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A Usable and Secure Crime Reporting System for Technology Resource Constrained Contexts

Aderonke Busayo Sakpere, Anne V.D.M. Kayem, and Thabo Ndlovu
olfade001@myuct.ac.za, akayem@cs.uct.ac.za, and ndltha025@myuct.ac.za
Department of Computer Science, University of Cape Town
Rondebosch, 7701
Cape Town, South Africa

***Abstract*—Crime in technology resource constrained environments has been shown to adversely affect economic growth by deterring investment and triggering emigration. To address this secure reporting channels are being investigated to encouraging anonymous crime reporting. In this paper, we present a system (CryHelp App) developed to enable residents of a university community situated in technology resource constrained environment to facilitate secure and covert crime reporting. We focus primarily on the usability of the application. The system was developed on the basis of user centric iterative approach. Deployment and evaluation results of our prototype system demonstrate that overall the system scored a 77.06% usability rating with a standard deviation of 0.05 for contributing scores on System Use, Information Quality and Interface Quality. This is indicative of the fact that users found the system to be very usable.**

I. Introduction

The penetration of mobile devices in technology resource constrained environments has triggered research towards using mobile devices for submitting crime reports to law enforcement agencies [1] [2]. Outcomes of studies indicate that mobile phone usage has not achieved widespread popularity as a crime reporting medium in technology resource constrained environments. Therefore a key concern users have with respect to mobile crime reporting systems is that of privacy.

Furthermore, outcomes of some other studies [3] [4] [5] reveal that a mobile device can serve as a security assurance in reporting crime especially if the victim needs someone to come to their aid immediately. However, according to the studies carried out in [6] users have different perspectives about the value of the security offered by their mobile device. For instance, some users publicly utilize their mobile device to express their connectivity as a means to ward off potential attackers while others see value in utilizing the device only after they have been attacked.

A. Motivation and Problem Statement

Unreported crime due to fear of privacy violations is an ongoing concern in technology resource constrained environments [7]. In a recent report from the South African Institute of Race Relations (SAIRR) roughly half of all crimes are never reported to the police [7]. This high rate of unreported crimes could affect the society in decision making and law enforcement agencies in allocation of resources. As a result, there is a need for a crime reporting platform that guarantees anonymity and security.

Crime reporting and the likelihood of an individual making a report are not as simple as filling a form as researched in [12]. It has been found that the digitising of the reporting process not only improves the likelihood of individuals to make crime reports but can also yield more comprehensive and meaningful reports.

According to [3] [12] [11], it is perceived that the use of mobile devices provides a good security platform for crime report. As a result, there is a need for a mobile application that can facilitate crime reporting in a secured and covert way. To this regard an interface must be designed that serves the full functionality of the paper based service whilst incorporating good design principles and ensuring it suits the mobile platform.

B. Contribution

In order to create an application that facilitates report crime in a secured and covert way, we digitised the crime reporting System in a University Campus setting. We achieved this by breaking down our solution to two components: front and back end. The system back-end addresses the communication and storage of the application. The front-end focuses on the development of the user interface. The interface allows users to create and effectively fill crime reports resembling the existing paper based crime report in a secured and covert way. The interface also allows for two types of crime reports. The first, which is tagged "a full crime report" is based on the digitisation of the existing paper based reporting system. The second report type tagged "emergency report" will automatically compile relevant user data and allow the user to send a report quickly in adverse conditions. The focus of this paper is on the front-end.

C. Outline

The rest of the paper is structured as follows. In Section 2, we present related work on privacy notions and existing cry reporting applications with major focus on those in technology resource constrained environments. Section 3, presents usability and interface design principles for our crime reporting application. In Section 4, we present results from our implementation and conclude in Section 5.

II. Related Work

Related work is analysed first by looking at privacy in mobile devices and second, via general crime reporting systems

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with major focus on those in technology resource constrained environments.

With the advent of mobile technology, more and more applications are been designed. These applications focus on providing relevant information to the individual by means of aggregating data, both from the user and from other individuals and as such compromise to a personal privacy is under question [4].

Personal privacy can be invaded in numerous ways on a mobile device. In order to gain and supply relevant data to users, location based services are often employed. This location data could play a vital role in designing a crime reporting system, allowing relevant authorities to figure out the exact location of victims in order to act swiftly. However the possible intrusion of location data, by unauthorized individuals presents a serious threat to the user's privacy. This vulnerability could result in cyber-attacks, spamming and inference attacks not to mention the physical security risk of strangers knowing the user's movement patterns and current location [5].

City Sourced (CS) [8] is "a real time mobile civic engagement platform". It allows users who download and install the application to report a public issue. A major disadvantage of this application is that it only caters for civil matters such as dilapidation and vandalism of public and private areas. Additionally it does not support emergency report.

Crime Line [9] is an initiative of the South African community, endorsed by South Africa Police Service (SAPS) to help report crimes and wrong doers. As a website and hotline it provides a platform for users to give information on a crime that has or is suspected to happen. When reporting via the web, the report is compiled as a tip off; users can report suspicious activity anonymously or supply their contact details. Crime Line then compiles the report and sends it to the relevant local authorities. A major setback of this system is that it is a web-based application.

Crime Push [10] is a mobile crime reporting application that gained much media attention during its launch, being featured on numerous television reports. Users can send an image and a description of what is happening in their surroundings. It also allows users to choose whom to send the report to, for instance medical contacts, family or the police. Key points in the Crime Push interface are that it uses icons and descriptions to help users quickly categorise a report, avoiding long possibly unnecessary text input and overall making the reporting process less time consuming. It uses large buttons and icons which also help make the process less daunting for nervous or first time users. Finally a red interactive bar is used to send the final report; ensuring users do not send a report mistakenly.

It is clear from existing work on crime reporting system in technology resource constrained environments that there is a need to integrate a component that will facilitate a secured emergency report of crime in cases of adverse conditions. Also, literature affirms that the use of mobile device to report crime ensures report is secure. In our work, we achieved reporting of an emergency crime by allowing users also to send a crime report covertly with little or no textual input in adverse conditions. We achieved this by allowing the following input: touch based gesture, motion based and audio input. Each input method was mapped to a different output method. Correct touch gestures resulted in a visual response. When a motion based input was detected haptic feedback was used for output. For microphone input, a sound was used to confirm the acknowledgement of the message.

III. System Design and Architecture

In our mobile crime reporting system (CryHelp), the user (reporter) uses a mobile device that runs Android Operating System to report crime incidents to a law enforcement authorities. Our framework consists of three main components namely, the "User Interface", "Secure Data Transfer" and "Data Storage". The user interface component enables users to create and effectively fill crime reports resembling the existing paper based crime report. The secure data transfer enables successful transfer of data from the mobile device into data storage. The data storage component manages the data collected from all the user reports that are sent to the authorities. It also manages the access control to the data within the authority organisation. The focus of this paper is on the user interface component.

In order to develop the user interface component of the CryHelp App, the user-centred design methodology in an iterative manner was used throughout the development stage of the Mobile Crime Application System. The objective of the design is firstly to investigate whether a mobile device can be used effectively to create a crime report based on existing crime reports used by law enforcement authorities. Secondly to investigate to what extent it is possible to create crime reports instantly to act as panic buttons in emergency situations.

A. Requirement Analysis

Early in the design process it was necessary to first list all that the requirements the application was intended to meet. These requirements align with the aim of the design, and in fact must be met in order to meet this aim. Requirements analysis was elicited primarily using interviews, discussions and the study of the literature as discussed before in the background chapter. Functional requirements define the function of the system. Key stakeholders identified for identifying these requirements were an Information Security Researcher and a crime Investigation Officer. Figure 1 shows the system diagram of the CryHelp App.

The functional requirements are classified into two categories: emergency and standard crime reports. The standard crime reports enables end user to use a mobile device to carry out a substantial crime report. The emergency crime report function enables user to use a mobile device to use a single input that enables reporter to submit a crime report. The non-functional requirements is classified into two. Firstly, the platform on which the system must run and secondly, the format storage for the input. The system must run on an Android device platform. The system must store user data in a XML file.

B. Iterative User Interface Design

In order to understand the crime reporting process and the users of the system, we carried out a mock crime reporting process.

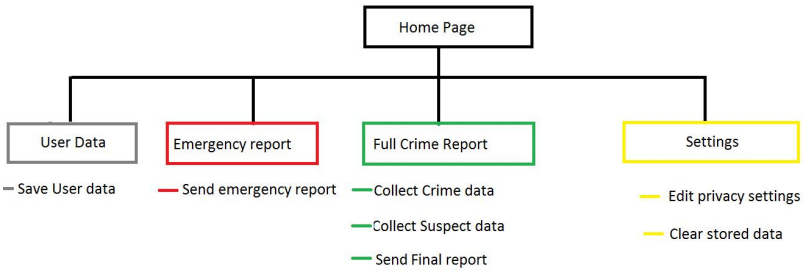

Fig. 1: CryHelp App System Diagram

1) User Requirements: A small sample of 5 users was selected to source user experiences with reporting crimes. The sample contained users who had been affected by crime before and only one user whom had never been personally affected by crime. The requirements were also supplemented by debriefing sessions carried out before and after prototype interaction using questionnaires. Users identified that they want the application to be easy to use, have option to hide user's identity, option to save the current report, option to allow users to fill it later and allow quick convenient input. Some users wanted a guarantee that the personal information provided would be stored securely.

2) Prototypes: Using the iterative design model, we develop prototypes. Prototyping is a means of letting users test a tangible element of the system, and is employed as a means of gathering user input. In this research, the use of prototypes allowed design of the interface to undergo criticism and evaluation.

We employed both low and high fidelity prototypes for the design process. Figure 2 shows the iterative cycle involved in the prototype design.

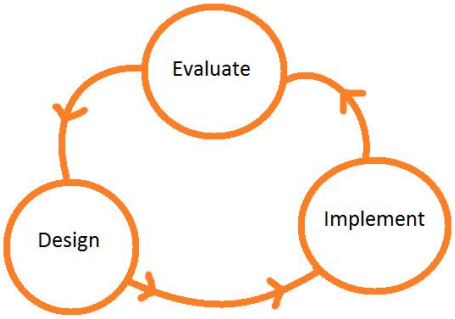

Fig. 2: Iterative Design Cycle

Paper based prototypes were used for the low fidelity prototyping. These prototypes were not only cheap to produce but also allowed users to manipulate them freely, without having to need computer skills or use a computer at all. Paper prototypes however have the disadvantage of being unable to implement numerous features such as animation and gesture input. Figure 3 shows examples of our paper prototypes. High fidelity prototyping was used when the basic interface model had been fleshed out. Prototypes were more involving and designed to work on the target device.

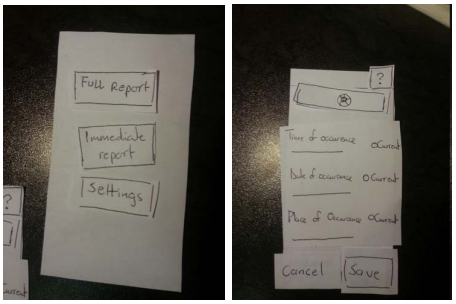

Fig. 3: Sample paper prototype Images

C. Emergency Reporting Design

The idea of quickly sending a report even in adverse conditions proved a difficult task to design and test, as previous works [13] had stated with regards to limitations of testing natural user interaction on a mobile device. In order to source suggestions we used the intended users of the system. Users brainstormed numerous ideas that covered nearly the full spectrum of sensors available on a typical target mobile device. A few propositions included being able to drop the device in a panic, throwing the device into the air, scribbling letters onto the touch surface or simply pressing a button on the device similar to E9 in effect.

IV. DESIGN IMPLEMENTATION

We designed a simple-to-use and flexible user-interface that produced content similar to what we mocked up using our paper prototype in order to produce content in a format that would fit on any android mobile phones. The design implementation consists of two iterations.

The objective of the first iteration is to get users to understand what a crime report is and help design an interface that is a logical extension of what the users understand a crime report to be. To achieve the objective of the first iteration, the users were given design input on the full crime reporting scenario, particularly the data capture. The design arguments and notes were written down by the designer for later reference. The users immediately identified 3 main functions with regard to the reporting process which are as follows: Main Screen, User Details Form and Full Report.

The objective of the second iteration is to present and evaluate the aggregated interface. It also implement scenario

tests and perform finer changes on the existing system. Based on the comments received from end users in the first iteration, the main screen received significant changes. One of the major change is that the user details functionality was removed completely. Users are only prompted for their details if they are using the application for the first time. This implies that old users have their details saved and so do not need to enter their details if reporting a crime. A new field was also added to the User Details form to handle privacy, users could choose to either have high, medium or low privacy settings.

V. CRYHELP APP SOFTWARE

The target devices for the final solution are Android Devices, the particular development device used was the Samsung Galaxy S3 running android 4.2. In order to meet the specifications of this device the following environment was used: SDK, Storage and Output.

In order to allow effective implementation of both the interface and communication components, we decided to use JAVA language. For the development of the interface the eclipse SDK for android development, a tool made available by Google was used. The target API for the application was the latest Android available at the time of development, Android 4.3 Jelly bean. The tool allowed development of all the features in the design including touch gesture input, however it did not reflect true performance of the final application as it was much too slow. The emulator ran on a desktop machine capable of GPU acceleration; however the emulator never peaked more than 10fps (frames per second). Despite this set back implementation was still possible.

Figure 4 and 5 show some screen-shots of the CRYHELP application. Figure 4 shows the main page and the user details page. The main page is the home page of the application. The user details page is the user page of the application. Figure 5 shows the crime and suspect details page. The crime page is the crime details page of the application. The suspect details page is the suspect page of the application.

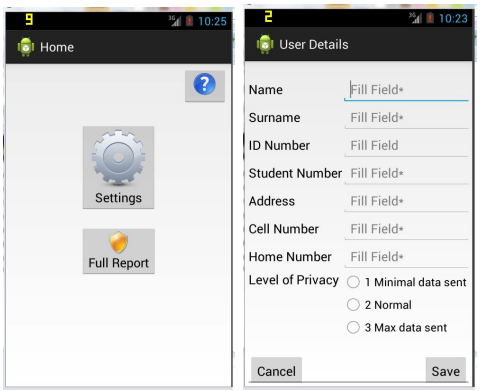

Fig. 4: Application Main Screen & User Details

VI. EXPERIMENTATION & EVALUATION

The experiment was open to any student living in the general area of the survey university community to partake in the study. The only criteria for participants pool was a balanced

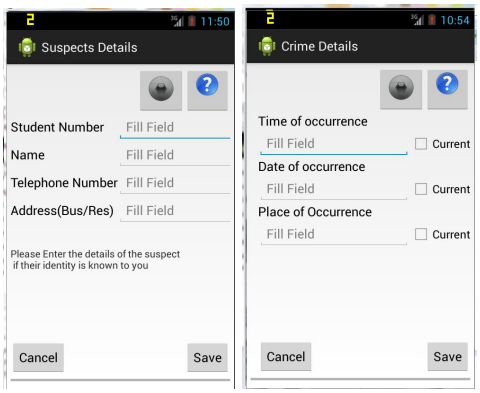

Fig. 5: Screen-shot of Crime & Suspect Details

number of the sexes. 10 participants were chosen for evaluation of the final iteration. The gender distribution was again, even at 5 per gender. The age distribution was between the ages of 20 and 24 inclusive. All 10 participants were in possession of a mobile device which they all reported to use daily, however only 4 users reported familiarity with the android platform. 8 of the participants had never reported a crime before. All the participants had high grasp of the English language needed to be able to carry out the tests.

Experimentation session was divided in two main tasks namely Full Crime Report and an Emergency Crime Report. The first main task, Full Crime Report was comprised of the overall task of sending the full crime report (filling in data), taking an image of the scene of the crime and tagging the image either suspect or victim. The second task was only possible after the first, participants faux details would be used to send emergency crime reports. Users were given an opportunity to perform the task and send an immediate crime report; the difficulty they faced was recorded by the researcher.

A. *Evaluation Instrument: Questionnaire*

The evaluation of the software's usability was conducted through the administration of a questionnaire. Some of the key questions posed include the following:

- Is the system simple to use?
- Is it easy to report crime quickly, effectively and efficiently using the system?
- Is it easy to easily and quickly recover a mistake?
- Is the information on the system screens clear?
- Do you like to use the interface?

B. *Findings & Results*

This section discusses the quantitative findings of the final iteration; it focuses on the data extracted from the questionnaire. Results of experimentation is given and discussed, followed by user experiences and feedback from the tests.

1) Ease & Time Spent on system usage : Participants graded both the ease of completing a task and the time taken to complete the task. Figure 6 shows the final average outcomes for the first four questions which centred around the ease and time spent. These questions were based on the IBM ASQ [11] and they were designed to be given to a participant after completing a series of tasks. The questions measure the ease of task completion and the time to complete the task.

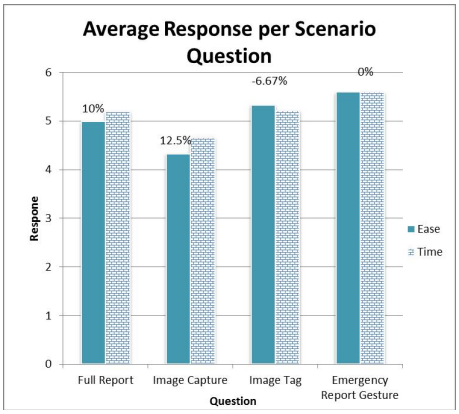

Fig. 6: The chart for the Ease & Time Spent Section of the Questionnaire (5 scale step), standard deviation of 0.54 Ease and 0.38 Time

From Figure 6, it can be seen that users give the same score to the time taken as that of the ease of use. This correlation could be a natural response or a user bias to grade the two as effectively the same. The average percentage difference between correlating ease of use and time taken is 3.96%. This suggests that the time it takes to perform a task is directly proportional to the perception of ease of the task. This often resulted in users giving the same score to the time taken as that of the ease of use.

The result also shows that the tasks were all of acceptable ease and the time taken to complete, the least satisfactory of all the tasks being the Image Capture task. The camera task had the least satisfactory response because the camera button was so small, often users would not find it without being made aware that they could capture an image to add to their report.

It must also be noted that although the gesture field was the most satisfactory in terms of both time and ease, based on the data it also had the most number of inapplicable responses, 50% to be exact. Therefore half the entire participant population could not comment on using the Emergency reporting gesture. This is due to the fact that participants struggled with getting the application to recognise their input. Of the 50% that got the gesture recognition to work, the average satisfaction was the highest of all the tasks (93.3%). These results suggest that the Emergency Crime Report gesture may need recalibration but is very successful in the cases that it works.

Based on percentage difference it can be seen that tasks are marginally quicker to perform than they are easy to perform when reporting a crime and taking an image. Tagging an image is slightly easier to perform that it was fast for a single participant; this outlier resulted in the slight disparity in the two on the graph. Ignoring the outlier suggests that image tagging is largely as easy to do as it is fast.

2) System Component Evaluation: The advantage of the IBM CSUQ [11] is that the questionnaire can be divided into scores, specific categories addressed by segments of the questionnaire, these categories are: System Overall, System Usefulness, Information Quality and Interface Quality.

- System Overall: the average of questions 1 to 18 give an overall score for the system
- System Usefulness: the average of questions 1 to 8 give an overall score for how useful the participants find the system.
- Information Quality: the average of questions 9 to 15 give an overall score on the information provided by the system
- Interface Quality: the average of questions 16 to 18 give an overall score on the effectiveness of the interface.

These categories allow evaluation of each individual component of the system to gauge which aspects perform well or poorly on average. These results directly address the issue of whether a mobile device can be used to effectively send a crime report.

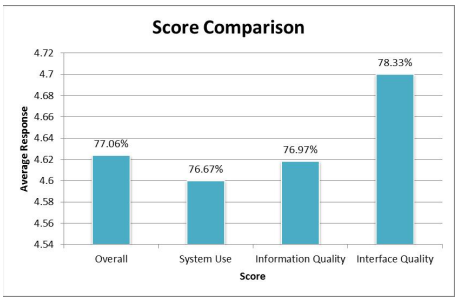

Fig. 7: The chart of the questionnaire score breakdown with standard deviation 0.05

Figure 7 shows the result of each component of the system. From the figure, it can be seen that overall the system was well received with a score of 77.06%. This suggests the users found the system very usable with a standard deviation of 0.05. It is not surprising to find that the interface quality (78.33%), though marginally, is the most appreciated aspect of the system as the design process was centred on the users. These results bode very well for the feasibility of a mobile solution for crime reporting.

3) Time Analysis: This section looks at the time taken to complete the tasks given in each session along with the perception of time participants gave in their responses.

Figure 8 shows the time it took each user to successfully report a crime. Of the entire set of recorded values of the study, participant overall times were the most varied with values between 124.55 to 580.3 seconds and a standard deviation of 164.18. In this case an average time for reporting would serve

very little use and perhaps the range would be more effective as a description of the time taken to complete a report. The reason for the large range is firstly largely due to the fact the participants were not reporting the same crime and secondly that the detail some participants put into the report was much more in depth than others, this was seen by observing the participants. Of course interaction also played a major role in the time taken to complete the task; however on average all participants were more than satisfied with the time they took.

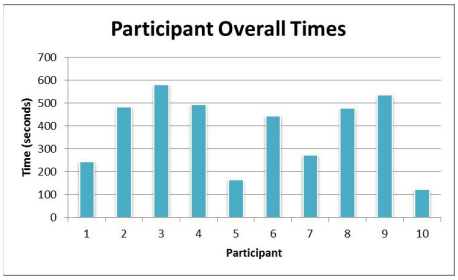

Fig. 8: The chart of application user with standard deviation 164.18

4) User Experiences and Feedback: In general all users expressed satisfaction with the system. The interface was the most intuitive and users did not need training to operate it. However there are the key errors and difficulties participants faced with respect to the application and its platform. The major difficulty is that users struggled with some of the fields of the report and requested explanations of what values they could enter in them. This is a recurring issue identified from the first high fidelity prototype that was apparently not fully solved. Secondly, users not accustomed to the Android OS had difficulties using the device. The largest difficulty was the location of the return button. Users often got confused when attempting to close the screen keyboard due to low visibility of the return key on the phone (the key is only shown with a backlight which is often dimmed when typing). This was solvable by changing the settings on the device. Other difficulties included mistakenly closing the application and shortcut bars obscuring the application screen elements.

VII. CONCLUSIONS

In the introduction we stated the general problem of crime and how technology resource constrained environments currently go about reporting crime, at a single point, the CPS office on the campus grounds. We also justified that there is a need for a system that will facilitate the report of crime in a secured and covert way. Furthermore [12] justifies the digitisation of crime report in order to improve likelihood of increased crime reporting. Therefore, we proposed and implemented a mobile crime reporting system because according to [3], [11], [12], the use of mobile phones aid in securely reporting a crime.

The final solution of our CryHelp mobile application was evaluated against users, stakeholders, heuristics and user requirements. The overall response from all of the above was very positive and validates that a digital crime reporting solution could be brought onto the mobile platform with reasonable success. Evaluation of data revealed that users needed hardly any aid in using the application which was deemed to have high overall usability and function in studies. Users also found it possible to send a crime report covertly with little more than a gesture. The testing carried out was limited by resources and the application could not be tested in context, instead the environment for crime reporting was simulated using images. The system interface can be considered as successfully usable. However the results of final evaluation suggest that improvements on implementation and functionality could further enhance positive feedback.

In the future, we believe that the performance of CRY-HELP can be enhanced by structuring crime reporting hierarchically according to user privacy preference settings. Furthermore, based on user's suggestion, the interface can be enhanced to support video and audio or even perhaps more than a single image, as often times a scene could be taking place, that could be better documented by audio or a series of images. Although this would increase storage and communication costs, the feature could prove to be an effective crime reporting tool.

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