MOBILE BASED CRIME REPORTING APP

A dissertation submitted for the Degree of Master of Information Technology

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2019

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ABSTRACT

The security situation in Sri Lanka has deteriorated over time due to the low number of police personnel in the country and the authorities lack concrete to solve crime incidents since there is no proper crime reporting system. Crime incidents happen everywhere but the witness to these crime incidents nonexistence a convenient and efficient method to report them. Security challenges have increased from mere theft to carjacking attacks and to more serious and evolved challenges like murder and terrorism. With increase of smartphones in Sri Lanka, an opportunity exists because of the untapped gap of incidents reporting.

The proposed solution was to develop a mobile application that can be used to report any crime incidents. The mobile application was developed on the Android platform and will integrate the use of GPS location services. It was developed concurrently with a web application developed in ReactJS language to supplements its functionality and MYSQL used as the database server. The solution has an administrative web-based backend that will be accessed by the police force to ensure they get detailed information of criminal activities. The web application was adapted the MVC architecture with object-oriented environment. In addition to that online UML tool is being used to draw UML diagrams. Thus, the mobile application comes in trend to provide a solution to the way users report crime incidents. The suggestions made by users were used to enhance the application functionality and performance. The application will allow users to report crime incidents that happen in anywhere anytime. Based on the overall statistics of user testing and evaluation, can say that the application fulfills its simplicity and usability requirement and based on the questionnaire responses, the application is generally considered easy to understand and use.

DECLARATION

The thesis is my original work and has not been submitted previously for a degree at this or any other university/institute.

To the best of my knowledge it does not contain any material published or written by another person, except as acknowledged in the text.

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Ms. R A N Sandamali under my supervision. The thesis has been prepared according to the format stipulated and is of acceptable standard.

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ACKNOWLEDGMENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

GPS   - Global Positioning System

PDA   - Personal Digital Assistant

CCTV   - Closed Circuit Television

WIFI   - Wireless Fidelity

SDLC   - System Development Life Cycle

USA   - United States of America

SQL   - Structured Query Language

DBMS   - Database Management System

UML   - Unified Modeling Language

OOD   - Object Oriented Design

OO   - Object Oriented

ERD   - Entity Relationship Diagram

REST API - Representational State Transfer Application Program Interface

IPFS   - Interplanetary File System

MVC   - Model, Viewer, Controller

GUI   - Graphical User Interface

OS   - Operating System

ICT   - Information and Communications Technology

CHAPTER 1

1. INTRODUCTION

1.1. AREA OF STUDY

Information technology plays a significant role in today's world. Technology has been applied in numerous domains such as mobile computing, gaming, messaging and so on. Recent researchers have identified mobile handheld devices as a conceivable tool for effective crime reporting as well as crime detection [1]. Technological advancements invented extremely powerful mobile handheld devices with GPS compatibility along with large and high-speed data transfer capabilities through mobile communication networks. Functions of mobile devices have evolved from merely making calls to performing complex computations over the past three decades [2]. The high computational power of smartphones, tablets and PDAs accounts for their high demand and usage by the public. Global sales of smartphones to end users returned to growth in the first quarter of 2018 with a 1.3 percent increase over the same period in 2017. Compared to the first quarter of 2017 sales of total mobile phones stalled and reached 455 million units in the first quarter of 2018 [3].

Another main factor making mobile phone technology a viable medium for fighting crime is the advancement of mobile networks technologies. The introduction of 3G/4G cellular network technologies by most mobile network operators has improved the communication demands for mobile users [4], [5]. With these two factors in place, development of dedicated mobile platforms for detecting and reporting criminal activities is a great possibility. The solution proposed in this research is based on service-oriented architecture with web portal and mobile application connectivity to report and track the crime status anonymously.

1.2. STATEMENT OF THE PROBLEM

As of today, the human oriented crime reporting system is lack in privacy and traceability. When the traditional process is concerned, the citizen has to go to the nearest police station to report a crime or incident or the person need to call the nearest police station for a faster action of the authority. As a result, the possibility of neglecting of reporting the crime by the concerned

citizen is enormous. Furthermore, there is no guarantee that the identity of the reporting person will not be revealed.

As well as the citizens neglect to report incidents to less hassle and the lack of knowledge in law. The authorities also lack in spreading the police station hotline in communities, most of the people in the community not aware of the hotline of nearest police station. Some of complainants are not familiar with the place where the police station is.

In most criminal investigations in Sri Lanka, CCTV footage has recognized as an important evidence and being accepted by the law. Still the CCTV was not deployed in every part of Sri Lanka like other countries. Also, it is expensive exercise to deploy CCTV everywhere. The video or photographic footages which can be obtained through the proposed system can be extended beyond CCTV footages, by the mobile phones owned by the users in their hands.

1.3. MOTIVATION

The crime rate has been increased in Sri Lanka [6]. Most of the criminal investigations have been abandoned due to insufficient evidences. Some of the criminal investigations may disrupt due to the people's reluctance to make a complaint. Significant examples are the bribery requests in government sector. Essentially, the anonymity is not guaranteed in human oriented complaint systems exist in the current society.

Mobile-based technology, such as smartphones and tablets are becoming commonplace. There are 27.38 million mobile phone connections in Sri Lanka [7]. Mobile phone is a vital tool which can be used to report crimes in real-time. Especially, the mobile phones are capable of capturing GPS coordinates for the captured photograph. The mobile phone has been utilized as a significant tool in child protection, tracking as well as terrorist alerting (SGSecure) [8]. In Sri Lanka, it was obviously a significant tool to report numerous crimes. For instance, people are reluctant to complaint child abuse cases assuming that publicity of such issue will affect badly to the victim's future. Therefore, there exists an important requirement of a solution, which ensures the reporter's privacy as well as he/she can be able to track the status of the maid complaint.

1.4. AIMS AND OBJECTIVES

The objective of this project is to develop a mobile application to report any crimes and accidents in real-time anonymously. This reporting application can be used for reporting a crime or accident

in any time anywhere using the mobile application. Also, the reporter can monitor the progress of their reported crime anonymously to ensure their reporting is worked, as well as reporter can be rewarded for their crime reporting incidents. The objects are listed below,

1. To develop an efficient mobile-based system to enhance the crime reporting anonymously.
2. Ensure the crime reporter's privacy has been preserved unless it was required to disclose in the court proceedings.
3. To have an accurate crime reporting in the country that makes the response of the authority faster.
4. To automate the system of reporting a crime in the country which may recognize the country as one of the safest in the world.
5. To ensure that the system will be simple to use, user-friendly and portable on the user to use.
6. To evaluate the proposed system of its reliability, accuracy and speed.

1.5. PROJECT SCOPE

The focus of this research is to develop a mobile-based solution to enhance the crime reporting procedure. It has been planned to develop as a mobile application, server application and web administration application. The hyper ledger fabric has been used to log the events in backend.

Below explained the assumptions made throughout project implementation

1. All the crime reporters will be connected to the backend by their mobile application through mobile data or WIFI.
2. GPS has been enabled on the reporting device, which integrates location information of the captured images of the crime to be reported, as image metadata.
3. The captured image is not edited and if edited, it could be identified by the primary verification in order to eliminate allege falsely an innocent party.
4. There will be enough police officers nearby to attend the location to take immediate action.
5. The developed application was limited to the Android platform only and the target users are assumed to have android devices.
6. The audience was also limited to Colombo Area.

1.6. STRUCTURE OF THE DISSERTATION

This report consists of five main chapters including current chapter. Current chapter is the introduction chapter which giving the overall picture of this crime reporting application. The structure of the report is as follows:

In chapter 2 an analysis of the existing similar projects and an analysis of the requirements are provided. Many countries have conducted similar projects on the same problem and they have identified innovative solutions. This literature review is very helpful in analyzing the technologies, design strategies and identify new way of solving the problem using untouched suitable technologies. When analyzing the literature, risk factors considered in each technology are studied properly. This chapter helps in giving a thorough understanding about the problem domain.

Chapter 3 delivers a detailed description about the methodology followed in implementation. This consists of several methodologies that could be used, and the approach chosen amongst them, with a proper justification. The chapter provides a detailed description of the selected approach of database structure, system architecture and the SDLC used. In addition, this includes the initial study conducted with the Web Application and the Android Application development. Meantime the problems faced when applying new technologies with implementation are explained.

In chapter 4, a detailed analysis of the outcomes of the developments. This chapter elaborates the major test plan of the project, test cases that are going to use for testing each module of the system, test data and test results received from testing process. As well as accomplishment of system requirements will also be evaluated within this phase. And user evaluation is also done in this chapter.

Chapter 5 contains about the conclusion and future work. This chapter summarizes the work conducted, discusses the findings and points out limitations of the current work. In addition, this chapter explains about the lessons learned during the study and how the work could be extended in the future.

CHAPTER 2

2. BACKGROUND

This chapter explains the review of similar systems available and technologies available and relevant to implement the system. And, this chapter identifies the alternative technologies that are available for implementation with their pros and cons.

2.1. REVIEW OF SIMILAR APPLICATIONS

The advancement of mobile computing technologies has led to more effective ways of detecting and fighting crime in society. [9] Today, software engineers and researchers have proposed and developed several mobile-based systems, especially for crime detection and reporting. This section presents an overview of some of the most powerful mobile-based crime reporting systems developed within the past years. The overview pays attention to functionalities and principles of operations of these systems. Some of similar applications are given in Table 2.1.

Year	Author	Title	Strength	Limitations
2015	Syed Mujtaba Raza, Leelavathi Rajamanickam [10]	A Proposed Solution for Crime Reporting and Crime Updates on Maps in Android Mobile Application	* Help public to see the locations on the map which will help them to track the current situation	* Does not provide a platform to register the cases * Do not have the application in iOS version
2015	Aanchal Dabhere, Aniruddha Kulkarni, Ketaki Kumbharkar, Vrushali Chhajed, Sneha Tirth [11]	Crime Area Detection and Criminal Data Record	* Can use text, picture and video data formats	* Lead to unauthorized access and thus results in misuse of the data
2017	Aswini .G, Dhivya .N, Jayanthi .R, Ambikapathy R. [12]	Fall Detection and Reporting Using Smartphone	* Users seek help by shaking their smartphones while in a dangerous situation. * Send GPS location	Lead to a misunderstanding between people because the phone may shake unintentionally.

Year	Authors	Title	Advantages	Disadvantages
2018	Budi Yulianto, and Setiono [13]	Implementation of Android-Based Urban Freight Transport Violation Reporting Application in Surakarta City	* Simple, easy to use, portable, handy and good images quality	*Only for Surakarta City, Indonesia * Only for Android platform
2019	Jason Pridmore, Anouk Mols, Yijing Wang and Frank Holleman [14]	Keeping an eye on the neighbors: Police, citizens, and communication within mobile neighborhood crime prevention groups	* Messaging groups can connect neighbors and enable real-time discussions about safety and criminal activity. * Neighbors inform each other about suspicious situations through this messaging application	* Focused on one city in the Netherlands and largely on the use of one mobile application in this context: WhatsApp * Mobile phone numbers are visible for all group members that are a part of WhatsApp groups * Privacy issues and judicial problems when police officers are members in the groups
2019	Tzay-Farn Shih ,Chin-Ling Chen, Bo-Yan Syu and Yong-Yuan Deng [15]	A Cloud-Based Crime Reporting System with Identity Protection	* Support authentication, data integrity, non-repudiation, prevention of case deletion * The reward mechanism	* Web-based application.
2019	Prof. Bushan Chaudhary Tejas Rajput Sneha Yadav Kalyani Thete Poonam Rajput [16]	We Safe (Anti-Crime Application)	* Panic mode * Availability of Alert mode *System keeps logs of a case and past criminal history	* Do not have the application in iOS version.
2019	Huaqun Wang, Debiao He , Zhe Liu , and Rui Guo [17]	Blockchain-Based Anonymous Reporting Scheme With Anonymous Rewarding	* Anonymous reporting mechanism with anonymous rewarding (concept of BB2AR)	* Web-based application.

Table 2.1: Summary table of related works

2.1.1. A Proposed Solution for Crime Reporting and Crime Updates on Maps in Android Mobile Application

Syed and Leelavathi [10] proposed and developed an android based mobile application which helps to increase the general public awareness of criminal status in a particular area. The crime locations from the previous history presented on the map. The system enables to acknowledge the criminal practices to law enforcement agencies.

2.1.2. Crime Area Detection and Criminal Data Record

Aanchal Dabhere et al. [11] "Crime Area Detection and Criminal Data Record" have proposed and developed Android Mobile Application to the police to speed-up the entire process of tracking down the criminals. Using cloud, they try to keep the availability of all information. Also, it will provide the general users with the facilities like reporting any incidents which would lead to traffic jam. Moreover, it will also provide an alternate safe path on user's demand before entering the crime area. The major function of this system is avoiding any false incidence reporting. For that the information provided will be first verified by the police officials. After approval of the information it will be broadcasted to other users using the application.

2.1.3. Fall Detection and Reporting Using Smartphone

Aswini et al. [12] Proposed a mobile application associated solution for the enforcement of security and surveillance for elderly people. The system enables real-time monitoring of the area where the elderly person uses to walk and detects violence with significant accuracy. The system sends alert messages if any attention required event happened.

2.1.4. Implementation of Android-Based Urban Freight Transport Violation Reporting Application in Surakarta City

Yulianto and Setiono [13] implemented an android based freight transport violation reporting application. The application provides real-time monitoring and controlling data in the Surakarta city. The results reflect that the system outperforms existing systems in terms of cost, efficiency and accuracy.

2.1.5. A Cloud-Based Crime Reporting System with Identity Protection

Shih et al. [15] Proposed an online illegal event reporting scheme which utilizes cloud technology, digital certificates, symmetric and asymmetric keys along with digital signatures. The system

processes illegal activities and issues rewards for the reporters. The system ensures that the reported case is not being erased as well as ensures data integrity with the platform which provides a convenient and secure platform for reporting and fighting crimes

2.1.6. We Safe (Anti-Crime Application)

Chaudhry et al. [16] Proposed a system which enables the users to register and provide a detailed report of crimes happened. The system provides three logins for the User, Police and the Administrator. The users are enabled to provide a criminal report with the current GPS location along with attachments such as audio, video and descriptions of crimes.

2.1.7. Blockchain-Based Anonymous Reporting Scheme with Anonymous Rewarding

Wang et al. [17] Presented a blockchain-based crime reporting application with crime reporting and rewarding scheme for the crime reporter. The system utilizes blockchain and elliptic curve cryptographic schemes operate. The results reflect that the system performs with significant efficiency for crime reporting and rewarding.

2.1.8. SGsecure

SGsecure is a crime reporting application launched in Singapore. The main concern was prevention of terrorist attempts in Singapore. Especially with the grown terrorist attempts were emerging in most of the countries. Singapore expects to make the people vigilant about these attempts because it will financially affect too.

It also enables "Alerts" is where users can check news flashes about emergencies. By tapping on the "map" icon on the top right of the screen, they can see where the event is happening on a map. The first event that appears in the app is not an emergency but the launch of the SGSecure movement.

2.2. AVAILABLE ALTERNATIVE DEVELOPMENT TECHNOLOGIES AND FRAMEWORKS

Lots of development technologies and frameworks are available for developing a web and mobile-based application. In this section it has been mentioned that most available and suitable technologies and frameworks with their pros and cons. It has been identified major two of alternative technologies and frameworks that suitable to proposed system.

2.2.1. ReactJS

For the administration web application, React JS has been used as the framework. React JS is a powerful JavaScript library which is with a lot of open source components. React JS further provides downward data binding which means that with this kind of data flow the child elements cannot affect parent data. ReactJS absolutely light-weighted because the data performing on the user side can be easily represented on the server-side simultaneously. The migration between versions is too easier in React JS since Facebook provides code mod tool to execute migrations. Essentially migration will be an essential feature on the focused research. [18]

2.2.2. React Native

React Native is an outcome of a hackathon effort in 2013. It consists of reusable JavaScript components and modules. In development perspective, React JS can be used to develop both iOS and Android applications. It is beneficial to the developers to reduce time as well as an optimum specialty for both applications. The key advantage of React Native is that it is a community-driven framework with many open-source modules. It also supports code reuse in the maximum level. Hot-reloading is an attractive feature of React Native framework. React Native also ensures optimized performance over the native Android and iOS. The modular and intuitive architecture is ideal for develop applications with complex functionality. [19]

2.2.3. Hyperledger Fabric

Hyperledger fabric used to ensure immutability and data provenance. Hyperledger composer was used to manage the blockchain.

It seems there is no open-source alternative available for the proposed solution. Therefore, the proposed system has to be developed from scratch. The system will mainly adhere to

microservices architecture and with modular components. Each service will run on the Docker containers. In contrast with the monolithic solution architecture, the microservices-based architecture provides a less failure risk with the elimination of single point of failure. Also, the modular development strategy will improve the efficiency of deployment.

2.3. AVAILABLE ALTERNATIVE DATABASE TECHNOLOGIES

The heart of any web-based, or mobile-based application today is its database. With many different options available for today's web or mobile developers and designers, it can be difficult to decide. Which is best suited for a specific project. Finally, two of most powerful and popular database technologies have been identified for the proposed system.

1. Microsoft SQL Server
2. MySQL

2.3.1. Microsoft SQL Server

Microsoft SQL Server is a relational database management system developed by Microsoft. As a database server, it is a software product with the primary function of storing and retrieving data as requested by other software applications which may run either on the same computer or on another computer across a network. [20]

Pros and Cons

One of the main benefits involved in choosing the Microsoft SQL Server database management system is its seamless compatibility with other Microsoft Windows and Office applications. The SQL Server has a few extra tools and wizards. But it's not completely free. Therefore, it does get some extra agency and neat add-ons. Overall, this makes everything converge and work together more smoothly.

SQL Server is a closed, proprietary storage engine with a more restrictive Sybase-derived engine over the MySQL. SQL Server has some additional advantages that some may argue elevate it above MySQL. And MySQL does not wholly support foreign keys, which means on a relational database scale it falls short in comparison to Microsoft's SQL Server.

SQL Server is geared with corporate and enterprise markets in mind. Its pros are widely known to be its feature completeness, functionality, and interfaces for administrative abilities and data

modeling. Its complexity means that performance is known to lack slightly when compared to MySQL in the regarding and the speed area. Because Microsoft SQL Server is more complex and feature-rich (a great plus), the software sacrifices some disk space, memory and performance.

2.3.2. MySQL

MySQL is the world's most popular open-source database, enabling the cost-effective delivery of reliable, high-performance and scalable Web-based and embedded database applications. It is also used in many high-profile, large-scale websites, including Google Facebook, Twitter, Flickr and YouTube. [21]

Pros and Cons

The most popular open-source SQL database management system and it makes it possible for anyone to modify and use the management software once it downloads from the internet. The greatest feature of this database is the fact that it's open-source, and it's free. But if it is the Enterprise edition of MySQL it will be received more feature-rich options.

The main goal with the MySQL database management is speed and performance. The database server is very fast, reliable, scalable and easy to use. It's free to anyone and everyone and it would make sense that the DBMS is accessible to experienced individuals as well as those that are new to database management.

Originally it was developed to handle large networks at a fast pace. Now it supports a wide range of APIs and standalone products. Furthermore, MySQL database can support a small set of applications and it can grow to manage entire machines or clusters of machines in a network. [22]

	MySQL	SQL Server
Definition	MySQL is an open-source relational database management system.	SQL server is a relational database management system.
Programmed	MySQL was mainly programmed in C and C++ programming language.	SQL Server was mainly programmed in C++ but some parts in C as well.
Multi-Lingual	MySQL is only available in the English language.	SQL Server is available in multiple languages.
Platforms	MySQL supports many platforms as compared to SQL server.	SQL Server supports only Linux and Windows platforms only.
License	It is open-source only.	It is commercial
Syntax	It is found that MySQL syntax is little bit complex	SQL server syntax is simpler and easy to use.

Table 2.2: Comparison table of Database Technologies

CHAPTER 3

3. METHODOLOGY

This chapter is concerned with the methodology of the software in development process of the mobile and web-based application. The chapter focuses on the System Analysis, Design Methods, Implementation Methods and Testing Methods employed.

The design section describes how analyzed requirements in the previous analysis section have been transformed into the physical and logical design in the system through UML diagrams.

3.1. SOFTWARE METHODOLOGY

Analyzing all requirements, the agile development model has been adopted as the process model for this proposed project. [23] Architecture of agile methodology is given by Figure 3.1.
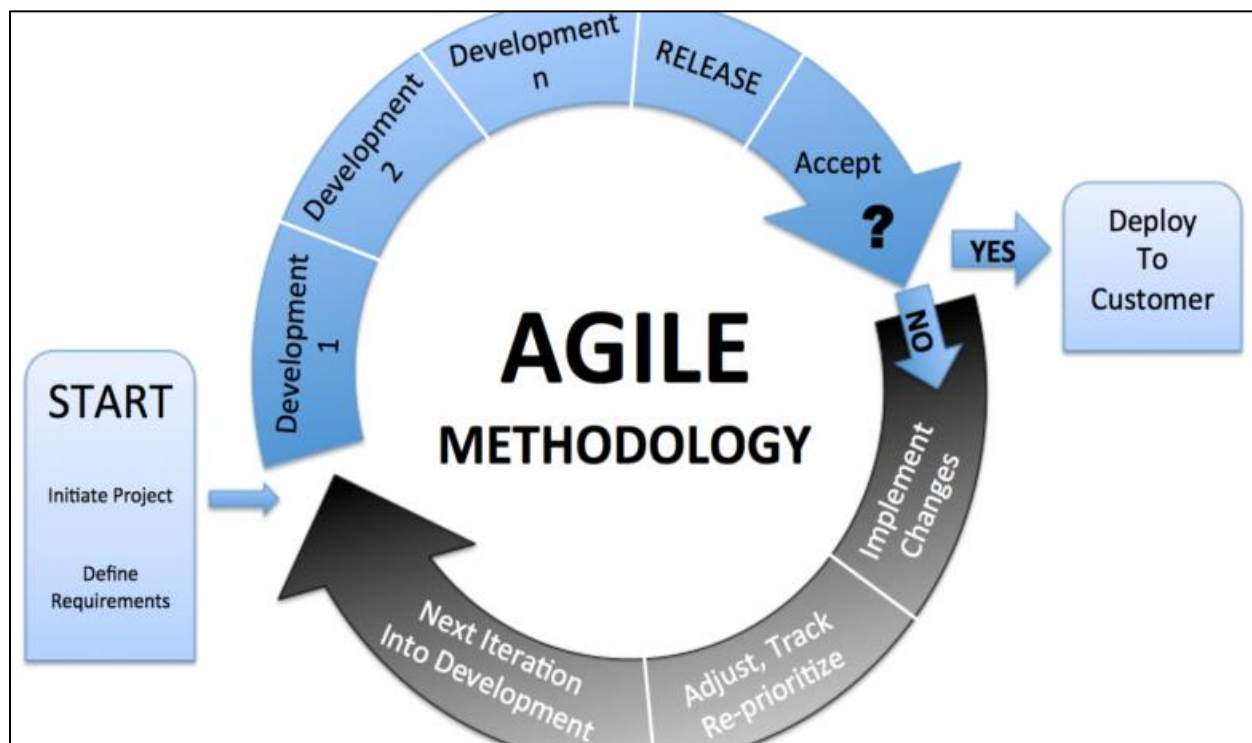

Figure 3.1: Agile Methodology

Advantages of using agile model has been mentioned below,

Supports Change:

This is the most important advantage of Agile. Because research is not a straight forward process. The implementation should support for changes. As development is done in iterations, the team has flexible access to return to the previous stage to make any sort and size of changes

Fast Product Delivery:

Since coding and testing is conducted synchronously with the plan and design phase of the development, all changes and improvements are adeptly made with the moving workflow. This increases the likelihood of an early product launch as well.

Increased Product Productivity:

Agile facilitates a constant room for improvement. At the end of each iteration, the finished product is tested for loopholes and made to improve after each testing cycle is completed. The improvements are also a continuous part of the development as customer feedback is retrieved throughout the project lifecycle.

Flexible & Evolutionary:

Agile supports evolving ideas and decisions to fit into the scope and development window of the project. This is especially beneficial for software apps and tools that do not have a defined end-goal and are subjected to changes based on customer experience.

3.2. SYSTEM DESIGN AND ARCHITECTURE

3.2.1. Design Technique

The system design was achieved by developing the system architecture after gathering requirements, the three-tier architecture, the context diagram, the entity-relationship diagram, the use case diagram and the sequence diagrams. The mobile-based crime reporting system was designed on the requirements gathered and presented using the design procedures of UML.

UML is a diagrammatic representation is for specifying the kind of Object-Oriented Programming design. UML allows system to be visualized in multiple dimensions, and it can be used to produce

several models at increasing level of detail. In this document we have use UML diagrams such as class diagram, sequence diagrams, use case diagram and activity diagrams to give server-side clear image of the system. [24]

Advantages of using object-oriented design can be described as follows: [25]

- OOD provides a more structured plan and design methods.
- Reusability of objects – Objects can be reused in different programs.
- Easier maintenance – Objects can be maintained separately, making locating and fixing problems easier.
- Modularity – Each object composes a separate entity whose internal workings are separated from other parts of the system
- Simplicity of program – Software objects model real-world objects. Therefore, complexity of program structure is reduced.
- Extensibility – Adding new features or responding to changing operating environments can be solved by introducing a few new objects and modifying some existing ones.
- Modifiability – It is easy to make changes in the data representation or the procedures in an OO program. Changes inside a class do not affect any other part of a program, since the only public interface that the external world has to a class is using methods.

3.2.2. Architectural Strategies

Since the proposed system is very large, its need to consider architectural strategies when developing the system. Therefore, some important architectural strategies have been described below.

Performance Strategies

This is a mobile and web-based system. Therefore, system performance basically depends on the bandwidth of the network availability and hardware specification of the server machine.

- The users of the system are permitted to access the mobile application from anywhere any time through the internet.
- Time limitations are not strictly followed in the system, but page loading and processing time should be lower with high-speed performance.

Security Strategies

The system is handling a considerably large database. And also, the data is updated frequently. Because of that data should be safe and available every time.

- Data backups will be periodically taken.
- The system will monitor and log activities within the system.
- Maintain the user's password of the both agent and client secure way. Password encryption and decryption methodologies are used. And use secure ways to deliver passwords to the users.

Extendibility & Flexibility Strategies

System functionalities are likely to be changed. Therefore, the system should be able to adopt the changes easily and should be flexible to add more features easily in future.

3.2.3. Object-Oriented Design

As it has been mentioned earlier, use case model has been used to represent the system. In this section it will be discussing the use case model relevant to the proposed system.

Platform User Interaction

The mobile application enables users to report crimes in panic mode way. Here user will be able to login to Mobile App and give brief description or upload images and press a button on the app and the nearest police will be able to pick the incident report.

Figure 3.2 shows the interaction between the citizens, the police and the mobile application
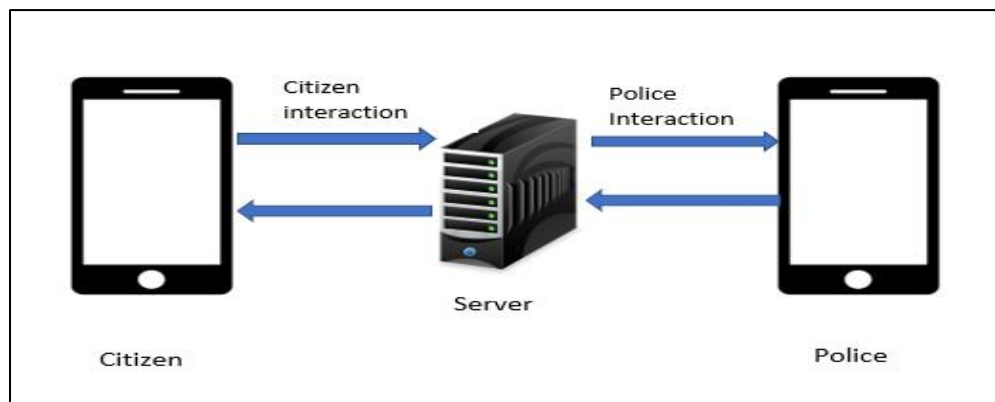
Figure 3.2: Platform User Interaction

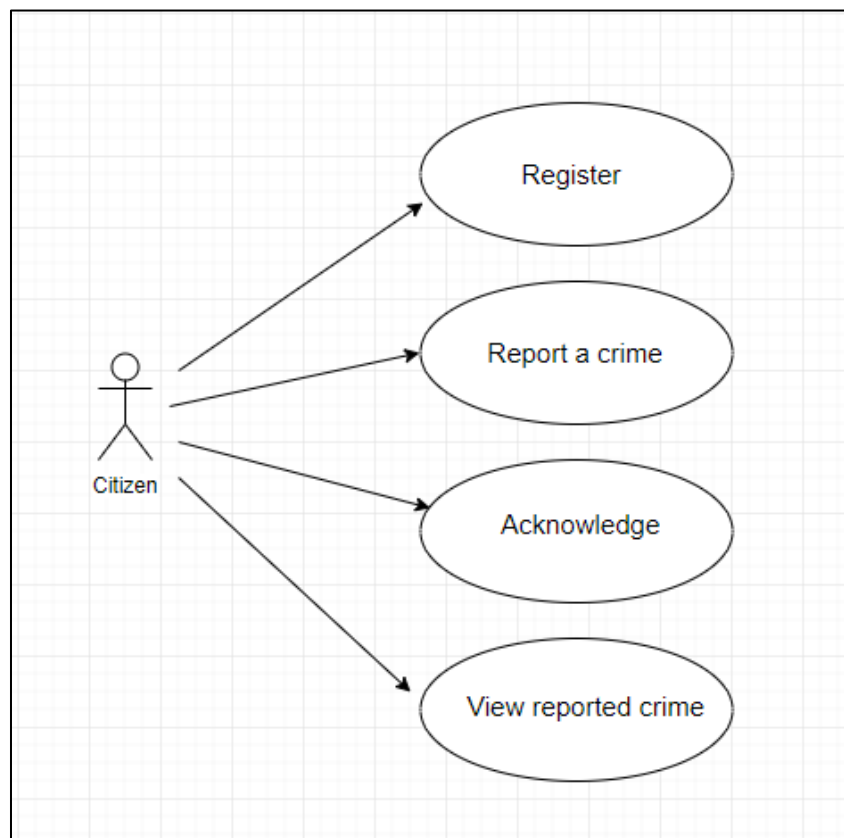The Police will be able to conduct the following activities on the system

- View reported crime incidents
- Assign reported crime incidents
- Analyze reported crime trends
- Acknowledge actions
- Report generation

Use Case Model

The use case depicts the activities that a user will be able to do in the system. The citizen will be able to do the following activities in the mobile application.

- Register
- Acknowledge
- Report a crime
- View reported crime

Figure 3.3 show the citizen's interaction with the platform

Figure 3.3: Citizens use case diagram with platform

The police officer will be able to do the following activities in the mobile application

- Receive Notification
- Accept crime reporting
- View reported crime incidents
- Acknowledge actions
- Analyze reported crime trends
- Report generation

Figure 3.4 show the use case for police officer
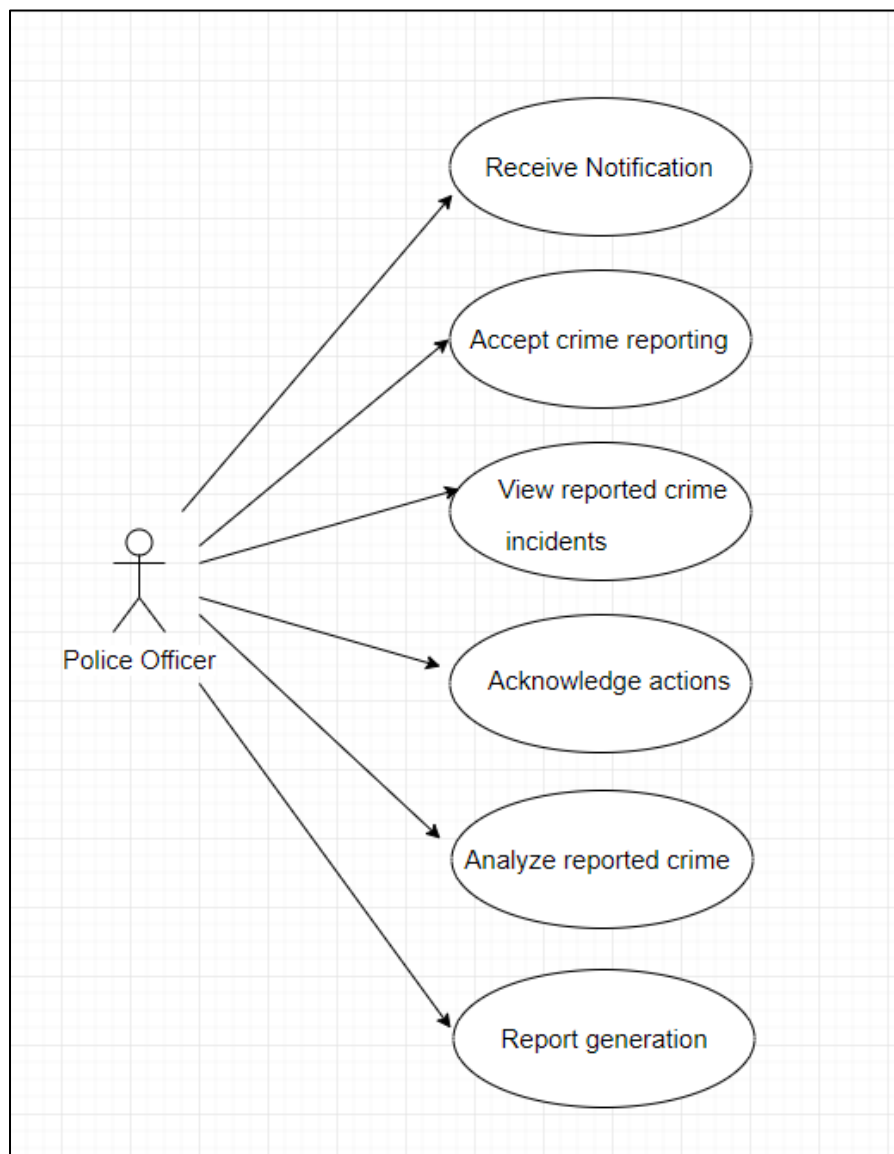
Figure 3.4: Police Officer use case diagram with platform

3.2.4. Sequence Diagrams

The sequence diagram below shows the chain of events in the system. There are two main actors, the citizen and the police officer and their roles and the order of the activities in the system have been defined. Figure 3.5 below shows the sequence diagram of mobile application.

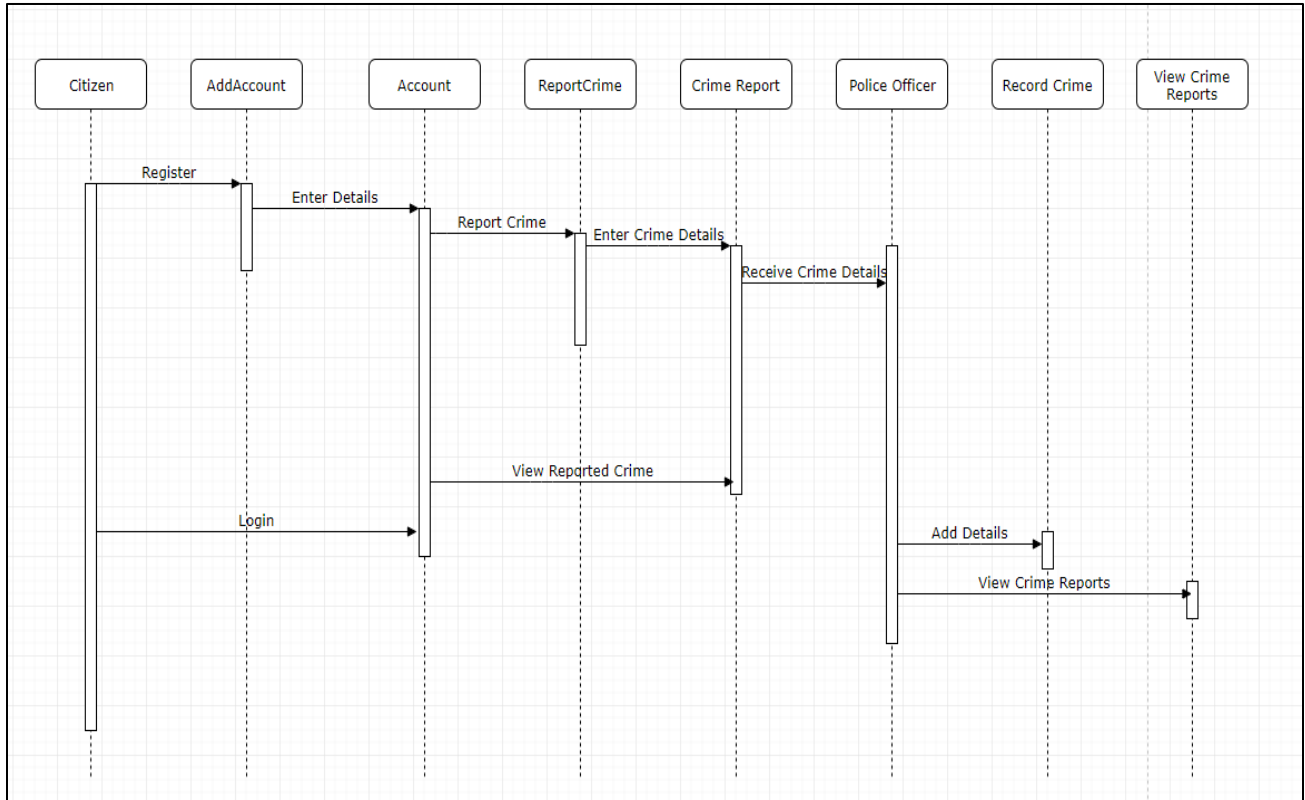**Crime Reporting and Monitoring Process**

Figure 3.5: Sequence diagram of mobile application

3.2.5. Database Design

Data design elaborates the data management architecture within the system database. For this purpose, Entity Relationship Diagram (ERD) has been used. After creating the ERD, normalization and denormalization techniques have been used to generate the database table structure. Refer Appendix A to see the database diagram.

Figure 3.6 below shows the Entity-Relationship Diagram (ERD) of the Mobile Application.
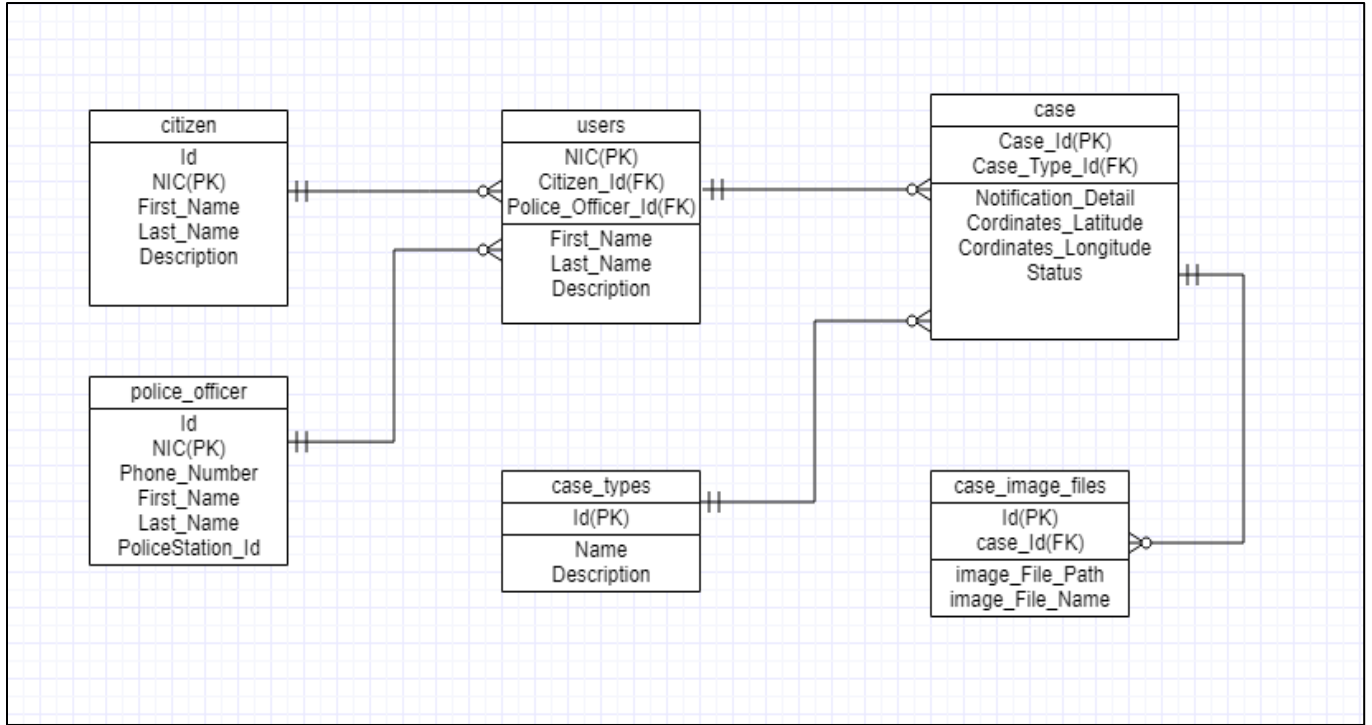
Figure 3.6: Entity Relationship Diagram

3.2.6. User Interface Design

User interfaces will be interacted with the system users. Therefore, user interface design is an important thing to success the system. Important interfaces have been shown in Appendix C. Please refer the Appendix C.

3.3. APPLICATION IMPLEMENTATION

Here focuses on the development of the mobile and web application for crime reporting where the all the functionalities of the application implemented. The screenshots of the application are presented in Appendix C for both mobile and web application.

3.3.1 Development Technologies and Frameworks Used

The application consists of a mobile application, administrative web application, REST API and storage. The mobile application has been developed using React-Native, which is a versatile JavaScript-based development framework. The administrative web application has been developed using React-Js, which is provided with numerous libraries. The REST API has been developed using Node Js. one signal push notification service has been utilized to send the push

notification for the users. Also, Hyperledger Fabric open-source blockchain platform integration was in progress for storage of the events on an immutable ledger.

3.3.2 Database Technologies Used

Mainly two kinds of alternative database technologies had been identified in the chapter 2. Finally, Microsoft SQL Server is used to implement the proposed system over the MySQL.

Reasons for selecting Microsoft SQL Server

Microsoft SQL Server integrates seamlessly with several programming languages and other web-based applications. And, it is only beneficial with Microsoft based products. Therefore, Microsoft SQL Server is fully compatible with most of the Frameworks. Other than that, below mentioned special features leads to select the Microsoft SQL Server as the database technology. [26]

Security: SQL Server provides two security models including integration with Windows Authentication to provide robust security platform for managing your organizations information. Security can be managed across all database objects including tables, views and stored procedures and at a very granular level, to provide complete information security. Database encryption is now available as well to secure SQL Server database at rest.

Scalability: SQL Server is a highly scalable enterprise database platform capable of managing pet bytes of data while delivering high performance. This allows organizations to deploy SQL Server databases with the confidence that SQL Server can continue to deliver superior performance even as their needs and businesses grow.

High Availability/Failover: SQL Server provides a variety of high availability features including failover clustering available on the Standard and Enterprise editions, database mirroring, log shipping, and database snapshots to meet your organizations' needs.

3.4. IMPLEMENTATION ARCHITECTURE

The proposed web system has been developed using the MVC architecture that is a software design pattern for developing web applications. There are lots of advantages such as reusability, maintainability and consistency of using this architecture. MVC architecture is very useful to reduce the complexity of the program and it divides the application into three parts as model, view

and controller. This MVC architecture is map into the input, processing, output roles in GUI realm. The MVC abstraction can be graphically represented as follows.
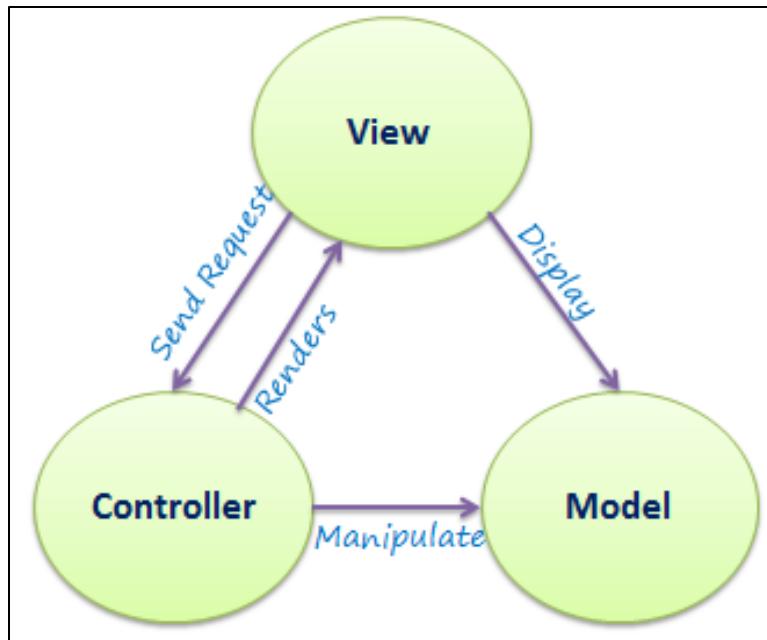
Figure 3.7: MVC Architecture

CHAPTER 4

4. EVALUATION

4.1. INTRODUCTION

Evaluation of a software system is done by carrying out Verification and Validation (V & V) process which is the process of checking the developed software to ensure whether it meets the expected specification and whether it is functionally acceptable. [27]

Software testing is a process, to evaluate the functionality of a software application with an intent to find whether the developed software met the specified requirements or not and to identify the defects to ensure that the product is defect-free in order to produce the quality product. The testing is comprised of Verification and Validation methods. Verification – refers to the techniques of finding out whether the built software meets all the customer requirements and Validation- refers to the techniques that ensure the software meets all the specified functional requirements. The testing process is considered dynamic; given that the process is carried out on an executable function of the system. Testing is a vital process to ensure a perfectly working system with fewer errors is delivered to the customer. [27]

4.2. MOBILE APPLICATION TESTING

Mobile application testing is a process by which application software developed for handheld mobile devices is tested for its functionality, usability and consistency. Mobile application testing can be an automated or manual type of testing. [28]

4.3. TEST STRATEGIES

Test strategies define the number of ways of evaluating the system functionalities to ensure that it performs as expected. These were carried out at different levels in the system implementation and involve different procedures for each. Using these strategies may vary from one project to another based on its nature to ensure the smoothness of the system.

4.3.1 Black Box Testing

This technique was used to ensure that the system is performing as expected as functions. This does not check the code in detail and do testing over the major functionalities, system has tested as components or whole functions.

4.3.2 Laboratory Testing

Laboratory testing, usually carried out by network carriers, is done by simulating the complete wireless network. This test is performed to find out any glitches when a mobile application uses voice and/or data connection to perform some functions. [28]

4.3.3 Performance Testing

This testing process is undertaken to check the performance and behavior of the application under certain conditions such as low battery, bad network coverage, low available memory, simultaneous access to application's server by several users and other conditions. Performance of an application can be affected from two sides: application's server-side and client's side. Performance testing is carried out to check both.

4.3.4 Load Testing

When many users all attempt to download, load, and use your app simultaneously, slow load times or crashes can occur causing many customers to abandon your app or website. In-country human testing done manually is the most effective way to test load.

4.3.5 Unit Testing

Unit testing was done at the lowest level. It tests the basic units of software, which is the smallest testable piece of software, and it is often called "unit", "module", or "component" interchangeably. Unit testing refers to tests that verify the functionality of a specific section of code, at the beginning of function levels.

The system was developed combining the several modules together. So, the purpose of conducting Integration testing is to determine whether all those modules/components are performing well after each module is integrated together. Many of the modules may work as it is expected in an isolated environment but not with integrated manner. Therefore, the integration testing is much important

to specify its performance and reliability when modules are combined with others. Stress testing also carried on the entire system. The main purpose of this is to determine the stability of the system and it specifies the robustness, availability and reliability of the system. The system was tested under some extreme condition and beyond basic operational capacity. This could identify what are the issues may arise in such circumstances and can implement recovery procedures for prevent the system from data loss or unexpected functionalities.

Finally, User Acceptance testing was conducted at the client premises to identify configuration problems and collect suggestions, feedback from user. This is known as Beta testing as well.

4.4. USABILITY TESTING AND EVALUATION

The sample used for testing the application was my Colleges and some of my office staff members. The respondents include students and workers. The office staff were chosen because they represent the target population who will make use of the application. The university students also mainly use android phones and thus represent the target users of the application.

The responses from the user acceptance testing formed the basis of summative evaluation of the application. a sample of users with varying skills in using mobile applications were approached and asked for their participation in testing and appraising the application. These samples were selected because they are representatives of the target users of the application.

In order to obtain proper evaluation mechanism for the application, I have designed two approaches. Firstly, after a brief explanation of the purpose and functions of the application, the users were given a task sheet containing a list of tasks for them to perform with the application. The second part of the evaluation, which asked both open and closed questions about the tasks performed by the users. The evaluation was to address both the functionality and non- functional capabilities of the application.

4.4.1 Evaluation of Results

A total of 15 questionnaires were handed out to potential users of the application. Out of the 15 questionnaires, 13 were filled and returned by the users. This Table 4.1 discusses the results from the filled work.

	Will impact	Will not impact			
Perception of Users on the impact of the application	77%	23%			
Impact to the citizen safety	54%	46%			
	Would use	Would not use			
Application Usage	63%	37%			
	Excellent	Very good	Good	Fair	Bad
Application Navigation	8%	15%	46%	23%	8%
Application User Interface	7%	8%	54%	31%	7%
Data Representation	7%	8%	69%	8%	8%
Backend User Navigation	7%	8%	54%	23%	8%
Backend User Interface	7%	8%	54%	31%	-

Table 4.1: User evaluation result summary

Finally, it can be announced that this Mobile-based crime reporting application has been developed successfully that after analyzing the user's feedback.

Please refer the Appendix D for the questionnaire sample and the result summary of the user's feedback with pie charts.

4.5. TEST PLAN AND TEST CASES

Test cases are separately developed for each module (Mobile App and the Web-based system). And test cases include all test scenarios, expected result and the actual results.

Please refer the Appendix E for test cases and test plan and test cases.

CHAPTER 5

5. CONCLUSION

5.1. CONCLUSION

The main goal of the dissertation was to develop a mobile application that can be used to report incidents and address the need of users with difficulty in reporting incidents. The opportunity that exists in Sri Lanka concerning crime incident reporting is not well tapped especially with the increase in the number of smartphones with Android OS. Thus, the mobile application comes appropriate to provide a solution to the way users report crime incidents.

Review of various incident reporting systems was web-based on social media to report incidents. The challenges of crime incident reporting on Sri Lanka was investigated successfully but it was noted that some of the crimes not reported in a proper way. Residents experience a lot of challenges with regards reporting of the crime because of the long distances to police stations and the fact that very few citizens even know the phone numbers of police stations and can therefore not contact them in case of an emergency. The other reason is that the Sri Lankan Police toll-free lines hardly work, and calls made to the toll-free number go unanswered. To safeguard citizen's lives and property, the integration of ICTs in crime reporting and monitoring process is key as this will effectively bridge the communication gap between the police and the public in fighting crime. The ultimate result of this study is to therefore develop a mobile crime-fighting application that will be used for crime reporting and monitoring.

The proposed solution is an android based mobile application was designed, developed and tested for use by citizens in Sri Lanka. The solution designed based on the users' needs for a platform to report crime incidents. The requirements were gathered and mapped using various diagrams such as use-case diagrams, sequence diagrams and entity-relationship diagram of the database. The application will allow users to report any incidents happened on the city. Based on overall statistics of user testing and evaluation, it is safe to say that the application is generally considered easy to understand and use. In Sri Lanka sometimes, the investigation processors altered by politicians. But with this Hyperledger blockchain in cooperation can ensure that data or the processors have been altered.

5.2. SUGGESTIONS AND FUTURE WORKS

Based on user feedback, the application will continuously be improved to cater for users changing requests. Further research should be done in the future to enhance functionalities of the application and thus ensure user retention. There needs to be more research on how to verify the authenticity of the reported crime incidents because the incidents are just reported by anyone with the application installed on their mobile phone.

Mobile crime reporting can further be enhanced to enable multimedia attachments and sharing so that the police can have audio or video evidence of the crime being reported. To incorporate multimedia into the mobile app, need to ensure that the carrier networks can transmit that content at acceptable speeds otherwise the whole crime reporting process will be risked.

The other feature that can be incorporated into the application is a live chat option with the police. This will allow the crime reporters or tipsters to engage in live chats with the police. This feature will eliminate a lot of false negatives because a live chat will enable prior engagement with the crime reporter before the police move in. The online chat will also offer a platform for citizens to just find out general information about the police and community they live in. This will lead to reducing the mistrust that is currently there between the police and the public.

The other enhancement that can be done is to enable the crime reporting tool to develop to run on other operating systems apart from Android such as iOS, Windows OS.

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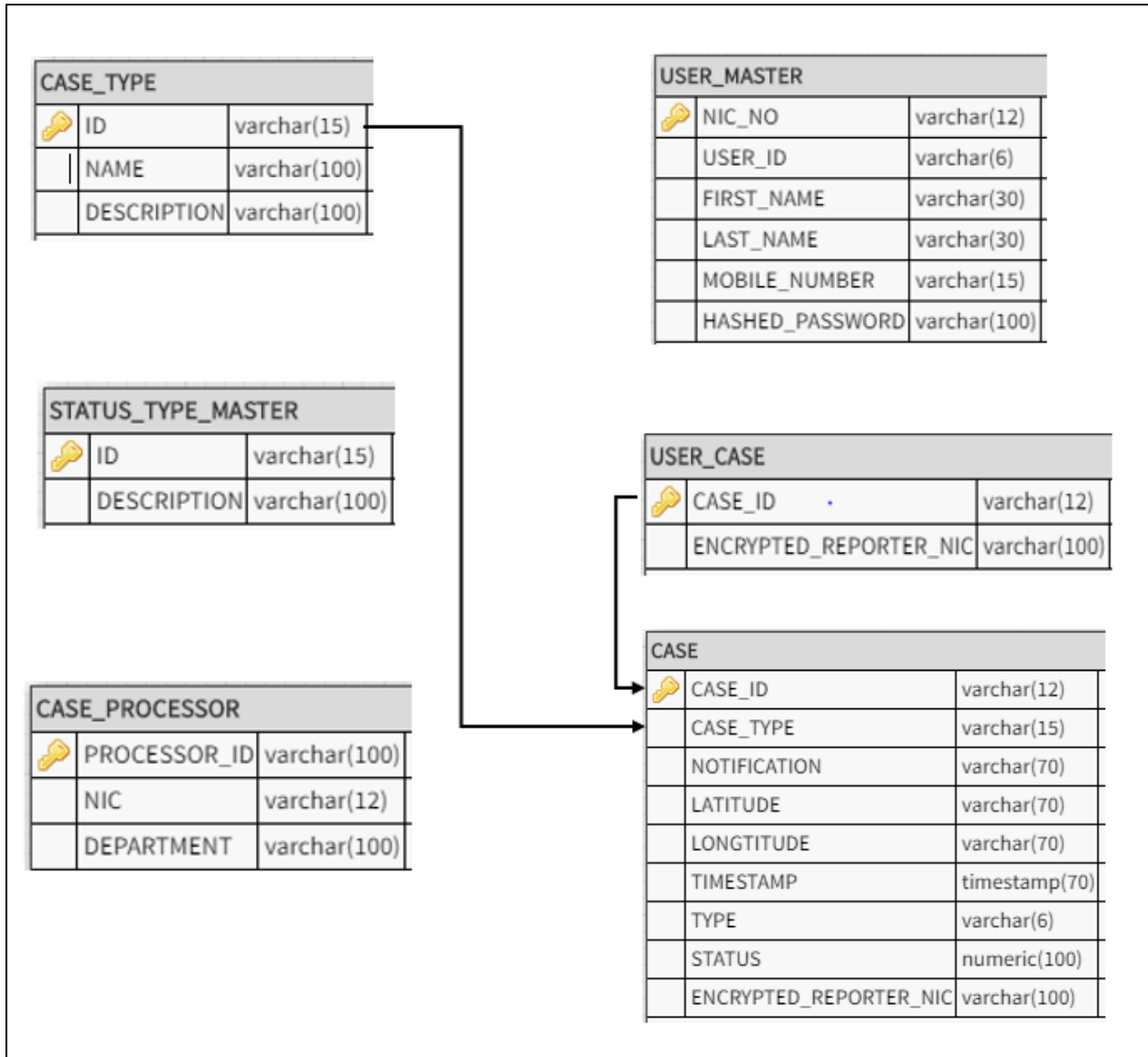
Appendix A: DATABASE DIAGRAM

Figure A.1: Database Diagram

Appendix B: MAJOR CODE FRAGMENTS

This section includes the Hyperledger fabric-related code details. To develop Hyperledger blockchain related to this solution Hyperledger has been customized as the application requirements.
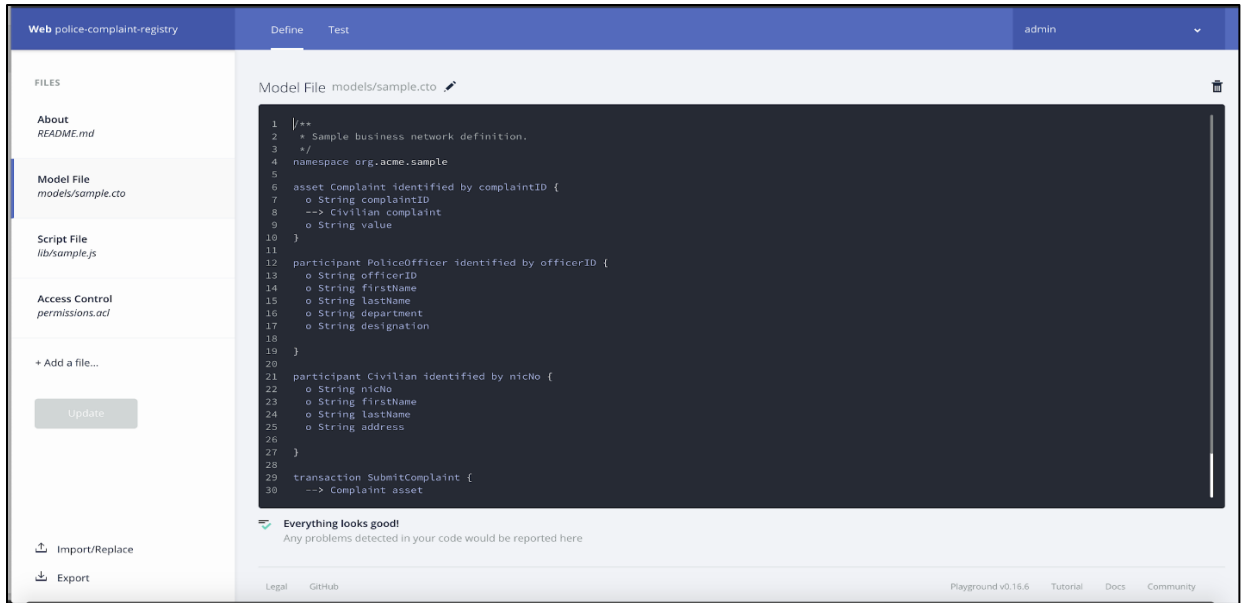
Figure B.1: Event definition Hyperledger composer
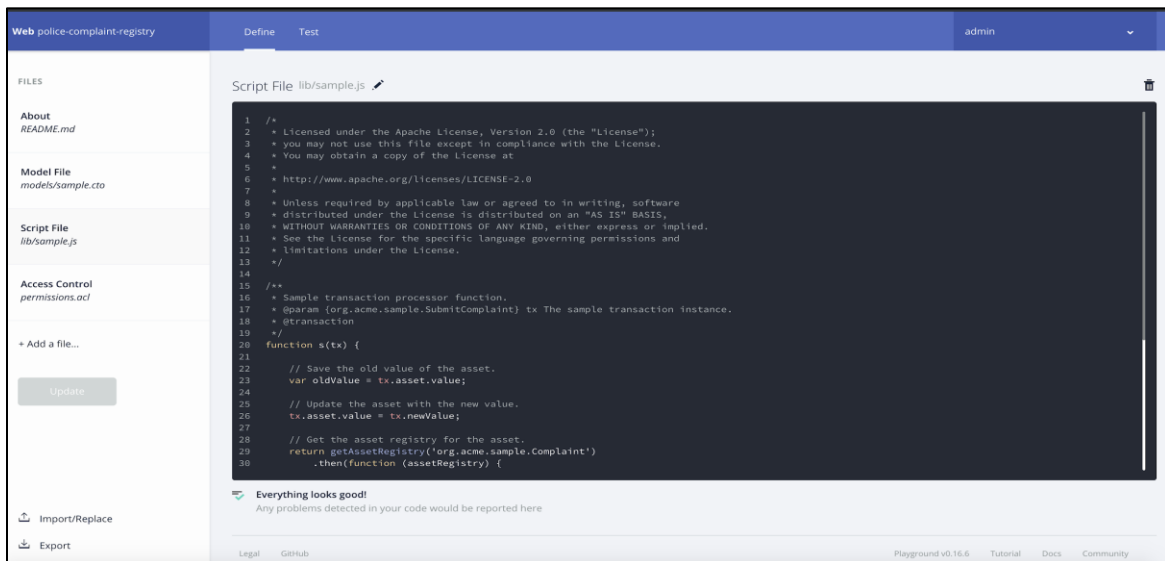
Figure B.2: Smart contract definition
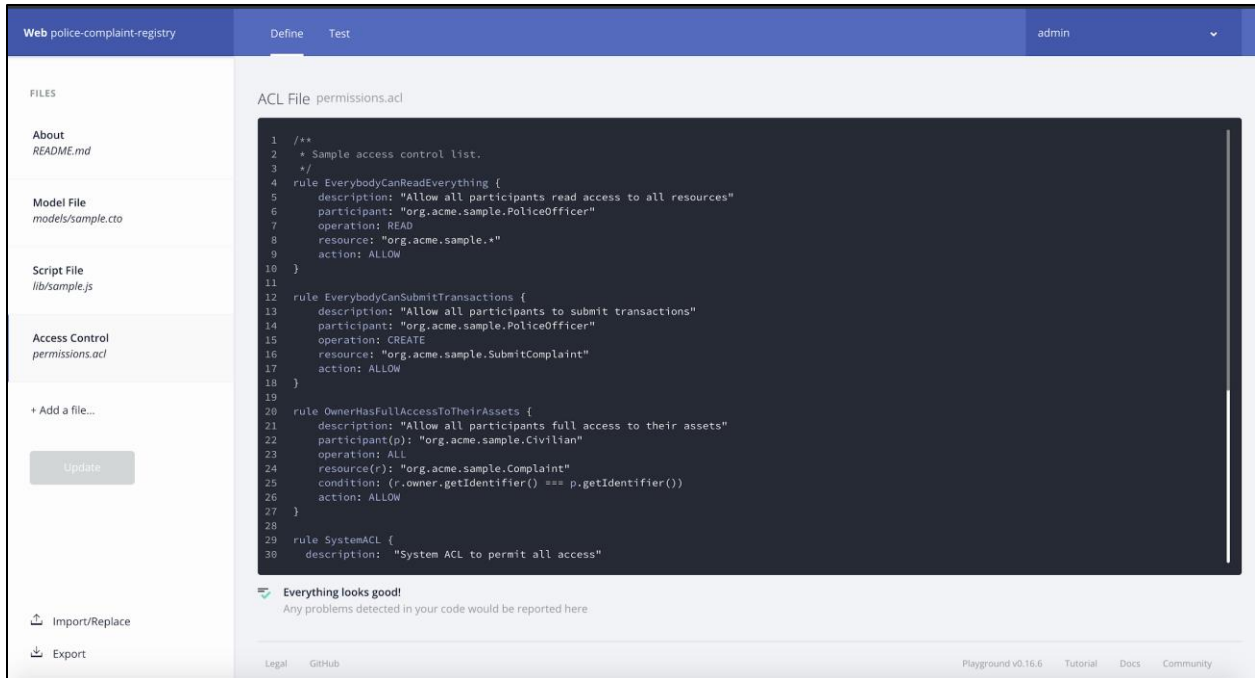
Figure B.3: Access control definition for each peer

Appendix C: USER INTERFACE DESIGN

User interface design is most important part of the system. In this section it will show some important user interfaces that related to the both applications.

Dashboard of admin application

This is the dashboard of the police admin application. Main menu is on lift side.
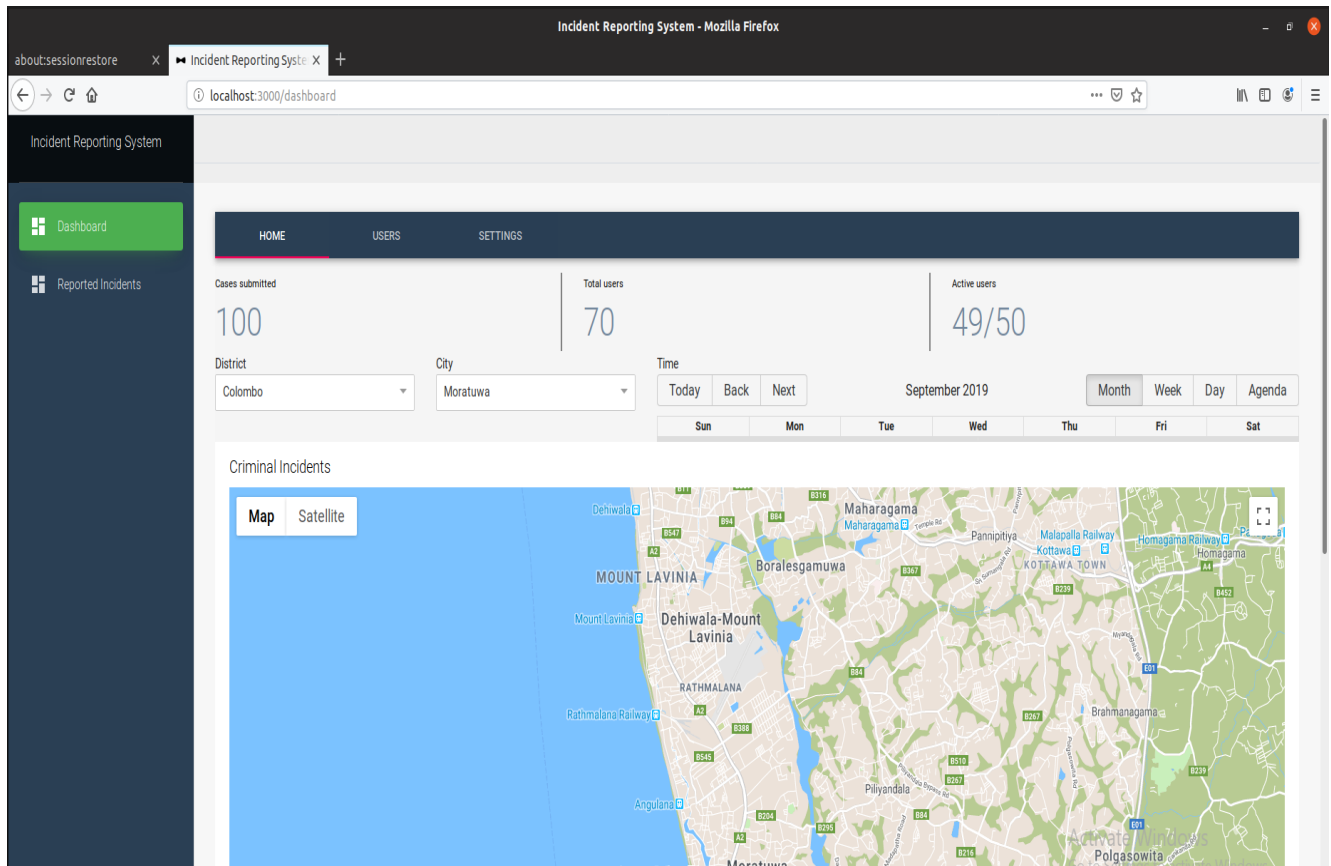
Figure C.1: Dashboard of the admin application

Here the police admin can view each and every reported crime incidents under Reported Incidents page. By clicking each row admin can view the image of the crime incident.

Figure C.2: Reported Incidents page of the admin application

Login screen of the citizen Mobile Application
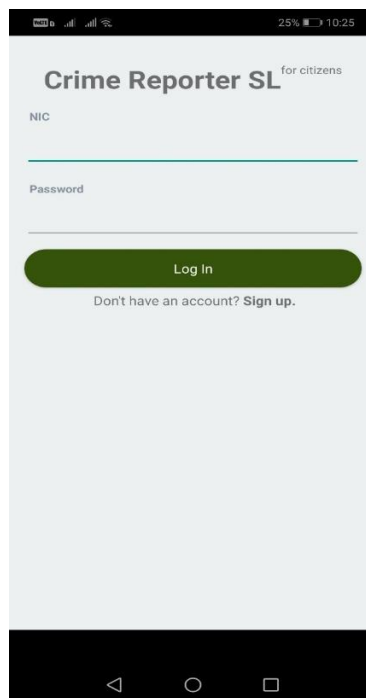
Figure C.3: Login screen of the Mobile Application

Sign Up screen of the Mobile Application

All the citizens need to register for the mobile application by using below screen in order to submit a crime.
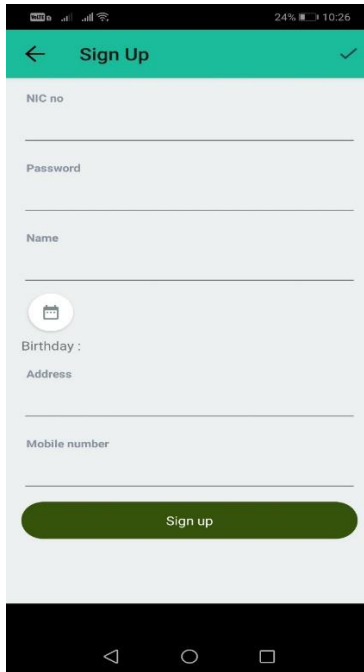
Figure C.4: Sign up screen of the Mobile Application

Submit Crime screen of the citizens Mobile Application

By using below screen of the mobile application citizens can submit a crime with picture evidence. Picture can be select from library or can take a photo. And address of the crime event is taken by the Google Map.
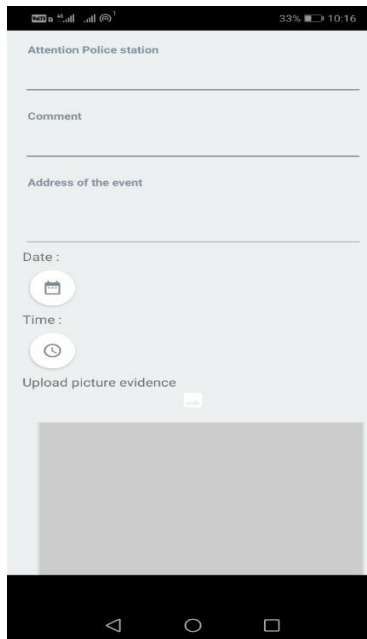
Figure C.5: Submit Crime screen of the Mobile Application

Landing screen of the Police Mobile Application

Below displayed the landing mobile screen of the police Mobile Application.

Figure C.6: Landing screen of the police Mobile Application

Landing page of the village headman web application

Below displayed the landing page of the village headman web application and by clicking each row of the data table he/she can approve the citizen registration to the mobile application.
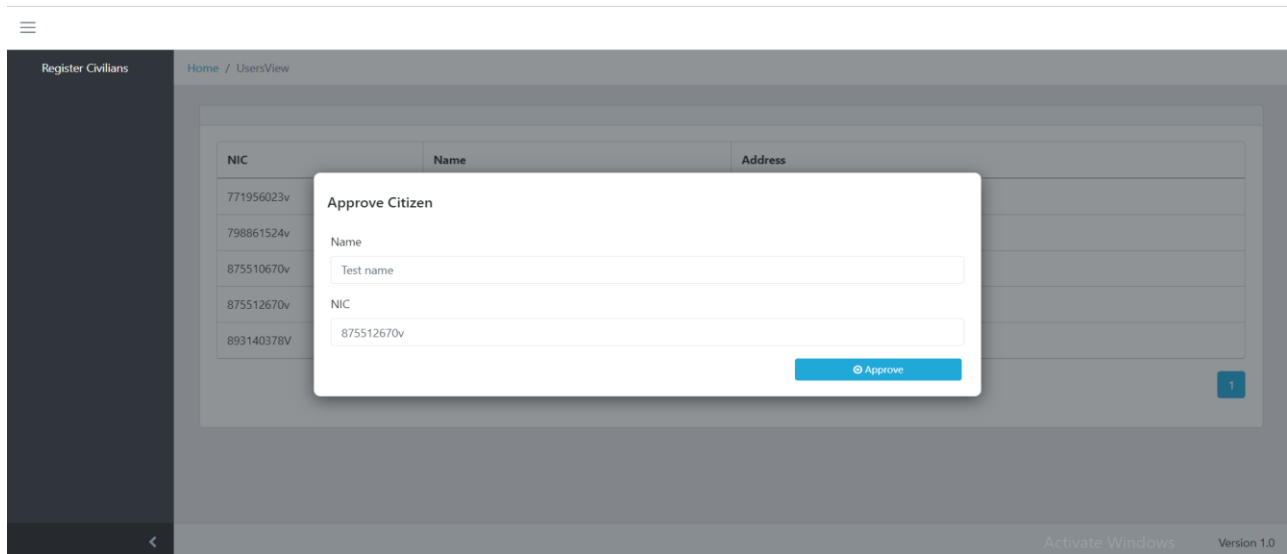

Figure C.7: Landing screen of the police Web Application

Appendix D: EVALUATION & TEST RESULTS

This chapter provides an overview of how the system functions were tested to ensure that the system has no bugs or pitfalls where the system might cause for failures. This was achieved by proper error handling. Test results were mentioned below. Testing process was carried out as mentioned in the Chapter 4.

User evaluation results also mentioned here with pie chats as mentioned in the Chapter 4.

Figure D:1 shows a chart detailing the Questionnaire

Questionnaire: Usefulness, Satisfaction, IS and Ease of use Please tick the most appropriate Please be kind enough to respond to all the items					
	Will impact	Will not impact			
Perception of Users on the impact of the application					
Impact to the citizen safety					
	Would use	Would not use			
Application Usage					
	Excellent	Very good	Good	Fair	Bad
Application Navigation					
Application User Interface					
Data Representation					
Backend User Navigation					
Backend User Interface					
If you would like to share any additional comments or experiences about implemented system, please write below; *Thank You Very Much for your Kind Corporation!!!!*					

Table D.1: Questionnaire

Impact of the Application may have to the Authorities Concerned

Figure D:2 shows a chart detailing the respondent's perception on the impact of the crime incident reporting application regarding the crimes as far as the response of the users is concerned.
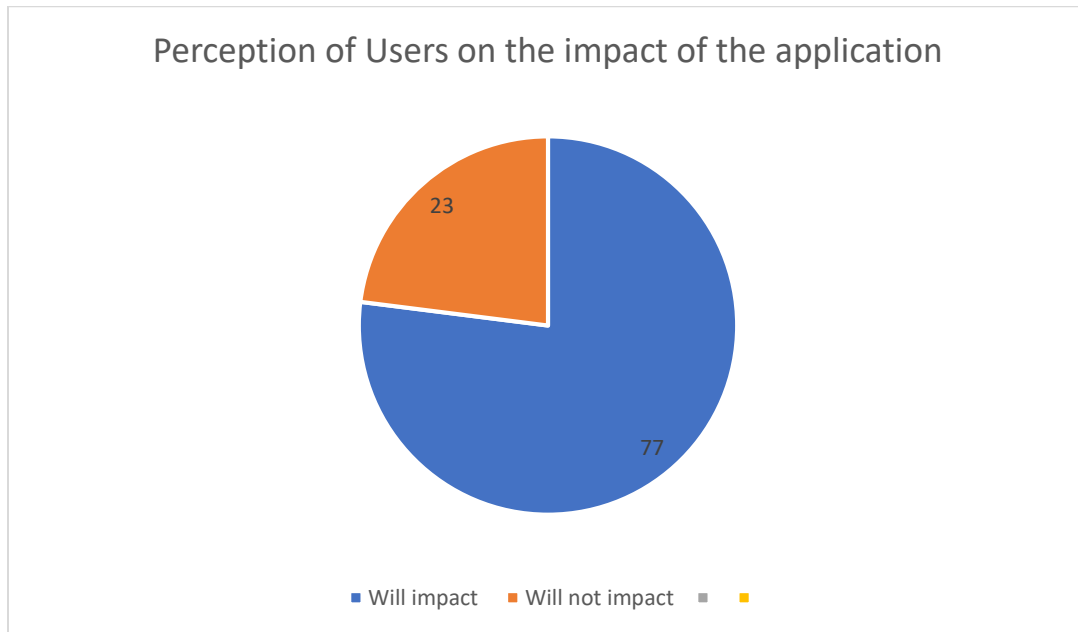
Figure D.2: Perception of Users on the impact of the application

23% of the respondents think that the application will not have any impact as far as the crime incident reporting is concerned. They had following reasons.

➢ There are other applications that may serve as better mediums to report such incidents. They said Twitter and Facebook would better medium.

The impact of the Application on Citizen Safety

Figure D: 3 shows a chart detailing the impact of the application on crime reporting.
54% of the respondents thought that the application will improve on the citizen safety. They had following reasons.

➢ It will help improve it but not necessarily prevent harmful crime incidents.
➢ It will help the authorities act faster since they will be getting hand information in real-time especially with the real-time tracking system.
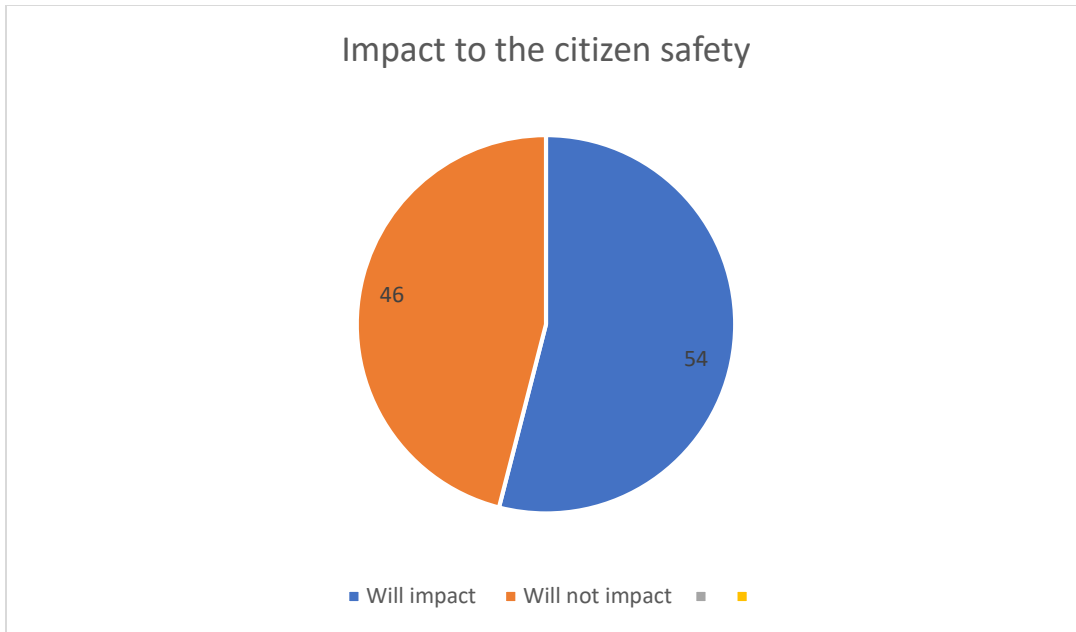
Figure D.3: Impact of the Application on citizen safety

Percentage of respondents willing to Use the Application

Figure D:4 is chart showing the percentage of respondents who would actually use the application versed those who wouldn't.
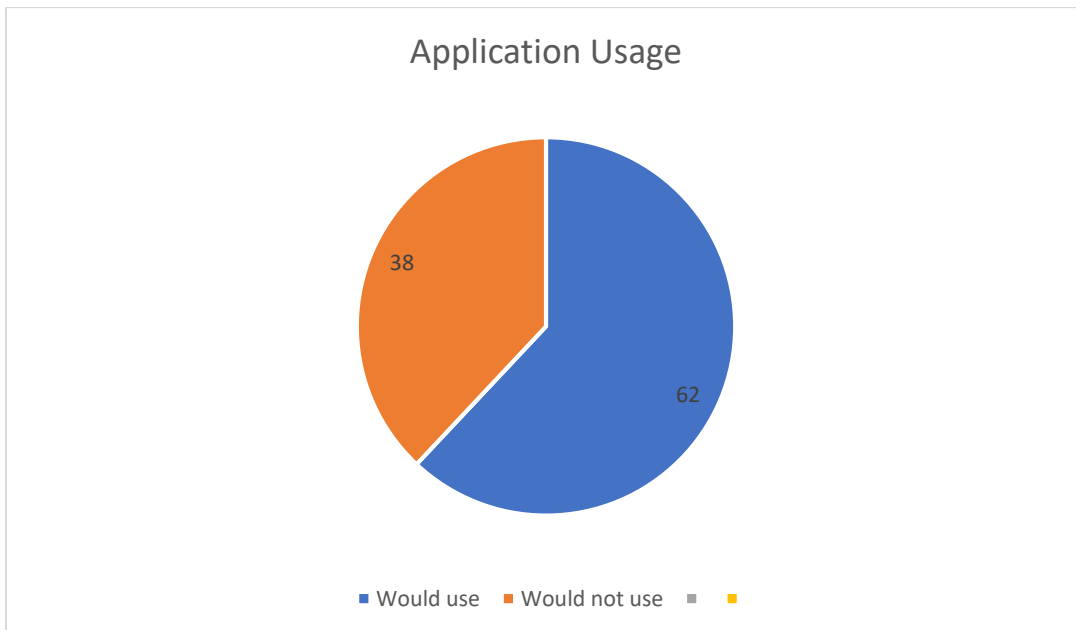
Figure D.4: Percentage of respondents willing to Use the Application

62% of the respondents responded said that they would use the application but under the following conditions.

  ➢ That their privacy is always respected and considered.
  ➢ If it proves to be effective in solving reported crime incidents.

38% of the respondents said that they would not use the application due to the following reasons.

  ➢ There are better reporting methods such as Facebook and Twitter.
  ➢ The application does not have other incentives other than just reporting

Ease of Use in Terms of Navigation

Figure D:5 is a chart showing how the respondents rated the ease of use of the crime incident reporting application in terms of the navigation.
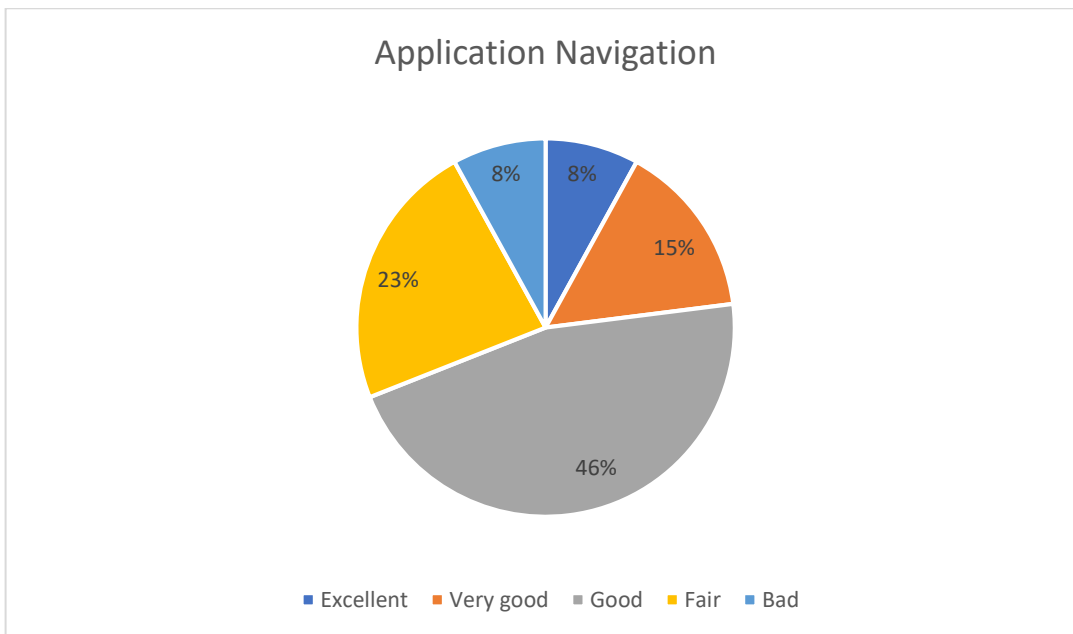
Figure D.5: Ease of Use of the Application

8% of the respondents thought the navigation of the application was excellent, 15% thought it was very good, 46% thought it was good, 23% thought it was fair and 8% thought it was bad.

User Interface Ratings

Figure D:6 is a chart showing the rating of the user interface as per the respondents.
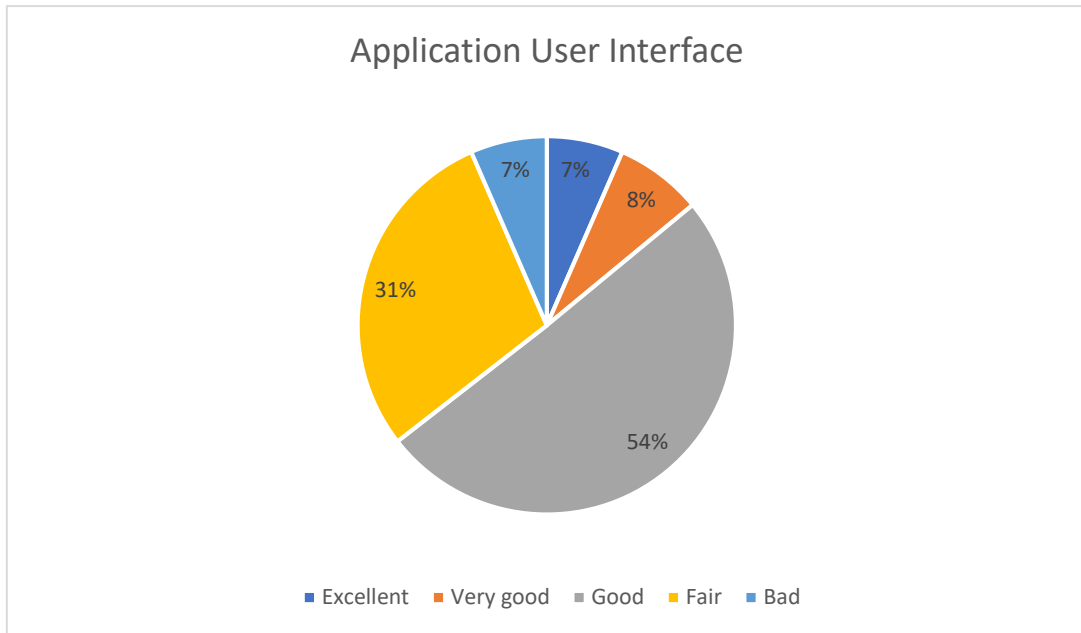
*Figure D.6: User-Interface Ratings of the Application*

0% of the respondents thought the front-end mobile interfaces was bad, 8% thought it was very good, 7% it was excellent, 31% thought it was fair, 54% thought it was good. The following were the views from the respondents.

➢ The application colors should be a bit bright.

➢ The application icons should be well placed and proportional especially on the backend application.

Data Representation Ratings

Figure D:7 shows a chart showing the ratings based on data representation in the back-end of the application.
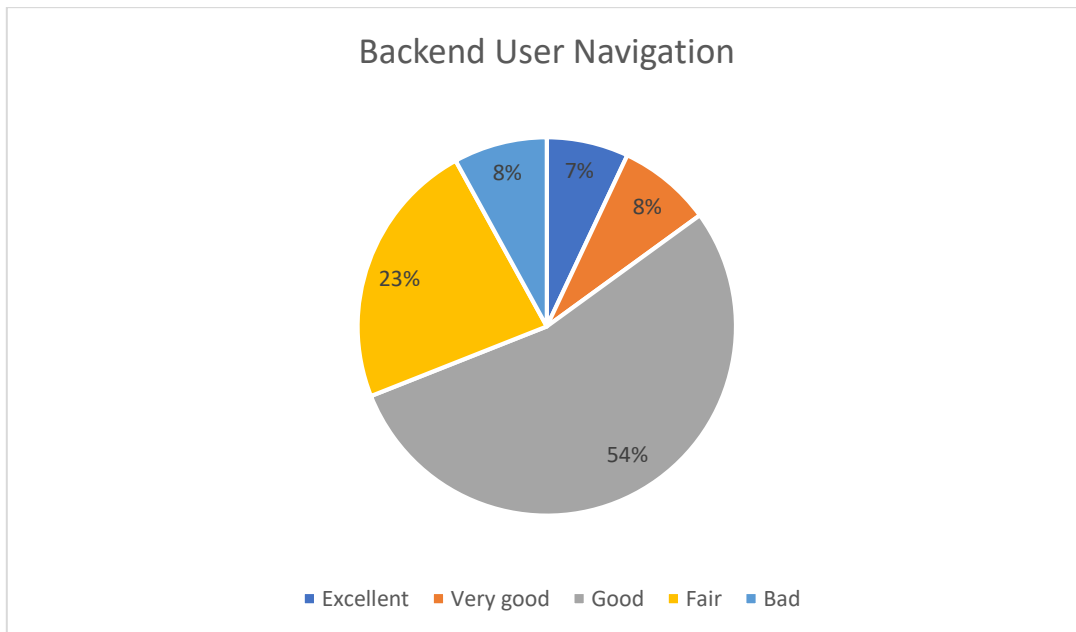
Here 8% of the respondents thought it was bad, 7% thought it was excellent, 8% thought it was very good, 8% thought it was fair, 69% thought it was good.
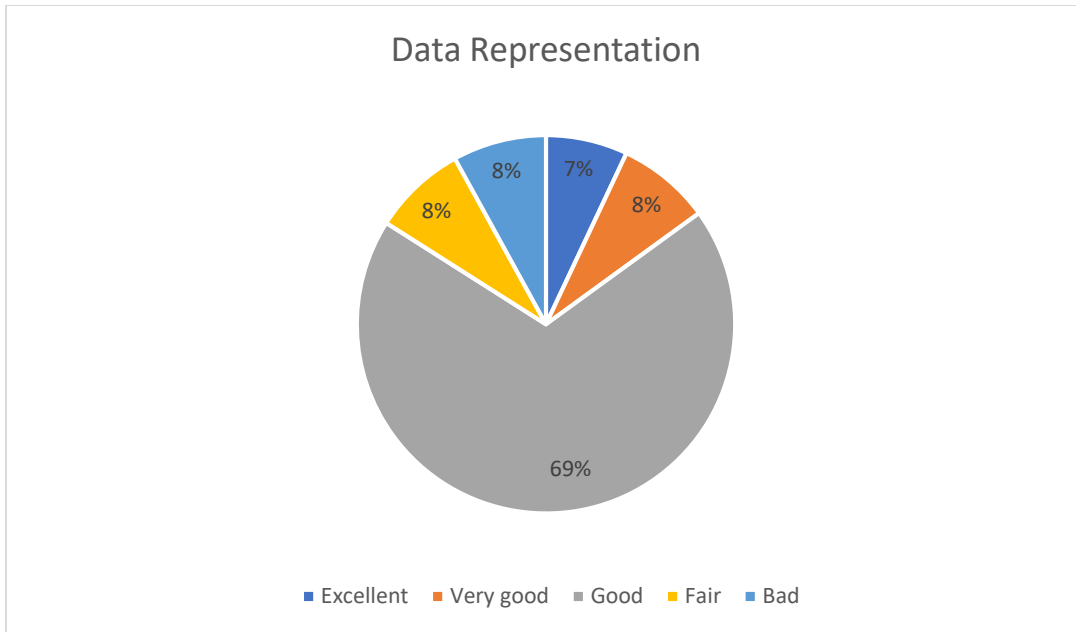
Figure D.7: Data Representation Ratings

Backend User Navigation

Figure D:8 shows the results from the users based on the navigation of the backend of the application.
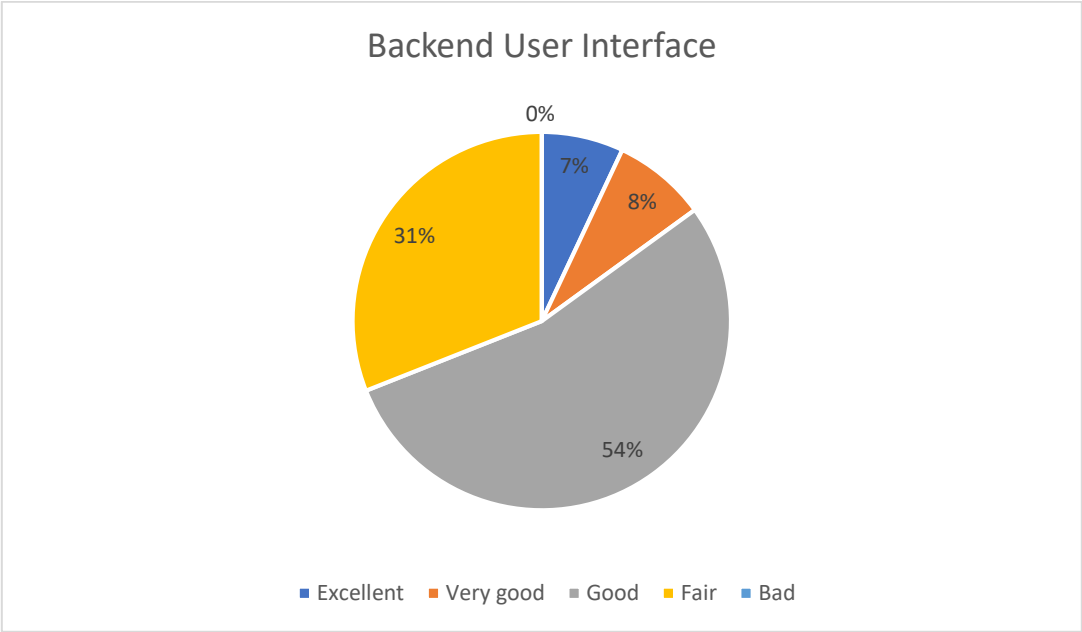

Figure D.8: Backend navigation

7% of the respondents thought the navigation was excellent, 8% thought it was very good, 54% thought it was good, 23% thought it was fair and 8% thought it was bad.

Back-End Look and Feel/Appearance

Figure D:9 is a chart showing the feedback from the users based on the appearance of the back end of the application.

Figure D.9: Backend Look and Feel

7% of the respondents thought the appearance was excellent, 8% thought it was very good, 54% thought it was good, 31% thought it was fair and 0% thought it was bad.

Appendix E: TEST PLAN & TEST RESULTS

Test Plan & Test Case – Mobile Application

The Android mobile application was tested for input validation when the user was expected to fill the suspicion forms across the four modules.

Table E.1: Below illustrates the Test cases for Sign Up of Mobile application

Test Case Name:	Citizen registration for Mobile App	Test Case Number:	1	
Brief Description	Test the action of filling in the form for registration - Sign Up			
Pre-conditions	The user has download and installed the mobile application into their phone and it is launched for the first time.			
Step	**Action**	**Expected Response**	**Actual Response**	**Pass/Fail**
1	User taps the Sign up	User is taken to Sign Up form	Same as expected	Pass
2	The user may choose to leave blank all fields	A prompt should display when the user attempts to submit without the filling the required fields.	Same as expected	Pass
3	Filed Validations - NIC	A prompt should display when the user attempts to submit without NIC	NIC number is empty	Pass
4	Filed length validation - NIC	A prompt should display when the user attempts to submit NIC with invalid length	NIC length invalid	Pass
5	Filed Validations - Password	A prompt should display when the user attempts to submit without Password	Password is empty	Pass
6	Field validation - Birthday	A prompt should display when the user attempts to submit with future date birthday	Invalid birthday for future date	Pass

7	The user fills all the required fields and tap Sign Up	User is taken to Thank you screen	Same as expected	Pass
8	Try to login to App before manual verification	A prompt should display with indicating manual verification needed	Same as expected	Pass

Table E.1: Test cases for Mobile application – Citizen Registration

Table E.2: Below illustrates the Test cases for Login function of Mobile Application

Test Case Name:	Citizen Login for Mobile App	**Test Case Number:**	2	
Brief Description	Test the action of Login to Mobile Application			
Pre-conditions	The user has download and installed the mobile application into their phone and Register for the App.			
Step	Action	Expected Response	Actual Response	Pass/Fail
1	User taps the App	User is taken to log in screen	Same as expected	Pass
2	The user leaves all fields as blank	A prompt should display	Same as expected	Pass
3	Filed Validations - NIC	A prompt should display when the user attempts to submit without NIC	NIC number is empty	Pass
4	Filed Validations - Password	A prompt should display when the user attempts to submit without Password	Password is empty	Pass
5	The user fills all the required fields and tap login	User is taken to landing screen	Same as expected	Pass

Table E.2: Test cases for Mobile application – Login

Table E.3: Below illustrates the Test cases for submitting crimes through Mobile Application

Test Case Name:	Citizen Login for Mobile App and Submit Crime	Test Case Number:		3	
Brief Description	Submit a Crime				
Pre-conditions	The user has to login to the App.				
Step	Action	Expected Response		Actual Response	Pass/Fail
1	User tap the icon	User is taken to submit crime screen		Same as expected	Pass
2	The user may choose to leave blank all fields	A prompt should display when the user attempts to submit crime without the filling required details		Same as expected	Pass
3	Filed Validations - Date picker	A prompt should display when the user attempts to submit crime with selecting future date		Invalid date for future date	Pass
4	The user fills all the required fields and tap Submit crime	Success message should be displayed		Same as expected	Pass

Table E.3: Test cases for submit a crime

Test Plan & Test

Test Plan & Test Case –Village Headman Web-based Application

The web application was tested thoroughly, and the all the attention was focused on its functionality.

Table E 4: Test cases for Web application below illustrates the test case which was conducted to check the user verification process works as per requirement.

Test Case Name:	User Registration verify by village headman	Test Case Number:	4		
Brief Description	User verification				
Pre-conditions	The village headman need to login to the web module				
Step	**Action**	**Expected Response**	**Actual Response**	**Pass/Fail**	
1	User enters invalid credentials	System shows a prompt that the credentials entered was invalid	Same as expected	Pass	
2	User enters valid credentials	User is successfully logged in.	Same as expected	Pass	
3	Verify citizen by clicking particular row in data table	Particular citizen need to be verified	Same as expected	Pass	
4	Check whether that verified user can log in to mobile app without any error	Citizen should be able to login to app	Same as expected	Pass	

Table E.4: Test cases for village headman Web application

Test Plan & Test

Test Plan & Test Case – Police Officer Web-based Application

Table E.5 below illustrates the test case which was conducted to demonstrate how the police officer can view submitted crime incidents.

Test Case Name:	View Reported crime incidents by police officers and acknowledge them.	Test Case Number:	5	
Brief Description	View reported crime incidents			
Pre-conditions	The village police officer need to login to the web module			

Step	Action	Expected Response	Actual Response	Pass/Fail
1	User enters invalid credentials	System shows a prompt that the credentials entered was invalid	Same as expected	Pass
2	User enters valid credentials	User is successfully logged in.	Same as expected	Pass
3	View crime incidents by clicking particular row in data table	Particular crime incident details should display with details	Same as expected	Pass

Table E.5: Test cases for view reported crime incidents by police

Appendix F: USER GUIDE

User Guide for Mobile Based Crime Reporting App

Table of Contents

Introduction

Purpose

This document is intended to provide a comprehensive guide for the system users of Mobile-based Crime Reporting App.

List of Stakeholders

The below-mentioned personnel will refer the document:

- Citizen
- Police officers
- Village Headman

Definitions, Acronyms, and Abbreviations

Term	Definition
GPS	Global Positioning System
WIFI	Wireless Fidelity

Document Overview

The rest of the document is structured as follows: The 2nd chapter explains the system features and user types. The 3rd chapter elaborates on the interface flow for user registration initiated through Mobile App and user verification initiated through web-based application. Chapter 4 describes the interface flow for submit crimes initiated through Mobile App.

System Features and User Types

System Features

The main features of the Mobile App and Web Application are as follows:

- Enabling citizens to register for the Mobile App after downloading and installing the Mobile App to android phone.
- Capability to submit crimes anytime anywhere through mobile phone with using WIFI or mobile data connection.
- Ability to attach images.
- Ability to take exact crime incident location address with GPS technology

- Web-based village headman admin Module - Implementing a streamlined user registration process.
- Web-based police admin Module - Ability to retrieve submitted crime incidents and view the crime details.
- Sending push notifications to the particular policeman when acknowledging the crime incidents. For that particular mobile phone settings must be granted accordingly. Such as push notifications, camera and GPS etc.
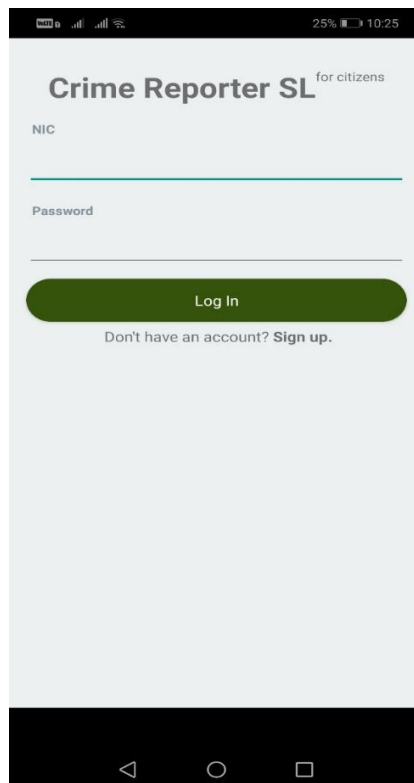
System User Types

The system user types are as follows:

- Citizens
- Village Headman
- Police officers

User registration and submit crime through Mobile App

1. Citizen download and launch the Mobile App and click sign up.

2. Fill the all required details and submit sign up form for user registration.

3. Citizen log in to the Mobile App.

After verify the sign up by village headman particular citizen can log in to the Mobile. In order to login to mobile app citizen need to give valid credentials.

4. Once login to the Mobile App user can submit crime. For submit a crime user need to fill all required fields. Image attachment can be either by picture library or can take form camera. Address of the event is taken by GPS and it can be select by below-highlighted icon.
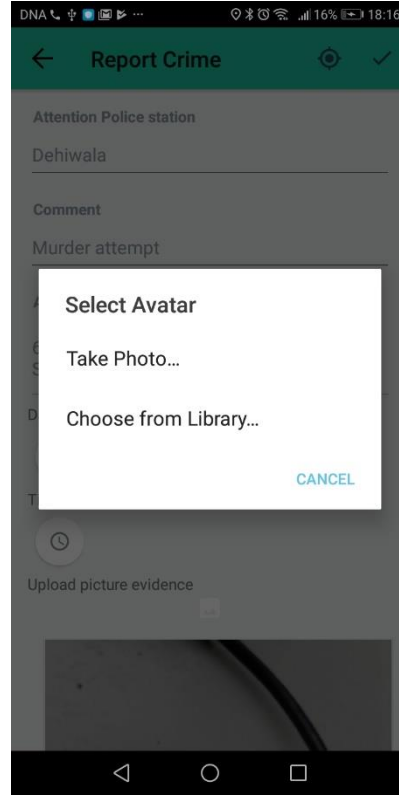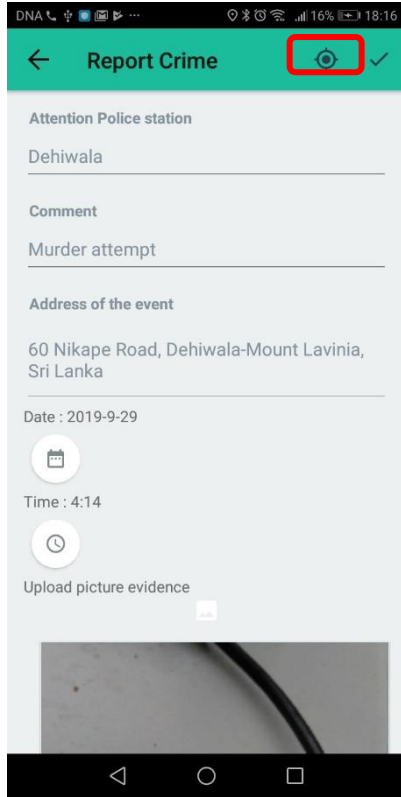
User verification and view the reported crimes via Web Application

5. User verification by village headman

For approve the user sign up, village headman need to login to the web application by giving valid credentials. Then by clicking particular row of the data table pop up will displayed and then village headman can approve the citizen sign up. Once the approval process completed particular citizen can log in to the Mobile App.
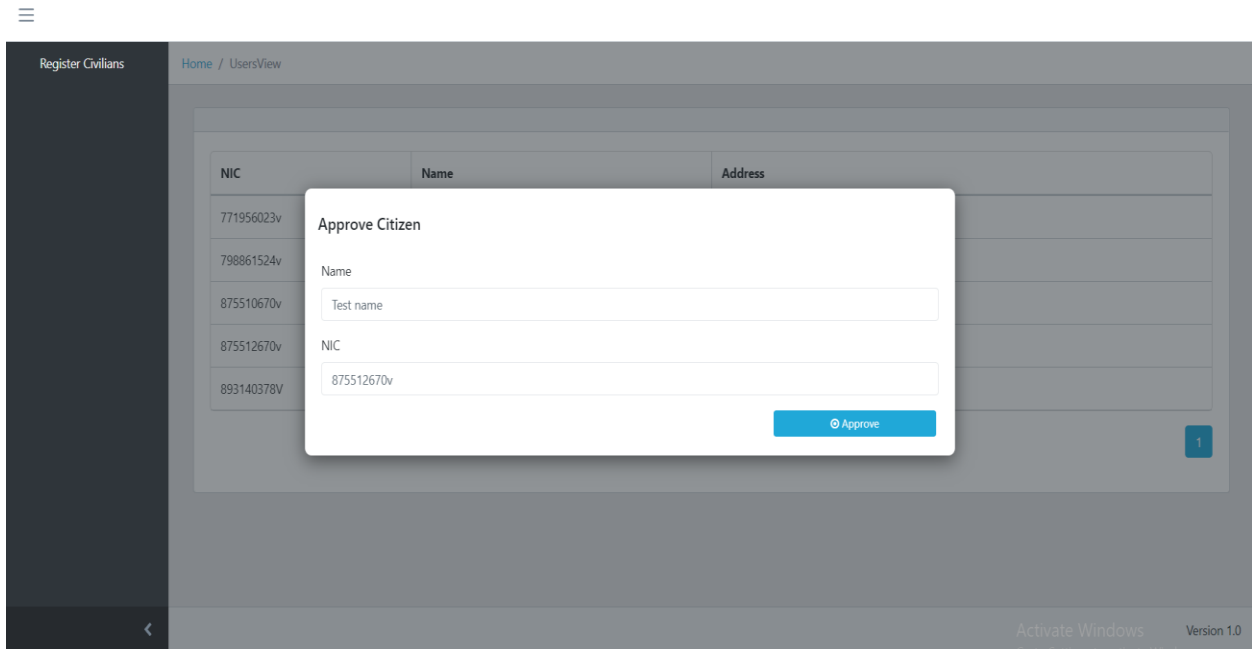
6. View reported crimes by police officers.

For view the reported crime details, village headman need to login to the web application by giving valid credentials. And then need to go to Reported Incidents menu. Then by clicking particular row of the data table pop up will displayed with crime incident details and uploaded picture.