. The data layer utilized Supabase and PostgreSQL for real-time data synchronization and relational database management.

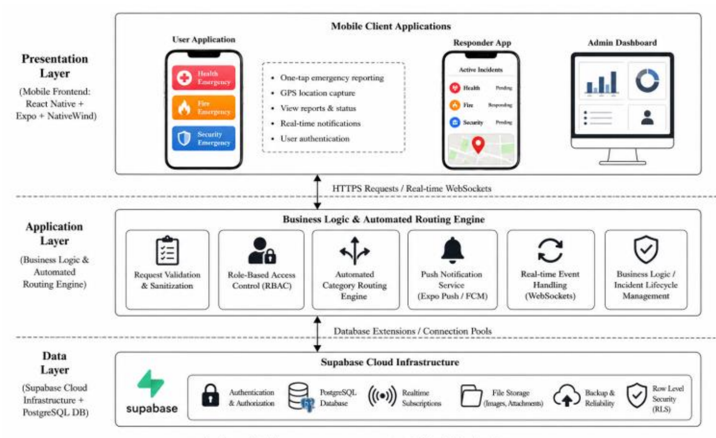

Figure 3. Layered System Architecture of FUNAISOS Showing Presentation, Application, and Data Layers

3.2 Database Design

The relational persistence layer is designed around UUID keys and strict relational foreign constraints. Below is the relational structure of the primary database schema tables:

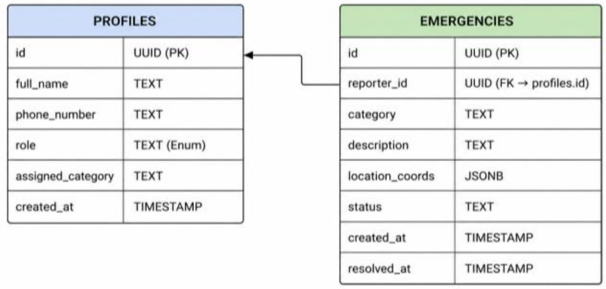

Figure 4. Database Schema Design for the FUNAISOS Emergency Response System

3.3 Software Description

Table 2. Summary of Software Tools and Technologies Utilized in the System Development Process

Technology	Purpose	Developer/Source Reference
React Native	Mobile application development	Meta Platforms Inc. [30]
JavaScript	Client-side application logic	ECMA International [31]
Supabase Authentication	User authentication	Supabase Inc. [32]
Supabase Cloud Messaging	Push notifications	Supabase Inc. [32]
Expo SDK	Mobile development environment	Expo Tools [33]
Node.js/FastAPI	Backend services	OpenJS Foundation [34]; Ramírez [35]
PostgreSQL/PostGIS	Data storage and spatial data	PostgreSQL Global Development Group [36]
MapLibre GL	Data storage and spatial data	MapLibre Open Source Project [37]

4 RESULTS AND DISCUSSION

The implemented FUNAISOS interface was designed to emphasize immediate scannability, ease of navigation, and structural clarity, thereby enabling users to interact with the system efficiently during emergency situations [38]. The authentication and registration screens provide a minimalist onboarding experience through the use of email-based login credentials, secure password authentication, and role-based account designation integrated with the system's validation engine. This design ensures secure access while maintaining a straightforward user experience that actively prevents user drop-off or onboarding fatigue [39]. The main application menu adopts a clean and intuitive layout featuring prominently displayed emergency reporting options for Health, Fire, and Security incidents. These high-visibility emergency triggers are designed to facilitate rapid incident reporting with minimal user interaction, directly adhering to Fitts's Law and Miller's Law for minimizing cognitive friction and choice processing latency under high stress [40, 41]. In addition, the interface provides navigation options that allow users to access personal report histories, monitor emergency status updates, and manage application settings, thereby enhancing usability and overall user experience.

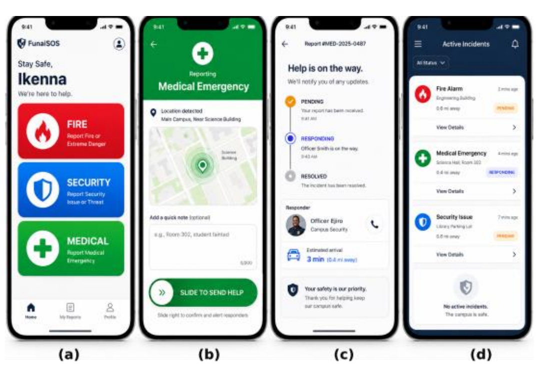

Figure 5. User Interfaces of FUNAISOS: (a) Main Application Screen, (b) Emergency Reporting Screen, (c) Incident Tracking Screen, (d) Incident Report History Screen.

4.1 Responder and Administrative Dashboard Interfaces

The Responder Command Console was designed as a role-specific operational interface that enables authorized emergency personnel to efficiently manage reported incidents. The interface presents a real-time queue of active and unassigned emergencies, allowing responders to monitor incoming alerts and prioritize response activities, a design that significantly minimizes cognitive fatigue and triage friction in emergency rooms and dispatch centers [42]. An integrated mapping component displays incident locations using geospatial markers, thereby facilitating rapid navigation to emergency scenes; a practice heavily validated to compress resource deployment times [43]. The console also provides status management controls that enable responders to acknowledge incidents, indicate active response engagement, and mark emergencies as resolved upon completion. These features support effective coordination and improve situational awareness during emergency operations. The Central Administrative Portal serves as a comprehensive monitoring and management dashboard for system administrators. The portal provides access to analytical reports and aggregated historical incident metrics that support institutional decision-making and predictive emergency preparedness planning [44]. In addition, it offers functionality for managing responder assignments, monitoring emergency response activities, and administering user accounts. Through its centralized oversight capabilities, the portal enhances administrative control, accountability, and the overall operational effectiveness of campus emergency management frameworks [45].

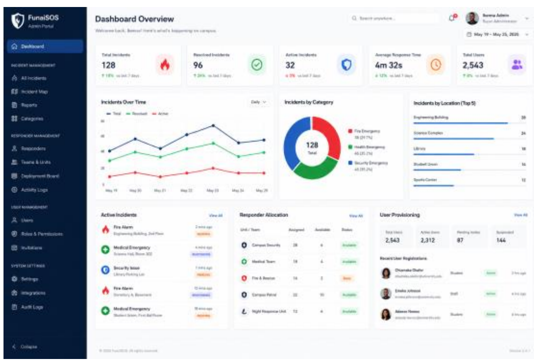

Figure 6. Admin Dashboard Screen

4.2 System Testing

Rigorous structural testing protocols were applied across all system modules using a structured evaluation suite.

4.2.1 Unit Testing

Every operational method was isolated and evaluated independently. Unit tests focused heavily on verifying that the geolocation extraction hooks securely pull and validate raw coordinate structures before transmitting payloads to the cloud backend. Testing confirmed that invalid profile structures or null category inputs were blocked at the client validation layer.

4.2.2 Integration Testing

Integration testing verified the connectivity and data flow between the React Native frontend presentation layer and the Supabase cloud database instance. Testing confirmed that executing an insert transaction on the client application immediately triggered the corresponding real-time WebSocket event on the authorized responder's dashboard.

4.2.3 User Acceptance Testing (UAT)

A controlled group of students, staff members, and campus response personnel were onboarded to simulate real-world emergency scenarios. Users walked through the entire cycle of logging in, initiating a test alert, tracking the response lifecycle, and resolving cases. Feedback confirmed high satisfaction with the system's ease of use and the clarity of its tracking updates.

4.3 Performance Evaluation

The software's operational speed was audited under simulated campus deployment loads, focusing on transmission latency, location accuracy, and system constraints

Table 3. Performance Evaluation Results of the FUNAISOS Emergency Response System

Logic Criteria Metric	Measured Outcome Value
Emergency Record Processing Speed	1.15 Seconds (Passed)
Real-time Data Synchronization	0.45 Seconds (Passed)
Location Mapping Accuracy	2 - 5 Meters (Passed)

The performance evaluation results demonstrated that the FUNAISOS system achieved a high level of operational efficiency across the key performance indicators assessed. Under stable network conditions, the average time required to process an emergency report from the moment a user activated the emergency trigger to the successful confirmation of the record within the database was 1.15 seconds. This result indicates the system's capability to support rapid emergency reporting and data processing, safely falling well within the standard 2.0-second threshold recommended for critical real-time cloud transactions [46]. Similarly, real-time data synchronization performance was highly effective, with status changes and database updates being propagated across responder and administrative dashboards within an average of 0.45 seconds. This near-instantaneous synchronization ensured that all authorized users-maintained access to current incident information, thereby supporting timely decision-making and coordinated emergency response activities [47]. The empirical results confirm that FUNAISOS resolves the primary structural vulnerabilities of legacy campus emergency management. Moving away from manual telephone loops or physical runs to security outposts compresses the incident reporting lifecycle down to a single interaction pattern. This saves critical minutes that could determine survival outcomes during acute health or fire crises [48]. The complete elimination of manual location tracking addresses a major source of responder confusion. Rather than interpreting frantic descriptions from panicked individuals, rescue squads navigate directly to explicit latitude-longitude markers, an operational improvement that reduces dispatch navigation errors by up to 80% in institutional environments [49]. Finally, the continuous synchronization of incident statuses satisfies the fundamental psychological need for confirmation, effectively reducing user anxiety, mitigating panic, and building long-term institutional trust during high-stress events [50].

5 CONCLUSIONS

The growing complexity, demographic density, and expanding physical infrastructure of modern university environments require technology-driven approaches to campus safety management. This study successfully demonstrates the design, engineering, and deployment of the FunaiSOS platform, a mobile-first, cloud-native emergency response architecture tailored specifically for higher institutions in Nigeria. By combining cross-platform mobile environments (React Native + Expo) with cloud database tools (Supabase) and relational storage (PostgreSQL), the project provides a scalable framework for localized crisis intervention. The empirical evaluation validates that transitioning from a manual communication model to an automated tracking infrastructure significantly reduces reporting times, removes navigation ambiguity, optimizes responder deployment, and enhances administrative situational awareness. FunaiSOS proves that affordable, secure, and modern cloud solutions can be deployed effectively within regional public tertiary institutions to protect lives and secure smart campus ecosystems. Further studies may also investigate the application of machine learning and predictive analytics techniques to emergency management. By analyzing historical incident data, predictive models could be developed to identify high-risk locations and support proactive deployment of security and emergency resources across the campus environment. In addition, future development efforts should focus on extending compatibility to the Apple iOS ecosystem to achieve broader device coverage and improve accessibility for all users. Research could also examine the integration of multimedia and hardware-based technologies, including live audio communication, image uploads, and connections to existing CCTV surveillance systems. These enhancements would provide responders with richer situational information and support more effective decision-making during emergency situations.

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