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An Ad-Hoc Crime Reporting Information Management System

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ABSTRACTS

Criminals often escape punishment due to delayed sharing of information with law enforcement agencies. The traditional method of reporting crimes is slow, thus, the need for a faster and modern approach, one that uses modern technology to apprehend perpetrators. It is therefore important to have a well-organized system for reporting criminal activities. This system should be free and easily accessible to the public. With information being delivered promptly and remotely, there is no need for visits to police stations, which can be time-consuming and tedious. This project aims to curb criminal activities by developing a smartphone application that enables victims or witnesses to report real-time information to security agencies, including GPS coordinates. The use of real-time data would prompt quick responses in emergency situations and make reactions proactive rather than reactive. The proposed methodology for the project involves designing and developing a user-friendly mobile app as well as a professional web application for security agencies. The creation of an integration platform allows for the registration of police stations and staff members. Feedback from users would help maintain and improve upon the app. Ultimately, this project aims at increasing public safety and improving crime reporting and management in Ghana by using modern technologies. By enabling citizens to report crimes in real-time, the mobile application has the potential to revolutionize crime reporting and foster a safer and secure environment. By collaborating with law enforcement agencies, the proposed solution can help provide a more efficient and proactive crime reporting system in Ghana.

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1. INTRODUCTION

Whenever the issue of "Crime" is raised, most minds are drawn to acts like murder, kidnapping, and terrorism – acts that threaten the lives of individuals. Much attention is not given to acts like theft, fraud, sexual harassment, and many other acts that might not put the life of individuals at risk. What is crime? The Advanced English Dictionary defines crime as an act punishable by law; usually considered an evil act. It also goes on to define it as an evil act not necessarily punishable by law. The former definition which talks about criminal law is termed in Latin as 'mala prohibita' and translates to 'bad because it is prohibited'. The latter describes acts against morality and is termed as 'mala in se' which translates to 'bad in itself' (Owusu-Gyan et al., 2022). A crime is typically an unlawful act that is subject to punishment by a governing authority. However, there is no universally accepted definition of the term "crime" in modern criminal law, although certain statutory definitions exist for specific purposes. Generally, the prevailing notion is that something is considered a crime if it has been declared as such by applicable laws. Crime definition of a crime is that it is an act that is harmful not only to an individual but also to a community, society, or the state, and therefore constitutes a "public wrong" that is punishable by law.

According to the Ghana Criminal Code of 1960, ACT 29 (Laryea & Kwansah-Aidoo, 2018), any unlawful act that results in harm to lives and property is considered a crime. These offences are punishable by death, imprisonment, or fines and constitute criminal offences against individuals or the state. Throughout history, people have tried to understand why individuals commit crimes. Some suggest that criminal acts are more lucrative than regular jobs. As of February 2023, Ghana registered a crime index of 44.5. The index measures the level of crime in each country or city. A crime index of 44.5 indicated that crime in Ghana was considered as being on a moderate level. In 2019, the level of crime in the country registered a peak of nearly 52 points and dropped each year since then to 46.81 by 2022 (Sasu, 2023).

In KNUST and its environs, crime is not anything new. Students fall victim to criminal activities, especially outside campus. In the contemporary world, technology is being used to improve all aspects of life. Security is a very vital aspect of life and thus the use of technology to improve our security is very necessary. The aim of this project is to demonstrate how crime fighting officials can use technology to analyze crime data and draw conclusions as to which areas are hotspots for criminal activities. It is also important to have mechanisms in place to nab criminals in the act of crime as chances of capturing them become difficult if they can escape. The creation of the software application is to capture ongoing criminal activities and report them to the appropriate authorities.

Although the volume of crimes committed has decreased in many cities, some crimes are not reported to authorities due to fear of involvement or the inconvenience of travelling to distant police stations. According to sources, there are four key factors to consider in investigating a crime: taking notes, securing the crime scene, managing evidence, and coordinating the response

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to the incident. Due to the lack of timely information sharing with law enforcement agencies, most criminals tend to get away with their crimes. The traditional method of reporting crime is rather slow and as such, there should be a more modernized and faster way of apprehending criminals with the use of technology. It is essential to have a process for reporting criminal activities that is well-organized and easily accessible to the public. The information received must be delivered quickly and remotely without having the need to visit the police station, which can be tedious and time-consuming. This problem can be alleviated by a smartphone-based application that transmits real-time information from victims or bystanders to security agencies along with geographic positioning system coordinates. The usage of real time data will encourage quick response in an emergency.

The crime reporting software aims at improving the processes used by law enforcement officials to apprehend criminals. With the transfer of audio-visual data, responding officers can access and analyze the level of threat of a crime even before they arrive at the crime scene. This helps them prepare adequately. This type of data is powerful as reporters might not be able to fully explain or communicate well the ongoing crime. The GPS coordinate system helps officers pinpoint the exact location of the crime. This is a crucial aspect of this software since it may be hard for those reporting the crime to identify the exact location they are. They might just be passers-by, or the location of incidence might be in a slum or a community with no landmarks or unnamed streets. There is also a feature which allows victims to contact the police in situations where there might not be enough time to write or capture what is going on. It can also be used where speaking or recording data might be fatal if caught.

The reporter of the crime and the responding agents keep in touch and progress updates are communicated. This might be important if the situation no longer requires the service of the police or there has been an escalation and backup is needed. The data transferred during crime reporting can be used as evidence to help in the investigation process. This data is stored, and such tampering of evidence is highly unlikely. The data stored is analyzed and a report is generated. This report helps the law enforcement agencies track the specific type of crimes that happen and in which specific locations along with the time. They can draw conclusions and identify hotspots of criminal activities. This also helps them to patrol better.

1. RELATED WORKS

Although reporting crime has many societal and individual benefits, it is common for criminal acts to remain unreported. Victims and witnesses have many reasons for not reporting a crime. Among these reasons, fear of repercussion, embarrassment, or shame, believing the crime is too insignificant or a personal issue, believing that reporting will not make a difference, and being unable to reach an authority are often cited. In the existing crime management system, most of the operations are done manually like sending complaints, taking actions against crimes, viewing status etc. Thus, with the existing system if one wants to make a complaint against crime, they must do it through the police. If the process is done manually, minor errors might occur (Jaiswal et al, 2023). The Ghana Police Service (GhPS) have

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implemented some computer technologies for crime database management which include an automated criminal records database, fingerprint identification system and the Case Tracker Software. However, there has been no technology produced to improve crime reporting.

Crime Stoppers, a non-profit organization that provides a way for the public to report crime anonymously. The software was brought into existence in 1976 (Carriere & Ericson, 1989). The group manages and keeps track of tips sent through its hotline or mobile app using software. The Crime stopper software is intended to handle and monitor anonymous tips about illegal activities. It is a useful tool for law enforcement organizations and neighborhood groups who wish to encourage people to report crimes without worrying about reprisal. In the journal article "Crime Automation & Reporting System" published by International Journal of Science and Modern Engineering (IJISME), Anil et al. (2013) worked on a project to develop an online crime reporting and managing system which was easily accessible to the public. This system registers complaints from people through an online platform to help the police department in catching criminals. People could make complaints at any time. "The proposed system can overcome all limitations of existing systems. The system provides proper security and reduces the manual work done. The Crime Records Management System applies to Police Stations across the country and specifically looks into the subject of crime prevention, detection, and conviction of criminals depending on a highly responsive backbone of Information Management. The efficiency of the Police and the effectiveness with which it tackles crime depend on what quality of information it can derive from its existing records and how fast it can have access to it (Jaiswal et al, 2023).

In 2015, Syed Mujtaba Raza (student) and Leelavathi Rajamanickam published a journal titled "A Proposed Solution for Crime Reporting and Crime Updates on Maps in Android Mobile Application" (Raza & Rajamnickam, 2015). The purpose of their research paper was to propose and develop an android mobile application for the public awareness of the crime situation in their area and to provide them with crime locations on the map. This application would also help the public to report a crime to law enforcement agencies. The android mobile application would also help the public to see the locations on maps which will help them to track the current situation of their surroundings. Their project focused only on people reporting crime so that other members of the community would know what was going on in their area in terms of the ongoing criminal activities and their exact location shown on a map. According to the workflow of their project, the information or evidence attached is a photo. Their project greatly helps combat crime as citizens can report ongoing crimes. Notifications are also sent out to other members of the community indicating where exactly on a map a criminal activity is taking place. It also does well to include visual information in reporting. Nevertheless, the project failed to include a system that would generate reports. The generation of these reports would help law enforcement analyze big data to be able to draw certain conclusions such as what types of crimes occur more often and at what day and

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time they mostly occur. This would help law enforcement utilize their patrol sessions. The use of pictures as evidence might not be enough as they might not provide enough context of the incident. The quality of the picture might be bad and end up not being helpful in the investigation process. This project focuses on using audio-visual data as evidence as they provide a much clearer context.

In May 2020 Ring LLC launched an application called Neighbors. Ring LLC, a division of Amazon.com Inc., is the owner of the hyperlocal social networking application (Neighbors) which allows users to have private conversations about crime and public safety in their neighborhood. Users may share pictures and videos captured by the devices' cameras to go along with their postings because it is integrated with Ring's smart doorbell and security camera solutions. The app is also utilized in collaborations between Ring and regional law enforcement organizations, who may broadcast verified public service announcements on the platform and use an online portal to gather footage from neighbors that can help with investigations (Joy, et al., 2022). In Ghana, crime reporting is carried out manually. In the case of the existing manual method, all records are stored in recorded form and are kept in various kinds of registers. The manual technique is unsuitable for maintaining records and data on crimes and offenders. The existing police system is not automated. Crime histories are manually recorded. Case files are housed on shelves, with some stacked high. There are some case files which are piled up in heaps. These important documents quickly accumulate dust, and poor storage causes serious harm to some criminal histories. Finding a known criminal, getting access to a suspect's past criminal history, and finding out the status of some closed cases all become exceedingly difficult, if not impossible, under these conditions. Staff personnel at police stations handle file processing, therefore the workload delays the criminal's information. Data redundancy, record updating, backup, and recovery are also problems (Vijetha et al, 2022). Vijetha et al. (2022) created a web application for crime reporting and analysis using machine learning. Their project used text and voice recordings as information or evidence when making a complaint against the police. It also focused on using data analytics and machine learning to predict crime - an aspect which would be incorporated in our work.

In the Sub-Saharan Region of Africa, similar work has been done. In 2023 Joseph et al. developed a software system for real-time management of crime reports in southwestern Nigeria (Akinyede et al, 2023). Their work addresses everything this project aims to achieve except for one feature - the introduction of a panic button. The work by Joseph et al. was almost done to perfection. It provides a platform for reporting crime and encourages the submission of photos and videos as evidence. It also generates reports which can be analyzed by law enforcement to identify crime trends and patterns. However, it fails to account for situations where reporters are victims of the crime and might not have enough time to report. In Ghana, similar works have been published, especially in the Ghana Journal of Technology. Duffour et al. worked on a GIS Mobile Application for Crime Reporting and Monitoring although their project focused mainly on crime monitoring (Duffour et al, 2023).

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The Station officer, District crime officer and System Administrators were the users of the software. These officers used the software to record crime and complaints. The article sought to map crime data, identify hotspots, and present patterns using GIS technologies to enhance data collection, visualization and informed decision making. Graduated symbol maps were used to represent the types of crime prevalent in La Dade Kotopon municipality. Their work did not focus on trying to curb ongoing crime and thus made their work more reactive than proactive.

iWatchDallas (iWatch Dallas, 2019) is a mobile crime monitoring program that allows residents of Dallas to report any suspicious or illegal activities. It is a proactive, hands-on collaboration between the residents of Dallas, and the Dallas Police Department to create a safer environment. iWatchDallas focuses on criminal activity and criminal businesses that may have connections to terrorist operations. Citizens are given an easy anonymous reporting tool to offer police tips and leads about crime that affects them and their neighborhood. In (Bhutto et al, 2015), an android application idea was presented to broadcast a video to help in stopping street crime. SVS (Social Video Streaming) enabled mobile users to stream live videos of street crimes anywhere, using 3G/4GLTE or Wi-Fi connection. This proposed prototype would provide a facility of live streaming of crimes onto a server through a mobile device which would let police or law enforcement agents get information on the spot to enhance more robust policing. (Khandoker et al, 2019) is an application for android for women's safety though men can also use it at a distress situation. It can be activated by voice command or SOS key. An alert message with location is sent to the user defined numbers every five minutes until the system is turned off.

(Tabassum et al, 2018) proposed an application that can be used by the individuals in Riyadh to report and manage their complaints. Further the system can be used by the people to register the complaints and was helpful to the police department in identifying the criminals. The main purpose of the application was to improve the effectiveness and efficiency of interaction procedures between the police officials and common people. It is a tool to monitor and track criminals around the country and have a complete online record of crime related information. (Lal et al, 2016) proposed a smart system that can be implemented for immediate crime reporting to enhance crime reporting which is highly required in today's scenario. (Maghanoy et al, 2017) would alert students of a crime that had taken place through their smartphones. This research would benefit both the local police and citizens living in Metro Manila.

Tzay-Farn et al proposed an online illegal event reporting scheme based on cloud technology, which combines digital certificates, symmetric keys, asymmetric keys, and digital signatures. The proposed scheme could process illegal activity reports from the reporting event to the issuing of a reward. The scheme not only ensures informers' safety, anonymity, and non-repudiation, but also prevents cases and reports being erased, and ensures data integrity. Furthermore, the proposed scheme was designed to be robust against abusive use

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and was able to preclude false reports (Tzay-Farn et al, 2019).

Security is a very crucial aspect of life and as such any threats to safety are scrutinized. There has been a lot of research done on crime and quite a few groups have come up with software solutions for crime reporting and monitoring. Most of the work produced was systems for filing complaints using software as visiting the police station might come along with its own problems. Some projects went along to generate data and analyze crime patterns. Unfortunately, most of the works produced in relation to this project topic failed to consider situations where those reporting the crime might be in danger. It also fails to consider situations were taking pictures or recording evidence of crime might be fatal. For example, if there is an armed robbery going on in a home, the victim would not be able to fill all fields required in the complaints form as it may be time-consuming or even fatal if they are caught. As such, the introduction of a 'critical' button or feature allows victims to report incidents where time is limited, or their lives might be jeopardized if they are caught trying to report. This 'critical' feature would generate an alert of the highest priority to the closest agency. This would greatly help in dire situations such as hostage situations, kidnapping, and abduction.

2. METHOD

2.1. System software architecture

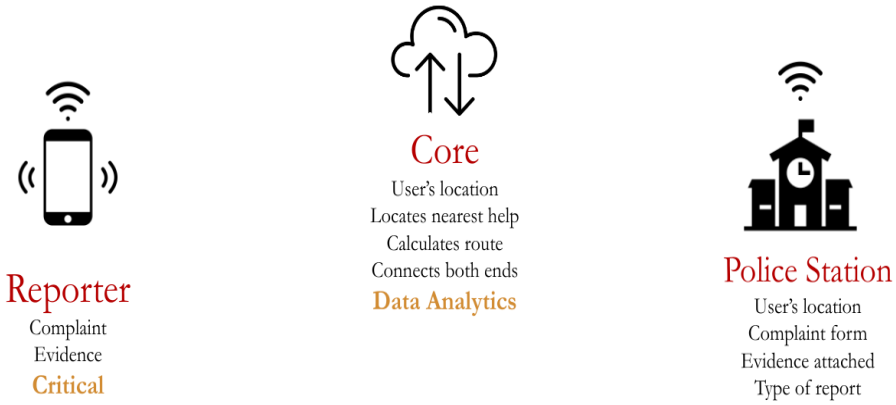

Fig. 1. Software system architecture

Figure 1 shows a visual overview of the proposed software information system. The system comprises mainly three ends that communicate seamlessly for quick reaction times in emergencies. The details of each segment are highlighted as follows:

2.1.1. Reporter's End

The reporter of the crime picks up a phone with the software application installed on it and makes a report or complaint. The user would also be able to attach evidence in an audio-visual form. The reporter's end sends the data to the core of the system wirelessly. This data includes the reporter's location, the report submitted, and the evidence attached if any. There is also a feature called 'critical'. This feature can be used in situations where there is little or no time to fill a report, for example, a kidnapping or an armed robbery. In such situations, the reporter's location is sent alongside an alarm requesting paramount attention.

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2.1.2. The Core

The core of the system then calculates and locates the nearest help centre. It sends the data submitted by the reporter to the police station. The core is also responsible for generating data analytics for the police station.

2.1.3. Receiver's End

The police station receives the reporter's data and calculates the route to the reporter's end. It also displays data for analysis.

2.2. System software development and tools

The software development process typically begins with Requirement Gathering and Analysis, followed by the System Design phase. During Requirement Gathering, the Software Requirement Specifications document is created, which serves as input for the System Design phase (Ruparelia, 2014; Kute & Thorat, 2014; Despa, 2014). In the System Design phase, Software Architecture and Design documents are developed, which in turn serve as input for the next phase, i.e., Implementation and Coding. During Implementation, coding is carried out, and the resulting software is the input for the testing phase. In this phase, the software is rigorously tested to identify any defects. Any defects found are logged into a defect tracking tool and retested once they are fixed. This process of bug logging, retesting, and regression testing continues until the software is in a go-live state. Once the testing phase is complete, the software is moved into production during the Deployment phase, after receiving sign-off from the customer. If any issues arise in the production environment, they are resolved by the developers during the maintenance phase.

The Waterfall model is a straightforward approach to software development where each phase is completed sequentially in a step-by-step manner. Well-defined deliverables are assigned for each phase, reducing complexity, and making the project easier to manage. The model is a simple and easy-to-understand approach to software development that can help project teams to stay on track and deliver the project on time and within budget (Despa, 2014). The Waterfall model has well-defined objectives and deliverables for each phase of the project, which helps project teams to stay focused and on track throughout the development process. The model involves completing each phase of the project before moving on to the next, which can help project teams to use their resources efficiently and minimize the risk of scope creep and it emphasizes the importance of documentation, which can help project teams to create a detailed record of the project and ensure that all stakeholders have a clear understanding of the project objectives and requirements.

Table 1 contains the various software tools used for the development of this crime reporting system software.

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Table 1. System application software tools

Tools	Purpose
Gitlab	GitLab is a web-based Git repository manager that provides Git repository hosting, continuous integration, and continuous deployment (CI/CD) capabilities. It is a platform that helps to manage software development processes, from code version control to testing, deployment, and monitoring. GitLab provides a centralized platform to store and manage code repositories, which helps to keep track of changes and collaborate with other team members more effectively (GitLab, 2023).
Language and Frameworks	For the development of the software system, the MERN stack was used. The MERN stack is a popular web development technology stack that combines four key technologies: MongoDB, Express.js, React.js, and Node.js. Each letter in "MERN" represents one of these technologies. Together, they provide a full-stack framework for building modern web applications.
ReactJS	React JS was used as the framework for developing the webapp on the receiver's end. It is a popular JavaScript library for building user interfaces for web applications. It was developed by Facebook and is now widely used by developers around the world. React JS is a component-based library, which means that one can build a user interface as a series of independent, reusable components. This approach makes it easy to manage complex user interfaces, and allows developers to build UIs that are flexible, scalable, and easy to maintain (React Dev, 2023).
React Native	React Native was used for the development of mobile applications. It is a popular JavaScript framework for building mobile applications for iOS, Android, and other platforms. It was also developed by Facebook, and it allows developers to use the same codebase to build native applications for multiple platforms. React Native uses a similar approach to ReactJS, with a component-based architecture that allows developers to build complex mobile user interfaces using reusable components. This makes it easy to maintain and update the UI of the application and ensures that the codebase is flexible and scalable (React Native, 2023).
MongoDB	MongoDB is a popular NoSQL database that is well-suited for building modern web applications. It is a document-oriented database, which means that it stores data as documents, rather than in tables like a traditional relational database. One of the key benefits of using MongoDB for database management is that it is highly scalable and flexible. It is designed to handle large amounts of unstructured data, and it can easily scale horizontally across multiple servers to handle increased traffic or data storage needs (Agrawal, et al., 2015).
NodeJS	Node JS is a popular JavaScript runtime environment that allows developers to build server-side applications using JavaScript. It uses an event-driven, non-blocking I/O model, which makes it lightweight and efficient, and allows it to handle many concurrent requests. Node JS is well-suited for building scalable and high-performance server-side applications, particularly those that involve real-time data processing, such as chat applications or streaming services. It also offers several tools and frameworks for building APIs and web services, such as Express JS. These frameworks provide a range of features and tools for building RESTful APIs, handling authentication and authorization, and integrating with databases and other services (Node JS, 2023).

2.3. System software build-ups

This software architecture system as depicted in Fig. 1 and 2 serves as the foundational blueprint for web and mobile applications. Just as an architect meticulously plans and designs the framework of a building before construction begins, software architecture

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involves careful planning and conceptualization of a software system to meet its intended purpose and fulfil the requirements of its users. Well-designed architecture can lead to a robust, flexible, and adaptable software solution that stands the test of time. As shown in Fig. 2, the main components of the system are the mobile app, business logic, integrations platform and police dashboard. These components are explained in detail in the following subsections.

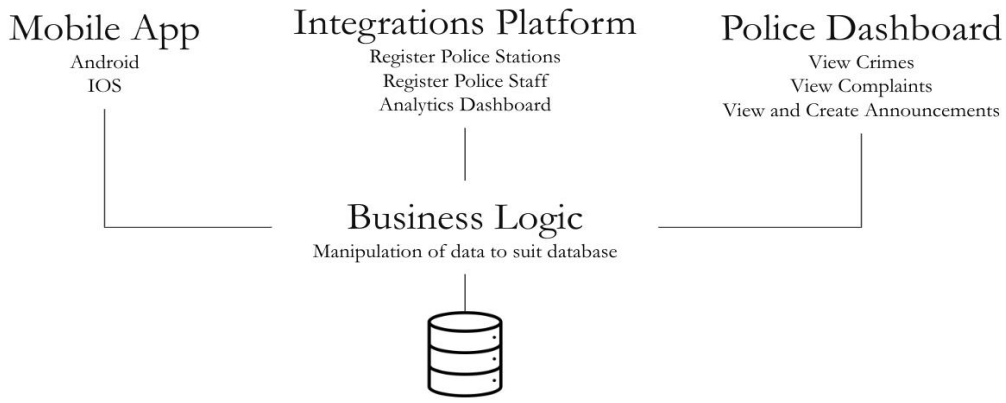

Fig. 2. Software system high level architecture

The mobile app is the only segment of the system that is released to the public. Mobile users, both android and iOS can install this software using bundled packages. The app provides users with the ability to report ongoing crimes and attach images or videos as evidence. It also has an announcement board which displays information posted by the police. The software is very simple and easy to use. The UI theme is very convenient and portrays a calming tone to help users relax as it is used in emergency situations (Macaranas & Riecke, 2015). The purpose of the mobile app is to create a seamless and efficient platform for community members to report criminal activities and enhance neighborhood safety. With its user-friendly interface and essential features, this app enables citizens to: File Complaints Easily: Report complaints without the need to visit the police station, streamlining the reporting process and encouraging more people to come forward. Report Ongoing Crimes: Provide real-time reporting of ongoing criminal activities, with the capability to attach video, audio, and picture evidence, helping law enforcement respond promptly. Priority SOS Reports: Allow users to report high-priority crimes where time is of the essence, such as armed robberies and abductions, ensuring immediate attention from authorities. Announcement board: Informs users of announcements from the police.

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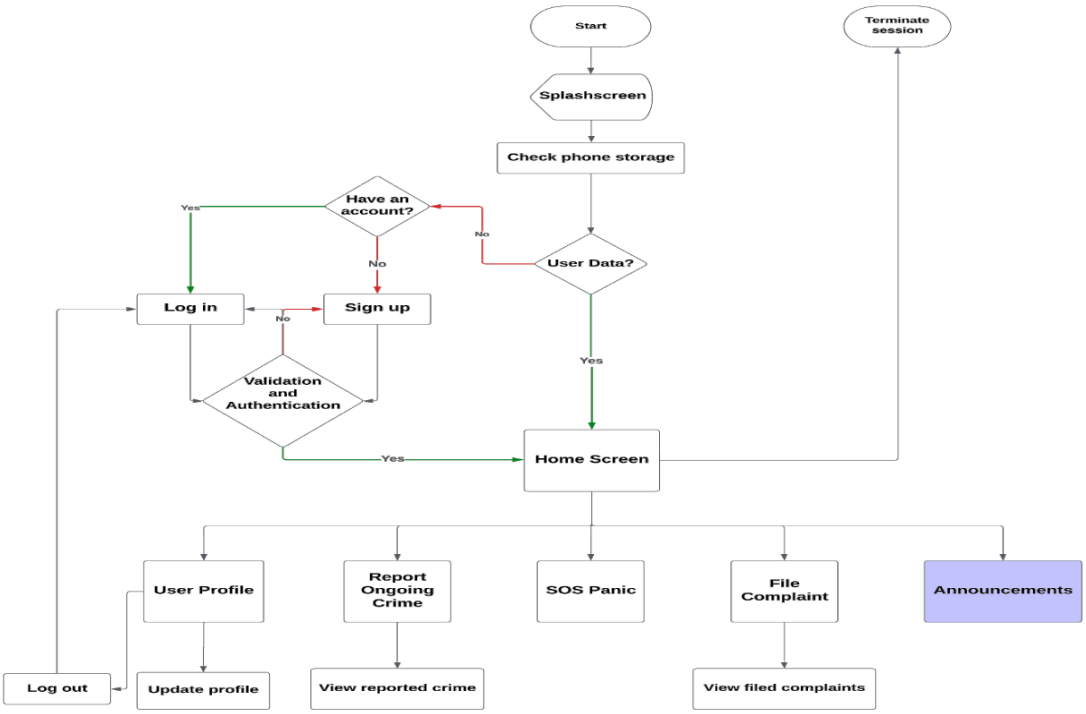

Fig. 3. Mobile application sequence diagram

Figure 3 depicts the mobile application sequence diagram, and its functional and non-functional requirements are listed and explained in Table 2 and 3. The ffunctional requirements define the specific actions and capabilities that the app must perform to achieve its intended functionality. These details a wide range of ideas, such as data processing and manipulation, application interaction, and other functionalities that exemplify how user needs are satisfied. Table 2 displays the functional requirements. The non-functional requirements describe the qualities and characteristics that the app possesses. They focus on how well the system performs its functions and the constraints it must adhere to. Table 3 lists the non-functional requirements of the mobile application software.

Table 2. Functional requirements of mobile application software

Functional Requirement	Description
Sign up	The app would make it possible for new users to register by offering information such as their name, phone number and a password.
Log in	Users can only log in by providing the proper username and password.
Log out	This clears the user data from the app.
Access location	It will permit the app to access the user's location with the user's consent.
Storage access	It would permit the app to access the phone's storage with the user's consent.
Report Crime	Citizens can report crimes that are occurring around them. During submission, they may attach any supporting any video or image data

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Functional Requirement	Description
File Complaint	Report complaints without the need to visit the police station, streamlining the reporting process.
SOS report	Allow users to report high-priority crimes where time is of the essence, such as armed robberies and abductions, ensuring immediate attention from authorities.
View crimes and complaints reported	Users will be able to see the report's development. Users of the system can view crimes and complaints they have previously. Reported including their statuses.
Reset password	Enables users to reset their password.

Table 3. Non-functional requirements of mobile application software

Requirement	Description
Performance requirement	This app has quick response times for loading screens and submitting reports to provide a smooth user experience.
Security requirement	The app encrypts sensitive user data during transmission and storage to ensure data security.
Usability	The system is very straightforward and thus very simple to use.
Scalability	The system architecture of the app makes it easy to scale and consumed by a larger audience.
Maintainability	The software architecture used makes it easy to maintain and update.

The software features provide a deeper look into the different components that come together seamlessly to provide great user experience like User Registration and Authentication. The "Sign Up" and "Login" components provide a secure and straightforward user registration process. New users can create an account by providing their full name, password, and phone number. Existing users can effortlessly log in to access the app's functionalities securely. These are demonstrated in Fig. 4.

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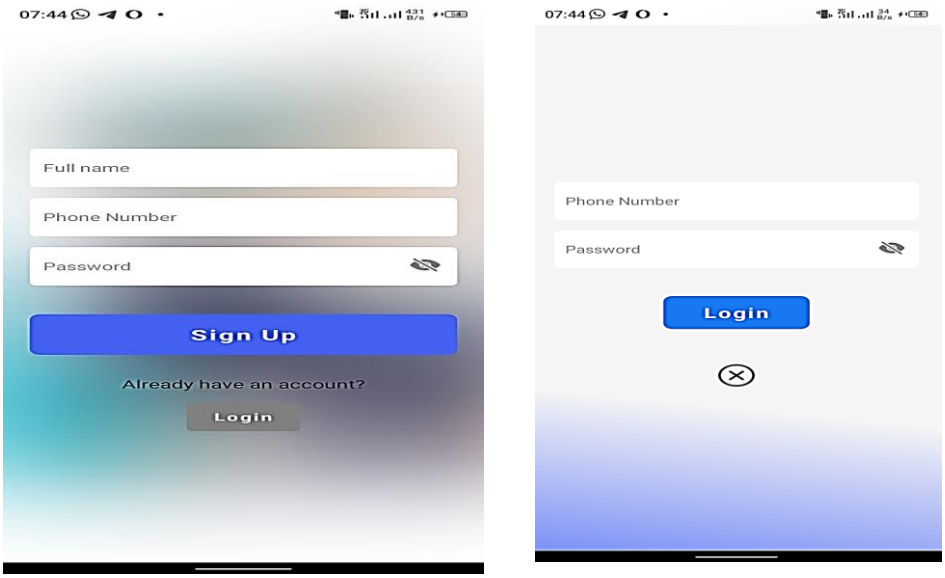

Fig. 4. Application sign-up and login screens

The "Home Screen" serves as the central hub for all app functionalities. Users can easily navigate to different modules, such as reporting ongoing crimes, filing complaints, accessing public safety announcements, and initiating SOS panic alerts. Avatar and Account Management - clicking on the user's avatar in the "Home Screen" grants direct access to the "Account Information" component. Here, users can view and update their personal details, add their birth year, and upload a profile picture, ensuring accurate and up-to-date account information. Logging out is also presented. These are demonstrated in Fig. 5.

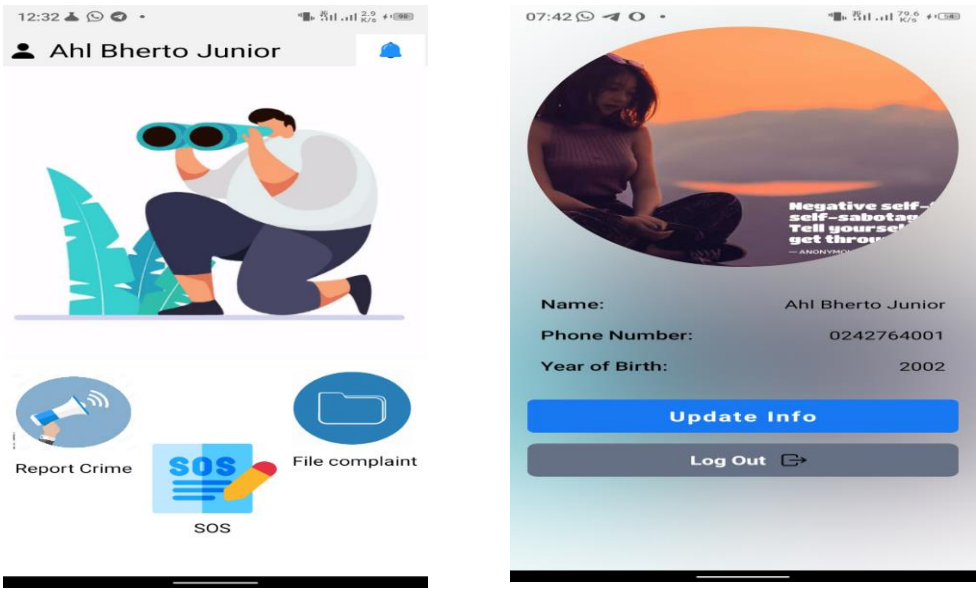

Fig. 5. Application home and navigation screens

The "Report Ongoing Crime" component enables users to promptly report criminal incidents in real-time. Users can provide incident summaries, detailed descriptions, and attach photos or videos as evidence. The app automatically sends the user's location and account information to the police, facilitating swift action. SOS Panic Alert - in emergencies, the "SOS Panic" feature offers a triple-tap activation to rapidly send the user's

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location and account information to the authorities. This high-priority alert system ensures immediate attention to critical situations like abductions. These are demonstrated in Fig. 6.

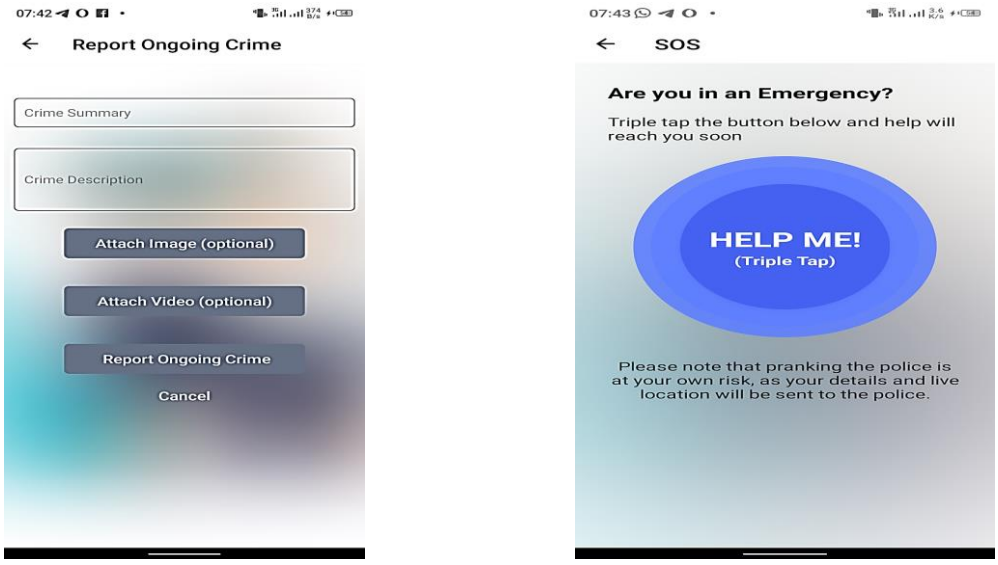

Fig. 6. Application ongoing crime reporting

Users can file complaints conveniently through the "File a Complaint" screen. The app prompts users to provide incident headings, descriptions, time, date, and addresses for detailed and streamlined complaint filing. The "Public Safety Announcement" component provides access to an announcement board where police authorities post crucial public safety messages, ensuring community members stay updated on potential risks and preventive measures. The app includes links to view previously reported crimes and complaints, allowing users to stay informed about the status and progress of their submissions.

2.4. System integration platform

The system software integrations platform is a web application built purposely for integrating security agencies into the crime reporting system application software. On this platform, police stations can register their stations and staff as well. The following subsections explain with screenshots the individual access and events on this platform. These in summarized in Tables 4 and 5.

Table 4. Requirements and specifications

Requirements	Description
Create Staff	The app would make it possible for police stations to register their staff
Register Police Station	Police stations can register their station details and location.
Access location	It will permit the app to access the police station's location.
Display app analytics	It would display data such as the number of users on the platform, number of police stations enrolled, number of staff, reports, etc.

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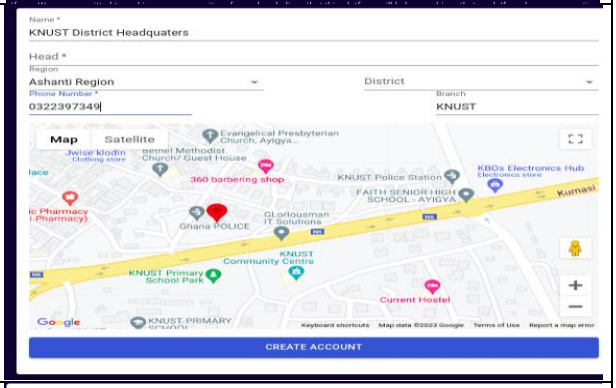
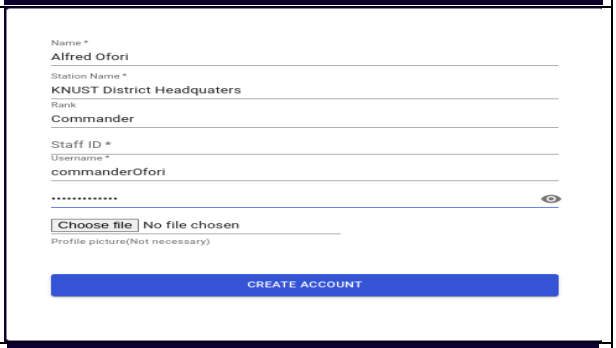
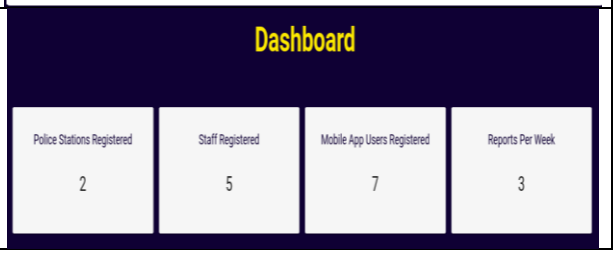
Table 5. Features and functionality

Feature	Function	Screen
Home page	This page introduces the user to the portal	
Police station registration page	This page provides fields for the registration of police stations	
Staff Sign up page	This page provides fields to be filled for the creation of security personnels	
Dashboard	This page provides information about the app, such as the number of users on the platform, number of police stations enrolled, number of staff, reports, etc.	

2.5. System police software dashboard

The police dashboard is an essential component of the system software application, aiming to facilitate seamless interaction between law enforcement agencies and the reported complaints from community members. This dashboard serves as the user interface for police personnel, enabling them to efficiently manage and respond to the complaints submitted by citizens. With its intuitive design and modern web technologies, the dashboard empowers law enforcement to actively participate in crime prevention and public safety efforts, fostering safer communities. The purpose of the dashboard is to empower law enforcement agencies to access and interact with reported complaints from the community members effectively. By

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providing police personnel with tools and functionalities to manage and respond to complaints, the mobile app strengthens the collaboration between citizens and law enforcement, enabling a prompt and efficient response to criminal incidents and security concerns. Through data visualization and insightful reports, the dashboard equips law enforcement with valuable crime data to identify patterns and hotspots, facilitating targeted crime prevention strategies.

Figure 7 depicts the police dashboard sequence diagram, and its functional and non-functional requirements are listed and explained in Table 6 and 7. The ffunctional requirements define the specific actions and capabilities that the app must perform to achieve its intended functionality. These details a wide range of ideas, such as data processing and manipulation, application interaction, and other functionalities that exemplify how user needs are satisfied. Table 6 displays the functional requirements. The non-functional requirements describe the qualities and characteristics that the app possesses. They focus on how well the system performs its functions and the constraints it must adhere to. Table 7 lists the non-functional requirements of the police dashboard software.

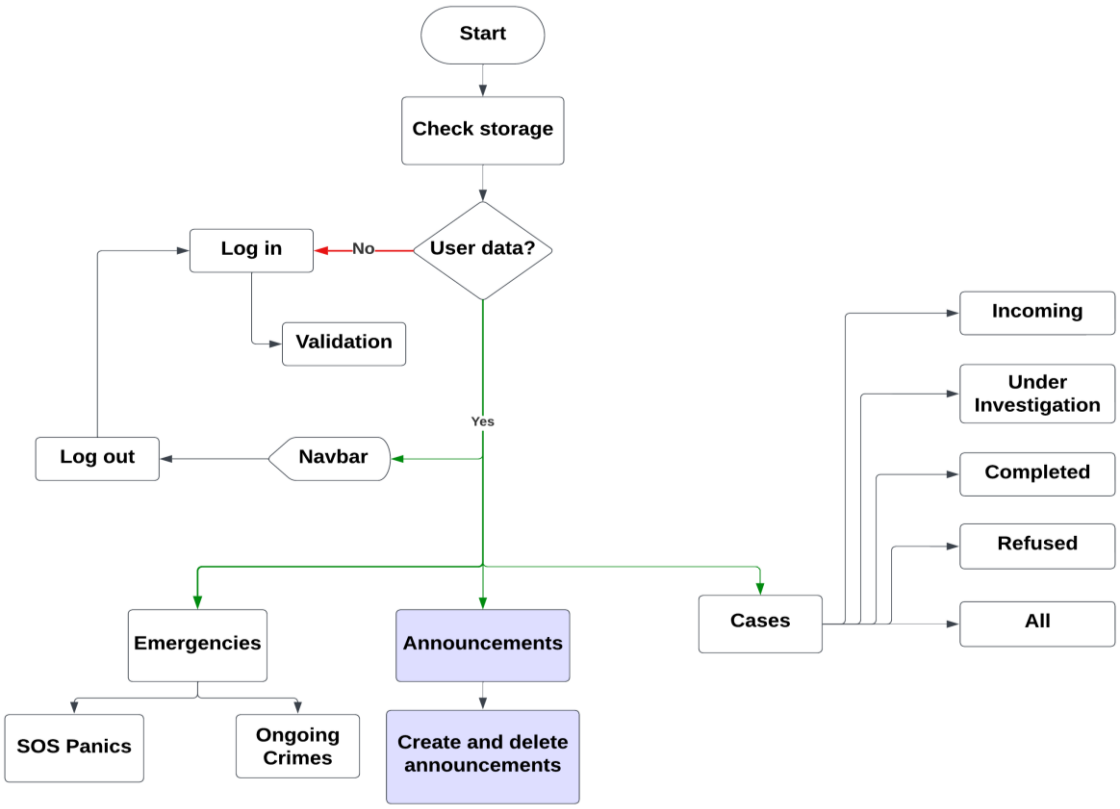

Fig. 7. Police dashboard sequence diagram

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Table 6. Functional requirements of police dashboard

Functional Requirement	Description
Log in	Users can only log in by providing the proper username and password.
Access location	It will permit the app to access the user's location with the user's consent.
Storage access	It would permit the app to access the local storage of the browser.
View reported incidents	Users will be able to see reported incidents. This includes filed complaints, t, ongoing crimes, and SOS situation.
View locations	Enable users to see the location of reported crimes.
Change statuses	This allows the security personnel to change the status of reports. These statuses are 'yet to be reviewed, under investigation', completed' and 'refused'.
Post and see announcements	This allows staff to create and post announcements. These announcements can be viewed in the mobile app.
Log out	This would clear the user's data from storage and terminate the session
Change theme	This allows the user to switch between the dark and light theme.

Table 7. Non-functional requirements of police dashboard

Requirements	Description
Performance requirement	This app has quick response times for loading screens and submitting reports to provide a smooth user experience.
Security requirement	The app encrypts sensitive user data during transmission and storage to ensure data security.
Usability	The system is very straightforward and thus very simple to use.
Scalability	The system architecture of the app makes it easy to scale and consumed by a larger audience.
Maintainability	The software architecture used makes it easy to maintain and update.

The system software institutional frontend offers key features and functionalities like: Complaint Management - police personnel can view a comprehensive list of complaints filed by reporters. Complaints are categorized based on severity, status, or type for efficient management and follow-up actions. Police staff can update the status of complaints, such as "Under Investigation", "Resolved", "Refused" and "Yet to be reviewed". Communication with Reporters - provides a messaging system or chat feature

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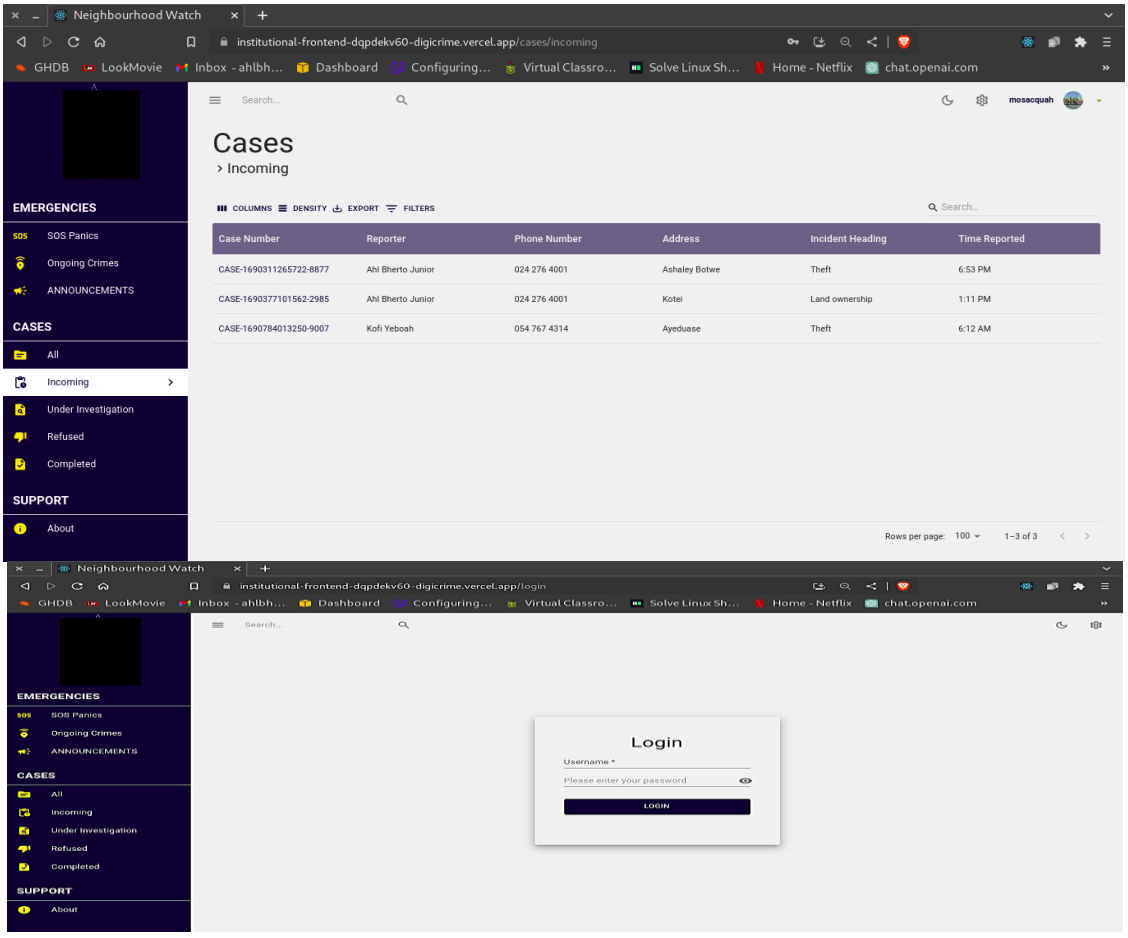
for direct communication between police personnel and reporters and enables police staff to gather additional information from reporters to assist in investigations. Reporters receive timely updates and responses on the progress of their complaints.

Secure User Authentication - ensures robust authentication and user validation to protect sensitive data and implements encryption techniques to safeguard user credentials and prevent unauthorized access. Search and Filter Functionality - enables police personnel to search for specific complaints based on various criteria, such as date, location, or reporter name. It also offers advanced filtering options to streamline the display of complaints based on their status or severity. Notifications and alerts and send real-time notifications and alerts to police staff for new complaints or important updates. Updates information every 90 seconds. It also keeps law enforcement personnel informed of critical incidents or priority complaints. Performance Optimization - ensures the frontend application's performance is optimized for efficient loading and data retrieval. Minimizes loading times and enhances the overall user experience.



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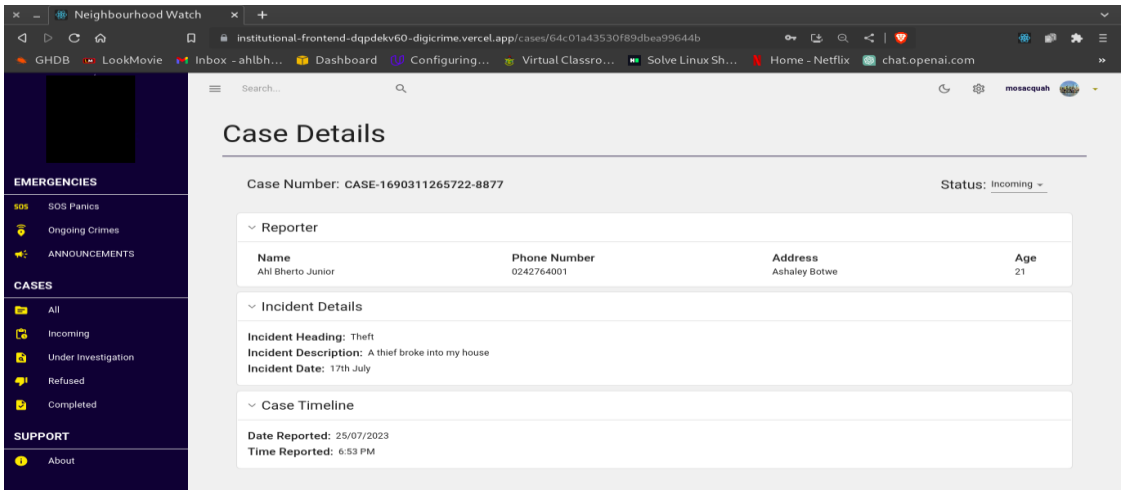

Fig. 8. Screen shots of application user interface

2.6. System software business logic

This system software business logic handles most of the logic in the application, from redirecting to storing of data. It was built using ExpressJS. The MVC architecture was used in the development of this segment. Sensitive data such as passwords were hashed before storage. Passwords are also not returned to the clients. Web tokens are generated to authenticate user sessions. The REST API was used in the development of the backend. Table 8 contains the routes and endpoints.

Table 8. REST API routes and endpoints

Route	Endpoints
/	/staff, /staff/login, /station, /stations, /user, /user/login
/emergencies	/sos, /station-sos, /ongoing-crime, /station-ongoing-crime
/cases	/, /complaints
/announcements	/
/support	/police-stations, /staff-registered, /app-users-registered, /reports-number, /cases-handled, /emergencies-handled, /cases-incoming, /cases-under-investigation, /cases-completed, /cases-refused
/analytics	/

The mongoDB was used for database management in this software solution. The structure of the database and interface as used in the application are shown in Fig. 9 and 10.

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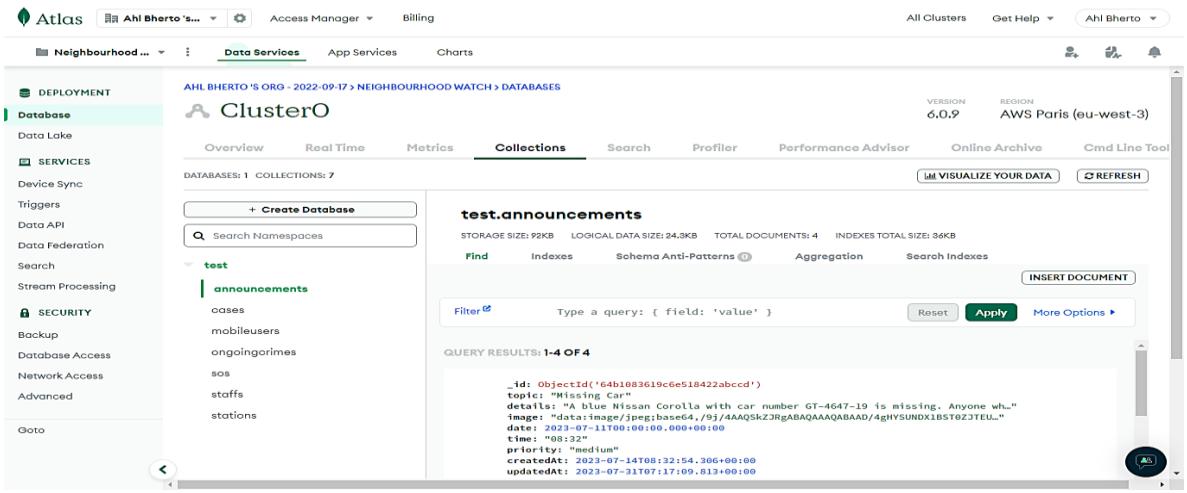

Fig. 9. System mongoDB database

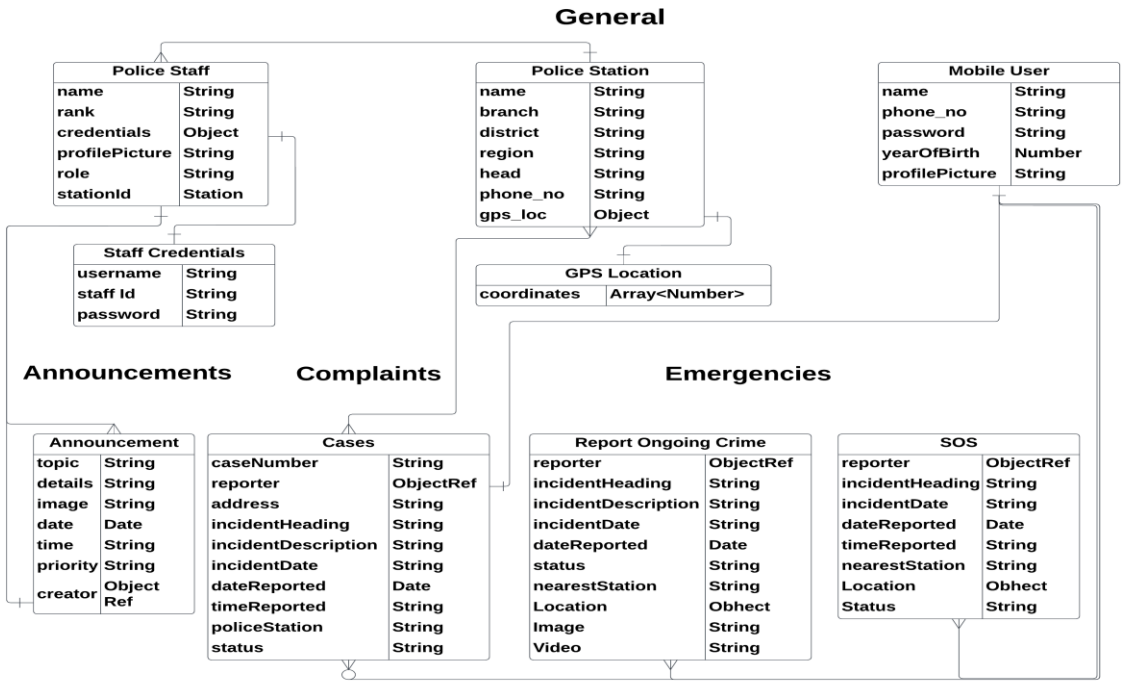

Fig. 10. System database architecture

3. RESULTS AND DISCUSSION

Testing plays a fundamental role in ensuring that applications function as expected, meet requirements, and deliver great user experience. By systematically evaluating the codebase, potential bugs and issues can be identified and rectified before they reach users, saving time, resources, and, most importantly, maintaining the integrity of the application. Deployment of the app makes it accessible by the intended consumers. For the testing, a few scenarios were considered: Viewing Filed Complaints Scenario: A registered user logs into the system and accesses their filed complaints. Here the user navigates

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to the “File Complaints” section then to the "View Filed Complaints" section and the system retrieves and displays a list of reports filed by the user. Users then click on a specific report to view its details and the expected outcome is shown and users can view their filed reports, and the details of the selected report are correctly displayed. This is illustrated in Fig. 11.

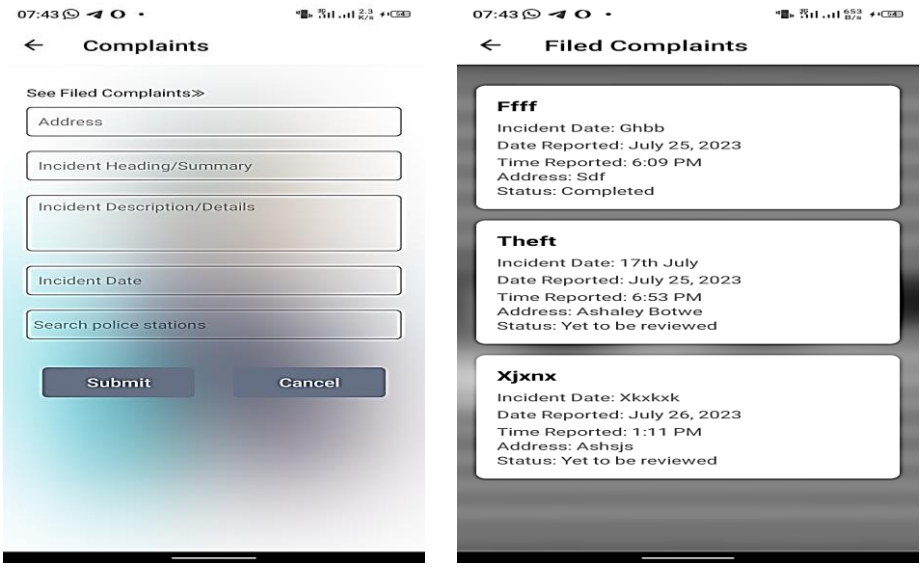

Fig. 11. System compliant filing

Sending Report Scenario: A registered user submits a new report regarding a security concern. Steps: User logs into the system and navigates to the "Report Crime" section. User provides all required information, including incident details and location and submits the report after which the system successfully records the new report, and make it accessible to relevant authorities. Updating Report Status Scenario: An administrator updates the status of a filed report. Steps: Administrator logs into the system and accesses the list of filed reports. The administrator selects a report and changes its status (e.g., from "Incoming" to "Under Investigation") after which the system allows the administrator to update the status of a report, and the change is reflected accurately.

View Police Announcements Scenario: An authorized user visits the announcements board to see announcements posted by the police. Steps: User logs into the system and navigates to the "Announcements" section after which the system generates a comprehensive report with analytics based on the specified parameters and illustrated in Fig. 12.

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Fig. 12. System announcement screens

User Registration Scenario: A new user registers on the platform. Steps: User accesses the registration page and provides the necessary information, including personal details and contact information. User submits the registration form after which the system registers the new user and navigates to the dashboard.

After completing the development phase, focus shifted towards deploying the applications to make them accessible to users. Deployment is a crucial step in the software development process, as it marks the transition from the development environment to a live, production environment. This section discusses how we deployed both the integrations app and the police dashboard to ensure seamless access for users. To host the front-end applications, we chose the Vercel hosting service (Madugalla, 2023) and for the backend, we used Render (Render, 2023). Post-deployment, we implemented monitoring tools to keep a close eye on the applications' performance and user interactions. Monitoring allowed us to promptly detect and resolve any issues that arose. Additionally, regular maintenance tasks, such as updates and security patches, were scheduled to keep our applications running at peak performance and safeguard them against potential vulnerabilities.

4. CONCLUSION

The development of a comprehensive crime reporting system for Ghana is crucial in enhancing public safety and providing law enforcement agencies with valuable data for effective crime management. The developed system's user-friendly interface, integration of audio-visual data and GPS, real-time analytics, and "critical" features for emergency reporting present significant advancements in crime reporting technology. The successful implementation of the crime reporting

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system requires collaborative efforts from law enforcement agencies, government authorities, and citizens. By fostering partnerships and raising public awareness, the system can become an invaluable tool in combating crime and creating a safer environment for all Ghanaians. The future of the crime reporting system is promising, with the potential to continuously evolve and adapt to changing crime patterns and technologies. Through constant improvements, feedback mechanisms, and innovative features, the system can establish itself as a leading tool in crime prevention and law enforcement efforts in Ghana. The government is encouraged to use e-tools that enhance law enforcement performance. The media must also encourage the citizens to use new technology services (Thamer et al, 2023). With the collective commitment of stakeholders, the envisioned crime reporting system can significantly contribute to the advancement of public safety and security in the nation.

Based on the findings and outcomes of this project and future work, we proposed:

Continuous System Improvement - the crime reporting system should undergo regular updates and improvements to keep pace with emerging technologies and user feedback. Regular improvements will ensure that the platform remains effective and user-friendly. Collaborative Partnerships - establish close collaborations with law enforcement agencies, government bodies, and relevant stakeholders. Their involvement in the development and implementation process will foster greater acceptance and use of the crime reporting system. Public Awareness Campaigns - conduct public awareness campaigns to educate citizens about the benefits and functionality of the crime reporting system. Raising awareness will encourage more proactive reporting, contributing to crime prevention efforts. Integration of AI and Predictive Analytics - Explore the integration of artificial intelligence and predictive analytics to enhance the system's capability to identify crime trends and predict potential hotspots. This will enable law enforcement agencies to deploy resources more effectively. Multi-Lingual Support - ensure that the crime reporting system provides multi-lingual support to accommodate citizens from diverse linguistic backgrounds. Effective communication is essential to encourage widespread adoption and usage. Cybersecurity Measures - implement robust cybersecurity measures to protect users' personal information and maintain the integrity of the data collected. Data privacy and security are critical for building trust and confidence in the platform.

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