A CONTEXT AWARE EMERGENCY MANAGEMENT SYSTEM USING MOBILE COMPUTING

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ABSTRACT

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In this thesis, an emergency management system taking advantage of mobile computing and its awareness on context is provided. The framework primarily aims to create an infrastructure for acquiring implicit and explicit data about an emergency situation by using capabilities of smart mobile devices and converting them into value-added information to be used in phases of emergency management. In addition to conceptual description of the framework, a real prototype implementation is developed and successful application of the framework is demonstrated. Sample cases are analyzed in conjunction with the prototype and an experiment for reporting an emergency situation is carried out by a group of participants in order to demonstrate the applicability and feasibility of the framework. Data collected during the experiment are examined in order to determine the advantages of the proposed system in comparison with traditional emergency reporting efforts.

Keywords: Emergency Management, Context Aware Computing, Mobile computing, Smart Mobile Device

ÖZ

AKILLI MOBĶL CĶHAZLARI KULLANAN BAĴLAM BĶLĶNÇLĶ ACĶL DURUM YÖNETĶM SĶSTEMĶ

Ceran, Onur

Yüksek Lisans, Biliĸim Sistemleri Bölümü

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Bu tez çalēĸmasēnda; mobil bilgi iĸleme ve onun baĵlam üzerindeki bilincinden yararlanan bir acil durum yönetim sistemi sunulmaktadēr. Önerilen sistem öncelikli olarak, bir acil durumla alakalē dahili ve harici iĸlenmemiĸ verileri akēllē mobil cihazlarē kullanarak almayē ve bu bilgilerin acil durum yönetimi fazlarēnda kullanēlmasē amacēyla deĵer eklenmiĸ bilgiye dönüĸtürülmesini amaçlamaktadēr. Sistemin kavramsal tanēmēnēn yanē sēra, gerçek bir prototipi geliĸtirilmiĸ ve baĸarēlē bir uygulamasē gösterilmiĸtirr. Prototip çalēĸma üzerinde uygulanan örnek senaryolar ve bir grup katēlēmcē tarafēndan gerçekleĸtirilen acil durum ihbarē yapma uygulamasē, çalēĸmanēn uygulanabilirliĵini ve yapēlabilirliĵini göstermektedir. Ayrēca geleneksel yöntemlerle ihbar yapma giriĸimine yaptēĵē katkē ve geliĸimi de göstermektedir.

Anahtar Kelimeler: Acil Durum Yönetimi, Bağlam Bilinçli Bilgi İşleme, Mobil Bilgi İşleme, Akıllı Mobil Cihazlar

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This thesis is dedicated to people who have a finger in the pie.

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LIST OF ABBREVIATIONS AND ACRONYMS

GPS : Global Positioning System

PSAP : Public Safety Answering Point

WE-911 : Wireless Enhanced 911

SMS : Short Messaging Service

IMEI : International Mobile Equipment Identity

IDC : International Data Corporation

PDA : Portable Digital Assistance

LBS : Location Based Service

MS : Mobile Station

BS : Base Station

GLS : Google Location Server

SSID : Service Set Identification

MAC : Media Access Control

AP : Access Points

A-GPS : Assisted-GPS

UK : United Kingdom

USA : United States of America

API : Application Programming Interface

GPRS : General Packet Radio Service

EDGE	: Enhanced Data Rates for GSM Evolution
3G	: Third Generation Mobile Telecommunication Technology
ID	: Identification Number
SIM	: Subscriber Identity Module
MD5	: Message Digest 5
WLAN	: Wireless Local Area Network
SMS	: Short Messaging Service
CPU	: Central Processor Unit
HTTP	: Hyper-Text Transfer Protocol
OHA	: Open Handset Alliance
MMS	: Multimedia Messaging Service
XML	: Extensible Markup Language
APK	: Android Packet File
SDK	: Software Development Kit
GLS	: Google Location Server
URL	: Uniform Resource Locator
JSON	: JavaScript Object Notation
TSI	: Turkish Statistical Institute
FCC	: Federal Communications Commission

CHAPTER 1

INTRODUCTION

Processing capabilities of computers and networking capabilities have evolved significantly during the last decades. Currently, personal computers have multi-gigabytes of storage and memory units, high-definition monitors, sound cards and graphical user interfaces and wide area networks provide high speed connection capability. In addition, a large number of software has been developed for various needs.

Similarly, mobile phone technology has evolved significantly. Initial examples of mobile phones were too big to carry and were not general use devices. With the developments and changes in technology; mobile phones which are small enough to carry have emerged and has become available for everyone. While early mobile phones were just for voice communication, mobile phones manufacturers realized that they can integrate other technologies into mobile phones in order to expand their feature set. Initially, the ability of being a fax machine and address book were added to mobile phones. Later, limited access to the Internet became available. And then, low-resolution cameras were integrated into mobile phones.

Today, mobile phones are programmable and offer a computer-like user-experience with the capabilities of high resolution cameras, larger and touch-based screens with less number of buttons and high networking abilities. They also include embedded sensors such as Global Positioning System (GPS), accelerometer, digital compass, gyroscope and microphone which makes it possible to sense environmental context such as location, direction, orientation and voice.

These capabilities shift the purpose of mobile phones from just voice communication to collection and sharing of digital content which in turn helps the development of useful and appealing services for users in a wide variety of domains such as healthcare, social-networks, safety and transportation.

1.1. Problem Statement and Motivation

In todayôs world, while computers are involved in all or a part of workflows in a large number of application domains, smart phones are utilized in only some of them. For example, emergency response staff who provide medical intervention as a result of an accident of two or more cars crash somewhere; firefighters who try to extinguish an ñordinary combustibleò or ñflammable liquidò fire somewhere; police forces who is called to duty for handling a suspicious packet, may use smartphones in their workflows in order to increase efficiency of such ñintervention tasksò or better coordinate the needed workforce. The responder staff has to be informed about these emergency situations in order to be able to intervene. For most emergency situations, the reporters are regular citizens who witness the situation. The responder staff is informed when a citizen calls the call center of these emergency foundations for reporting purposes. With the gathered information, responder staff makes decisions to intervene an emergency situation. This information is as valuable as what and how reporter expresses the situation and what the call center staff understands from these descriptions. Interviews with the call center and first responder staff indicate problems about gathering information from such reporters, which later cause consequently difficulties about intervention to those emergency situations in terms of time and decision effectiveness.

In a traditional call center of the first response units, when a citizen calls for reporting an emergency situation, a call center staff, if there is an available one, responds to the phone call. First, the call center staff asks for the type of the emergency situation, and then tries to determine the location of the occurrence. If the reporter does not know the explicit address, the call center staff asks questions to the reporter in order to help him describe the exact location. The call center staff uses a digital map to determine both the location and responsible regional unit to intervene with the emergency situation. According to the emergency situation, the call center staff tries to get additional information which may be useful for the first responder unit. These may include information about the situation, such as how many cars are involved in an accident, the type of fire ongoing, or what the identified suspicious packet looks like. All such information including address or additional details is recorded by the call center staff into a system, in order to be used for navigation of responders to the emergency location (figure 1 in the Appendix).

For all types of emergency situations, ñlocationò information is the most important one for the responder but it is also the biggest problem for the call center staff to obtain it from reporter. If a responder has only location information for an emergency situation something can be done to attend it, but if there is all information about the emergency situation except its location, not much can be done. In an interview, a firefighter expert mentioned that ñif we know the location of fire in terms of neighborhood we can find the exact location by following the smoke in the air if it is daytime, but although we know the location of the fire in terms of neighborhood we cannot follow the flame of the fire at night, since it means that there is little to do for a firefighter if flames are already outside the building, which means fire is at the last stageò (Expert, 2012). A call center staff highlights the problems while getting information from reporter: ñThe most encountered one is omitting the address of the emergency situation by the reporter even if the location is his/her home, because of excitement or shock. If the reporter has no idea about the location, we try to estimate it by helping reporter describe the environment or his/her moving direction. If the reporter gives wrong information, or we are not familiar with the described location, it is hard to estimate the locationò (Expert, 2012). The call center staff also tells about increase in call time with the reporter which causes not only the late intervention of responders to the emergency situation but also increased waiting time of other reporters waiting on the line: ñThe reporter who will give information about a traffic accident starts describing its location from the starting point of his movement. As the reporter tells that he departed an airport, we locate our digital map to a location which is close to that airport. After some conversation with him, we realize that he from the airport twenty minutes before and he is now close to another neighborhood, which we then need to relocate on the map. Sometimes a reporter, who gives information about a fighting incident, starts the conversation by giving unnecessary details such as that he was cooking in the kitchen and when he went to his balcony to drop litter he saw some teenagers fighting in the park. And then reporter talks about his children who also play at that park and the number of fights taking place day by day. Sometimes like in the previous example, when we get the necessary information for responders, we try to break the conversation to let other reporters calling and also make responders to intervene with the situation as soon as possible. But the reporter thinking that he was not listened to enough by the call center staff, he calls the call center again in order to complain about it. Sometimes, a reporter expresses the emergency location like ónear a shopping mallô or in street óxò which he thinks that these places must be well-known by all citizens. If the call center staff has no idea about these locations and asks for detailed address, the reporter gets angry about that call center staff for not knowing these ñwell-knownò locations. After some argument with the call center staff, he finishes the conversation and calls back again in order to talk to another staff member about the same emergency situationò (Expert, 2012).

First responders are also facing some problems while intervening with emergency situations which can be overcome more quickly if there is additional information gathered before. A firefighter expert tells about these problems: ñA reporter informs the call center about a fire, and due to excitement or panic regarding the situation, he may exaggerate the size of the fire. As human life is more important than anything else; taking all possibilities into account, the management center navigates more fire trucks to the location than needed. After reaching the location and seeing that the fire is not as big as reporter told, redundant trucks navigate back to the center. This may be a problem when simultaneous fire situations occur. Fire department has different types of trucks with different lengths of staircases, different sizes of water reservoirs and different sizes of trucks on its own. If a fire truck with a shorter length of staircase is navigated to a fire occurring at the ninth floor, firefighters cannot intervene. Sometimes an ordinary combustible type of fire occurs in a five-floor apartment where a gas station is situated nearby. Firefighters should take additional issues into account for this situation and also use different equipment to extinguish the fire before it moves to that critical place.ò (Expert, 2012).

In this study, a framework consisting of reusable set of modules deployed on smart mobile phone devices for location determining, voice, video and photo capturing, picture marking, text input, information sending, is proposed for reporting emergency situations with more accurate location determination and additional information for better decision-making and decreased latency for responding, and decreasing the reportersô wait times.

In the literature, frameworks for reporting emergency situations exist, however they are not adequate for some situations such as the M-urgency project which helps mobile smartphone users stream live videos with audio to Public Safety Answering Point (PSAP) with real time location information (Krishnamoorthy, & Agrawala 2011). However, this project is not able to act when there is no internet connection and since every reporter interacts with a PASP staff, it does not help with decreasing the reporterǿs wait time. It uses only GPS or Wi-Fi based coordinates for location determination and does not support saving and using pre-determined locations with floor and door number.

Wireless Enhanced 911 (WE-911) project created by Federal Communications Commission aims directing a reporter to the appropriate PSAP and identifying the reporterǿs location however, it does not support getting additional information about the environment regarding the incident (Kenny, 2010).

1.2. Scope of Study

Within the scope of this thesis, when a user wants to report an emergency situation, he determines his location via GPS or Wi-Fi/mobile network or use locations pre-defined by him. He uses video recording or photo capturing sensors of the smart mobile device in order to give additional information. Reporting is finished by writing comments or recording a voice comment before submission to the first responder. He can send all this information via internet or send some of it by using Short Messaging Service (SMS). The first responder gets the reporting over a web application where he can see all the information sent by reporter including his phone and International Mobile Equipment Identity (IMEI) number, longitude and latitude information on a map, additional video, photo, voice or textual information. Processing of reports received via SMS is out of the scope of this thesis.

1.3. Thesis Outline

The thesis consists of 5 chapters. Chapter 2 includes literature about context-aware computing, mobile computing, location context, sharing knowledge, pioneer studies about emergency management systems.

Chapter 3 explains the proposed framework. Main characteristics as well as activity flow of the proposed framework are explained. Mobile device structure and details, web application components are described in this chapter.

Chapter 4 introduces the prototype implementation. Components and activity flow of the prototype, and use cases are described. Next, results and statistical information regarding testing of the prototype are given.

The conclusion of the thesis is provided in Chapter 5 with the summary of the study, contributions, discussions and possible future work regarding this study.

CHAPTER 2

LITERATURE REVIEW

This chapter provides literature information about the subject domain. First, Context Aware Computing and Mobile Computing are analyzed, followed by descriptions of related technologies for getting location context. Then, sharing of context via mobile computing is explained. Finally, context aware mobile computing for emergency situations with pioneer studies is described.

2.1. Context Aware Computing

When used as a language term, context defines limitations of the communicative situations that effect language use and variation. While archeological context describes the physical location of a discovery or an artifact, context in the computer environment jargon may be defined as any information which may be used to describe the situation of an entity namely; a human being, place or an object that is considered relevant to the interaction between a user and application. (Orajärvi, 2007)

Schilit, Adams and Want (1994) describe context aware computing as software that examines and reacts to an individualðs changing context. Dey and Abowd (1999) defines context aware computing as gathering available context for creating meaningful information for users and systems. They classify context mainly into four types: location, identity, activity and time which can in turn be used to find other contexts like finding someoneφs phone number context from the identity context.

According to literature (Orajarvi, 2007), the term context awareness is firstly mentioned in a study which was done by Schilit and Themier in 1994. The focus of the study was publishing of location information about objects which were located in a region by an active map service (Schilit and Themier, 1994). Even though the term was mentioned for the first time, this was not the first study on the topic. The first study was done by Want et al. in 1992. With this study, it was aimed to determine location of people who were wearing badges transmitting location-determiner signal to a location service using a networks of sensors for enabling a telephone receptionist to forward an incoming call to the room where person is located (Want, Hopper, Falcao & Gibbons, 1992)

Aware Home project (Kidd, Orr, Abowd, Atkeson, Essa, Maclntyre, Mynatt & Starner, 1999), which was a research project of Georgia Institute of Technology, aimed to support elderly or sick people on their everyday life by observing the identity, location, activity and state contexts. The contexts were gathered by embedding computing infrastructure and sensory network into a house.

2.2. Mobile Computing

According to the technological development, people have used many different mobile, stationary and embedded computers. In todayφs world, desktop computers for personal usage mainly gave place to notebooks and it is close for notebooks to give place to tablet computers which are computers with a flat touch screen and being operated by touching this screen instead of using a physical keyboard.

Mobile phones or smart phones with their increasing programmability, operating and sensing capabilities are becoming the computing and communication devices in peopleφs daily lives. According to Lane et al. (2010), availability of cheap embedded sensors, programmability for supporting applications for users to share real time activities with others on social networks such as Facebook, lowering barriers for programmers to enter business domain, vendorφs offerings different kinds of applications on application stores for the users across the world led the increase of the number of smart phones and new developments on sensing applications.

Figure 2.1 shows the mobile device shipments between 2004 and 2008. It also gives a forecast about shipments between 2008 and 2013.

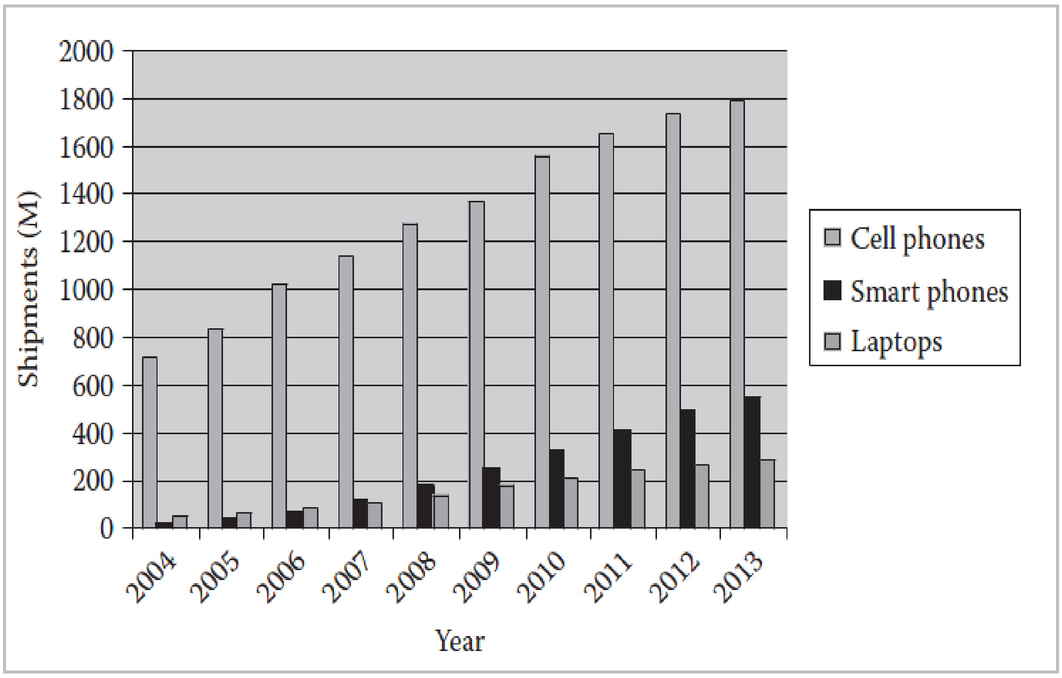

Figure2.1 Mobile Device Shipments 2004-08 and Forecast 2008-13 (Want, 2009)

According to International Data Corporation (IDC) (Framingham, 2012), which is a global provider of market intelligence for information technology, telecommunications and consumer technology market, 491.4 millions of smart phone shipment was done in 2011.

According to literature (Schilit, Adams & Want, 1994), ParcTab project concerning both mobile computers and mobile people is the first mobile computing system which was built for exploring context-aware software. The project was created over the ParcTab mobile hand held hardware called as tab which was acting as a graphics terminal to send inputs to a remote server to be processed over an infrared-based network with a bandwidth of 19200 bits per second (bps). The tab had 128x64 pixels of display and a piezo ï electric speaker for the outputs. It was aimed to form mechanisms for building four categories of context aware applications which are ñproximate selection and contextual informationò defining nearby located objects which may be common use devices, people on the same room or gas station to go; ñautomatic contextual reconfigurationò defining to add new components in the place of old one; ñcontextual information and commandsò can be defined with an example that print command prints to the nearest printer and ñcontext-triggered actionsò defined by commands which are invoked according to predefined rules.

Cooltown Project (Kindberg, Barton, Morgan, Becker, Caswell, & Debaty, 2002), aimed to give location-specific service to people about the place where they visit. In the Cooltown museum, visitors were able to get information about a painting with using their portable digital assistance (PDA) which was connected to internet over a wireless network. Priory-placed infra-red beacons next to the paintings were providing URL of corresponding point of web presence. When visitors sensed this beacon with their PDA, they were able to get information about that painting. Figure 2.2 shows an example of Cooltown sensing.

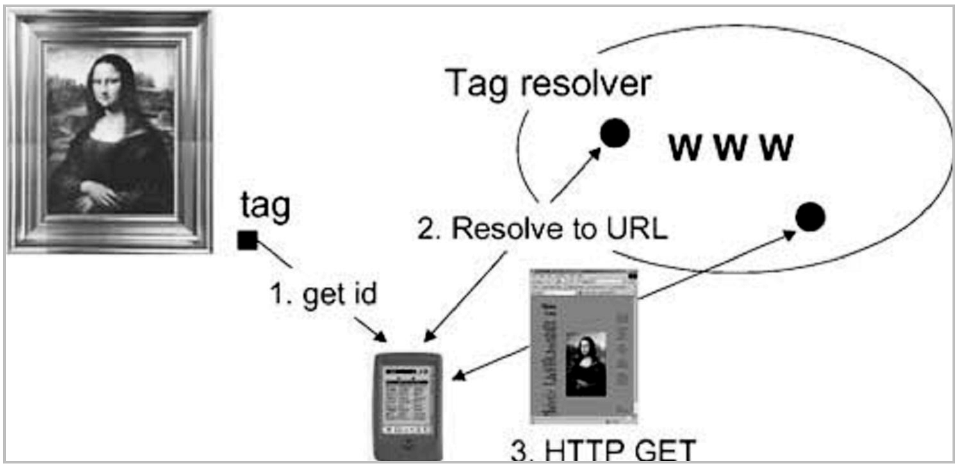

Figure 2.2 Getting the Web Presence for a Painting (Kindberg et al, 2002)

Vtrack project (Thiagarajan, Ravindranath, LaCurts, Madden, Balakrishnan, Toledo & Eriksson, 2009) aimed to lower the time that driver spent in the traffic by informing them about large travel times called as ñhotspotsò on roads with making travel time estimations using some routing algorithms. Time estimations of the project were done by periodically-gathered location information from driverõs smart phones equipped with GPS and Wi-Fi positioning sensors.

Today, smart phones have rich sensing capabilities such as ambient light, proximity, HD camera, GPS, accelerometer, microphone, compass, and gyroscope; computing power and different communication capabilities like Wi-Fi, 4G or Bluetooth. A number of application domains are related with mobile computing some of which are transportation, environmental monitoring, health domains and etc. According to Beach et al. (2010) mobile social networks will be the key research direction of mobile computing and these social networks like Facebook, Twitter, MySpace and LinkedIn provides contextual information of an individualõs personal interests and preferences.

There are 543 million of mobile Facebook application users ("Key facts," 2012). A mobile Facebook application user has the abilities of sharing a captured photo or video simultaneously, updating status with writing on the accountõs home page, stating its location with latitude and longitude data sets, or sharing any other context gathered from web sites.

Instagram is a mobile application for smartphones which provides users to take photos and apply some filter over them to make that photo look better for sharing them over social networks Facebook and Twitter. According to statistics (Bullas, 2012), by April 2012 there are 30 million of Instagram users and in 2011 August 150 million photos uploaded by using the application.

2.3. Location Context

Location context has been important for computing environment. The first context aware project was aimed to determine peoplesô location in a room to be able to navigate phone calls to proper room (Olivetti, 1992). Pioneer studies in mobile computing domain are related to location context. A study which was made with 20 participants about mobile information needs for two week duration indicated that %37.8 of the needs were local and answering the question of ñwhereò. (Sohn, Li, Griswold & Hollan, 2008). A survey done with 929 mobile searcher participants indicated that all participants searched for places with geographic location (Teevan, Karlson, Amini, Brush & Krumm, 2011).

A mobile computing application which provides people some services based on their geographical location is called as Location Based Service (LBS). The answers to the questions ñwhere is the closest restaurant to meò, ñhow can I go to national library from hereò are the subject of LBS. With LBS, not only users but also service providers get benefits. While users are reducing the amount of the data entry for accessing a service, service providers gathers a huge amount of data which provides them to build improved service models (Shek, 2010)

Dannert (2010) examined positioning mechanisms for mobile devices in three approaches. Network-based approach describes that the network computes the location of the mobile station (MS). MS has not an active role in positioning process. Terminal-based approach also called as MS-based approach where network has passive role in positioning and calculations for localization is done on the MS. Non-conventional approaches describes the alternative ways for localization. This approach consists of positioning via Bluetooth, WLAN and MyLocation by Google. With MyLocation, Google builds up a database containing longitude and latitude coordinates gathered from Cell IDs used by MSes. If GPS is not available, MyLocation determines the location by sending the Base Stationôs (BS) cell ID to Google Location Server (GLS) to retrieve longitude and latitude coordinates. Figure 2.3 shows the architecture of MyLocation. Google also captures Service Set Identification (SSID) and Media Access Control (MAC) addresses from Access Points (AP) and stores them in GLS.

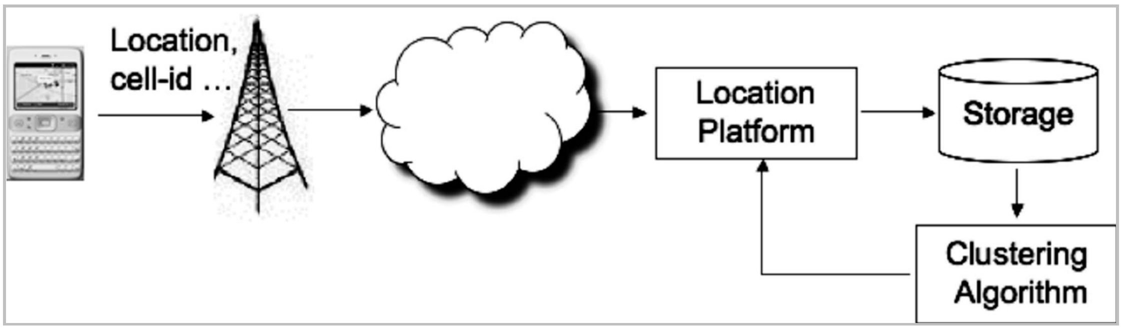

Figure 2.3 MyLocation Architecture (Dannert, 2010)

Shek (2010) also examined positioning mechanisms for mobile devices in three approaches but in a different way. The first approach is GPS-based positioning which uses 2 technologies. One of them is GPS in which positioning is provided by triangulation of at least GPS satellites signals. GPS technology has the advantage of 5-10 meters accuracy on positioning and no requirement for mobile network provider. But a GPS receiver needs some time and high power to lock onto satellite signals. Also, GPS technology is only available to use where clear satellite signals are sensed so it does not work indoors. Second one is Assisted-GPS (A-GPS) which is the enhanced form of GPS. A-GPS annihilates the disadvantages of GPS obtaining mobile network into process of gaining the position. But this technology is only available where mobile network is also available. Both GPS and A-GPS require GPS sensor to be used on mobile device. Second approach is mobile network-based positioning that is mainly based on the signal exchanging between MS and BS. The propagation or angle of the signal to the BS or approximate coverage of BS helps calculation of the location. The advantage of this approach is that mobile device does not require any specific sensor, but this approach provides poor accuracy. Last approach is Wi-Fi based positioning which is provided by calculation based on access point locations and signal strength of mobile device to them. When compared with GPS approach it needs lower power for calculation and when compared to mobile network-based approach it provides more accurate location determination. But it has the disadvantage that Wi-Fi access points may not be available for many places.

2.4. Emergency Management

Emergency can be described as a situation that causes instant risks over health, life, property or environment and generally requires also instant intervention to prevent it becoming worse. Life risky emergency may be about individuals having cerebral hemorrhage or about some people being in a location where an explosion occurs. Health risky emergency may be also about individuals or some number of people having no risk over life but need immediate help. A traffic accident with two drivers having broken legs may be an example. A fire of a car may be an example for property risk emergency which is not about human but its goods and chattels. Environmental risk emergency can be described as a situation in which nature and species are affected because of the situation like release of liquid petroleum into the sea causing pollution.

According to Bolla et al. (2011) emergency response services are mainly related with three services which are Police emergency service, emergency medical services and fire service which are called as core services. Police emergency can be described as a service providing public safety and fight against crimes. Emergency medical service provides critical and urgent medical care to patients with injuries or illness and transportation of that patient to the nearest healthcare organization such as hospitals (Kobusingye, Hyder, Biashi, Joshipura, Hicks & Mock, 2006). Fire service provides extinguishment of fires. In some countries these core services are performed by different organizations and have different emergency telephone numbers. In Turkey Police emergency uses 155, emergency medical service uses 112 and fire service uses 110 as the emergency telephone number. However some countries perform these core services under a single organization with using a single emergency telephone number. United Kingdom (UK) uses 999 and United States of America (USA) uses 911, India uses 108 as the emergency telephone number (Bolla, Dudala, Rao, Bandaru, Patki & Kumar, 2011)

Search and rescue service, coast guard service can be described as the supporter emergency services.

According to the literature (Souza & Kushchu, 2011), emergency management is described as range of activities to get control over the emergency situations and creating a framework to help people for avoiding or recovering the impacts of this situation. Eraslan et al. (2004) describes emergency management as coordination of organizations with all their sources to annihilate or lower the effect of the damage of emergency situation.

Emergency management has four phases including mitigation, preparedness, response and recovery (Fajardo & Oppus, 2010). The mitigation phase includes activities about reducing the risks of emergency situations or chance of emergency situations happening by analyzing measurements about them. Immobilizing shelves to the wall may be an example of mitigation phase. Preparedness phase can be described as planning of action about a presumptive emergency situation for response and rescue operations. Training with simulations of emergency services or maintenance of service equipment can be given as an example. Response phase is putting plans into action which are made on the preparedness phase. Activities of this phase occur during the emergency situation. As an example, evacuation of people from a building in a fire situation can be given. The last phase recovery defines activities for returning the situation to previous state or even safer after an emergency. Figure 2.4 shows the cycle of four emergency management phases.

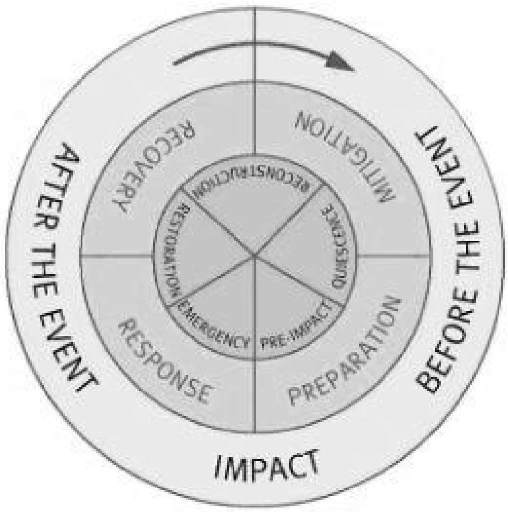

Figure 2.4 Emergency Management Phases (Alexander,2002)

Emergency have affected human life since its creation. Governments, civil organizations or people by themselves produced many techniques and technologies for different phases of emergency management. For instance, the Egyptian calendar was discovered in order to prevent the negative effects of Nile flood.

New advances provided by the technological development in computer area have also created new vision in emergency management area. Since information management become easier and more accurate, electronic systems were constructed in order to be used in emergency management purpose.

AFAYBIS (Eraslan et al., 2004) is an emergency management project aiming at creating an information system according to standards of e-government to provide effective and timely help service not only after but also during the emergency situation. The project is mainly established on the base of reaching the information, which is about natural hazard, ecosystem and infrastructure, after and during the emergency for creating maps and statistical information to be shown over internet.

2.5. Mobile Computing for Emergency Management

With the evolution of smart phones as ñSwiss army knifeò of media devices (Shim, Varshney, Dekleva & Nickerson, 2007) mobile computing has become one of the key elements of emergency management area. Governments, civil organizations or people are also creating or using value-added services by taking advantage of wireless data and computing infrastructure of mobile computing for emergency management purpose.

Zigkolis et al. (2008), indicates that in an emergency situation, it is crucial for emergency services to build an immediate and accurate view of that situation to response.

According to UK Central Government Cabinet Office (2010) communication, which deals with passing reliable information correctly and without losing time between those who need it including the public, is one of the eight characteristics of effective emergency response.

Sung (2011) emphasizes the importance of information sharing, collaboration and coordination during or after an emergency situation for the response phases.

2.6. Pioneer Studies in Mobile Computing for Emergency Management

According to the literature, there are studies for effective emergency response. Some of the studies are about mobile computing usage of emergency management personnel for an effective response. Some of them are about mobile computing usage of people who are faced with the emergency situation or seeing it, for response phase of emergency management.

2.6.1. Studies about Mobile Computing Usage of Emergency Management Personnel

2.6.1.1. Project Siren

Siren project (Xiaodong , Chen, Hong, Wang, Takayama & Landay, 2004) aims to provide integrated and distributed information for firefighters in a fire emergency situation to make accurate and rapid decisions. In a fire situation for firefighting activities, firefighters need to exchange information between them such as their situation and surrounding environment. These information changes occur in a dynamic way because of dynamically changing situation of fire event and according to those firefighters. Exchange operation is mainly done over 800 or 900 MHz radio band. In a fire situation, since there is a lot of noise because of burning of items, breaking windows and etc. it becomes hard to communicate for firefighter via voice. Firefighters are also facing with the danger of incomplete picture of situation in terms of weak floor or oxygen starving and etc.

According to these findings Siren project architecture is designed with three components. First component is ñstorage managerò which abstracts the gathered information, second is ñcommunication managerò controlling passing of messages between devices and last one is ñcontext rule engineò controlling context aware feedbacks of users.

In a usage scenario of Siren, each firefighter has a Wi-Fi enabled PDA providing peer-to-peer communication over 802.11b protocol with each other and also Wi-Fi enabled sensor such as smoke detectors or temperature sensors to be deployed on the fly. The PDA screen is divided into three sections representing all firefightersô location on the building plan, situation of the locations in term of dangerousness and messages from firefighters. When a firefighter changes his location during the action, his PDA measures the temperature level of the surrounding environment using sensors to warn the firefighter in case of a reaching dangerous level of temperature or smoke. Since that firefighter sees other team membersô locations on his PDA, he warns others to act according to this situation.

2.6.1.2. Liveresponse Project

Liveresponse project (Bergstrand & Landgren, 2009) is created in order to provide innovative capabilities for emergency responders in a traffic accident situation. According to Landgren, ñsituation specific informationò, which shapes the organization of responder, is a kind of snap-shot information about what a person realizes about it. Therefore, video may convey situation specific information.

Liveresponse project is mainly predicated on using live video streams to improve awareness of responders about situation. Liveresponse application provides two features which are dynamic map service and live video support from many different sources. The live video broadcast about traffic incident is captured by using Bambuster service. Bambuster is a service that provides broadcasting low-latency live video and audio to the web using 3G or Wi-Fi from mobile terminals. It also provides geographically tagging of broadcasts and sharing them to many social networks.

In the event of a traffic accident an incident commander captures the situation with the application and broadcasts it to the command center operator and chief of the staff. This broadcasted video is used for staff meeting and conference during this accident response activity.

2.6.2. Studies about Mobile Computing Usage of People for Emergency Situations

Many applications are available for being downloaded by the users from application stores. Some of these applications are about emergency situation which provide users information about how to perform first aid for different emergency situations (AR First Aid-emergency & Home application) or fast dialing capabilities for emergency contacts like police and ambulance (Emergency Contacts application). These kinds of applications are prepared for individual usage.

On the other hand, some of the applications or projects are created for usage of people for reporting an emergency situation that they are facing or seeing, to emergency responders for making good decisions or plans by immediate and accurate view of the situation for intervening.

2.6.2.1.MyFlare Project

MyFlare application is created for protection of an individual user in the event of emergency (Zwerling, 2010). It is mostly designed for an emergency situation which is not suitable to communicate responders like userøs not being able to call emergency service because of running in order to avoid or for the situation that user has a rapidly changing location affecting responders intervene to the situation.

MyFlare application has two modes. First mode is about calling emergency service without dialing any number to make calling activity faster. In second mode, MyFlare application sends predefined text messages to multiple predefined emergency contacts via SMS by only touching one button. These text messages include userøs GPS location and are sent both via SMS and e-mail, one time in every three minutes updating the userøs location information. The application allows user to capture 20 seconds of video in order to give additional information about present environment to be sent as an attachment to e-mail messages. If GPS or Wi-Fi is not turned on by the user, the application automatically turns these sensors on when activated.

With second mode, it is aimed to inform contacts who are more available or suitable to inform emergency responders, mostly police, about userøs emergency situation according to gathered text messages with GPS information (Figure 2 in Appendix). It also provides user to make this informing activity faster.

2.6.2.2.M-Urgency Project

According to Krishnamoorthy and Agrawala (2011), crisis management succeeds only if relevant, critical and, timely information can be provided. In order to provide successful crisis management, m-urgency project is created. M-urgency is a public safety system project improving emergency calls to first responders. It provides users to connect Public Safety Answering Point (PSAP) by video streaming. It also enables to share real-time location, disabilities of the user to the PSAP. It is available with M-Urgency to forward the video stream and additional contextual information to first responders like police or ambulance to provide effective first response service.

M-urgency is developed on the Rover 2.0 architecture which is an advanced implementation of Rover. Rover (Almazan, 2010) is a context-aware platform providing a framework for application developers figuring out what context may be useful and can be shared between ecosystems.

Rover 2.0 includes three tiers of service, interface and context. Service tier consists of service engines providing users useful and meaningful data by forming unstructured information. Service tier consists of three services. Location service transforms Wi-Fi or GPS based coordinates to physical location information. Streaming service provides applications to make a video stream connection with the system. Lastly, external service provides external information to the context data like traffic or weather information. Interface tier describes an interface correlating system with clients or applications through Application Programming Interface (API) calls. Context tier mediates flow of context information from source to client or user. This information is then filtered and reorganized for enabling some services.

M-urgency System has three components to communicate Rover 2.0. Caller application running on a smartphone provides user to create an emergency call to the PSAP with a video stream and location information. Dispatcher console application is used by PSAP personnel. It provides to see both location information of the caller with streaming video and available responder information to assign one. Emergency responder application provides to see callerôs location and streaming video for an effective response after assignment is done by PSAP. Figure 2.5 shows an instance of M-urgency according to information model.

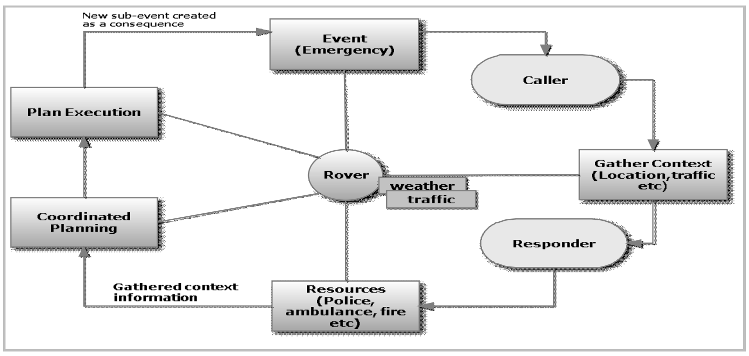

Figure 2.5 an Instance of M-Urgency According To Information Model

CHAPTER 3

PROPOSED SYSTEM

This chapter provides the conceptual description of an emergency management system using mobile computing advantages. The proposed system offers reporting of an emergency situation by a particular citizen by using smart devices, and sharing of value added information with stakeholders of emergency management sites.

The major contribution of the proposed system is using a variety of sensing capabilities of smart mobile devices for reporting an emergency situation so that first responders are aware of the situation and make better decisions about the emergency response activities. There are different categories of emergency situations and for each category there are different sub-categories which also require different response types, equipment and expert work. In order to make an efficient response, smart mobile devices provide advantages compared to making a voice call to the PSAP.

There are three main components of the proposed system. The first component is the user interface describing processes running on a smart mobile device. Second one is the central processor processing raw data to create meaningful and useful information. Third and the last component is the management interface describing not only the management of both hierarchical domains according to locations and tasks and flow of information but also the usage of meaningful and useful information. These components are explained in detail in this chapter. General structure of the proposed system is shown in Figure 3.1

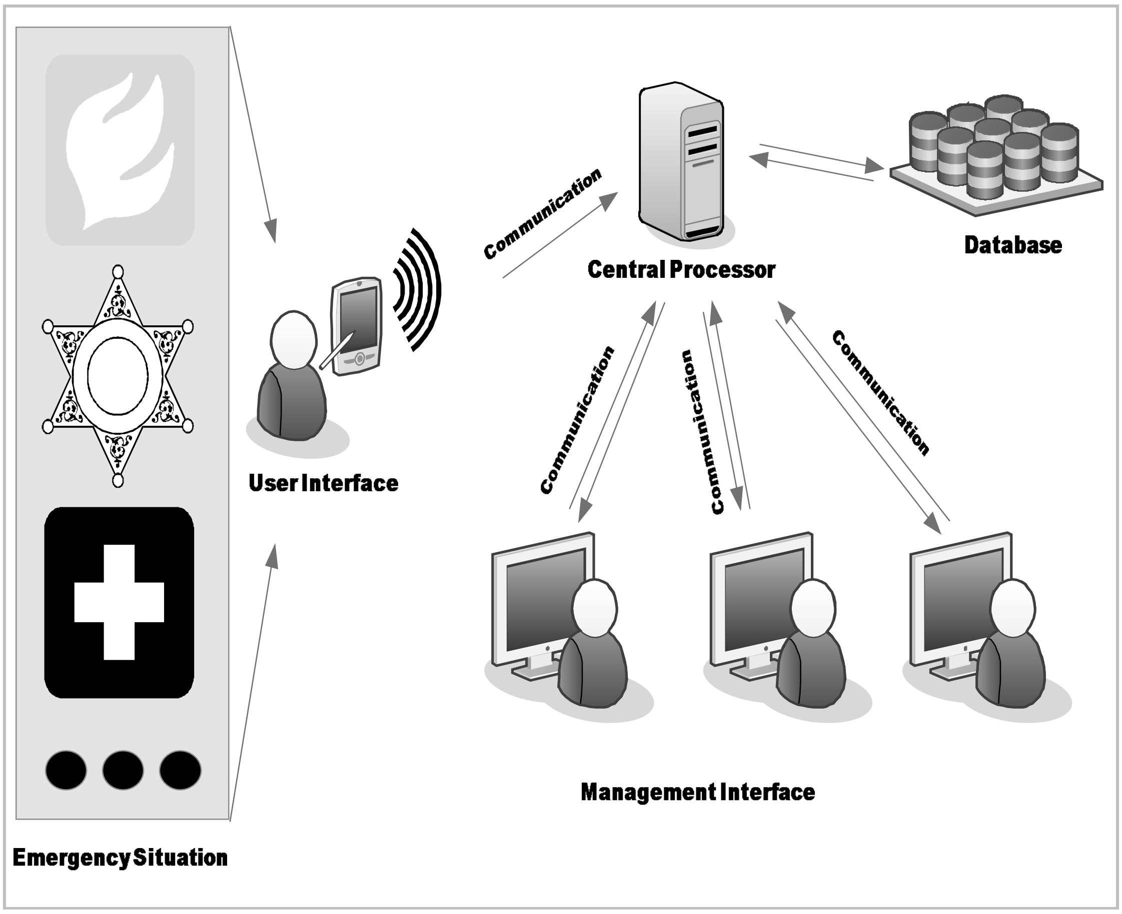

Figure 3.1 General Structure of Proposed System

3.1. Components of the Proposed System

There are three main components of the proposed system: user interface, central processor and management interface. These components together with sub-components are illustrated in Figure 3.2, and are described next.

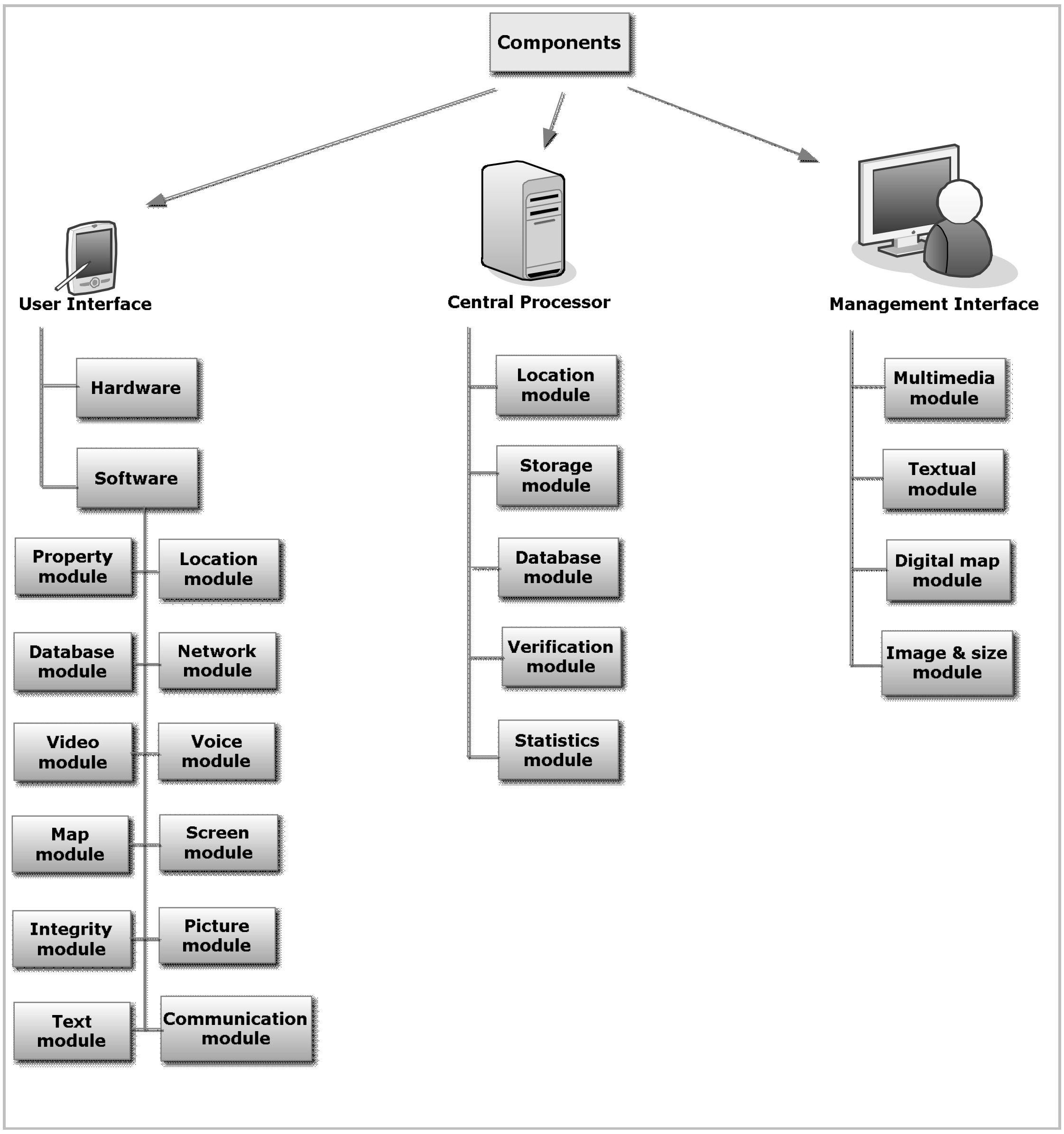

Figure 3.2 Components and Sub-components of the Proposed System

3.1.1. User Interface

The proposed system uses a mobile smart device for collecting and sending contextual data to be processed for retrieving meaningful information. For everyday life, it is not surprising to face with an emergency situation. Since emergency situations mostly happen without a warning and unexpectedly anytime and anywhere, it is aimed to use ubiquity of mobile smart devices for collecting and transmitting different kinds of data. The user interface includes two sub-components.

3.1.1.1. Hardware

The mobile smart device used in the proposed system is equipped with functional hardware components. For detection of location and to create location context for central processor, mobile smart device includes GPS and A-GPS. Wireless connection adaptors which are Wi-Fi and cellular network supporting General Packet Radio Service (GPRS), Enhanced Data Rates for GSM Evolution (EDGE) or the Third Generation Mobile Telecommunication Technology (3G) are essential for both location determination process and transmitting the overall data to another component. Capacitive touchscreen, which is used for user interaction for process flow, is another hardware component for location determining. Camera is an important feature for the proposed system in terms of hardware which has the capability of capturing both images and video. Capacitive touchscreen hardware component is also needed for adding value to captured images. Microphone and loudspeaker components are functional hardware for both input and output of voice data. An external storage unit is required for storing collected data such as photos and videos.

3.1.1.2. Software

The tasks associated with the user interface component are mainly accomplished by the software installed on the mobile smart device. This software is the core of the user interface and includes various modules which can be re-used for different purposes.

3.1.1.2.1. Location Module

The location module provides the software for determining location (longitude, latitude) of users by using GPS, Wi-Fi or mobile network. This module makes use of a digital map to locate the user according to gathered longitude and latitude. Using a digital map also provides the user an alternative way to determine approximate location, in case no features are available in terms of positioning techniques.

3.1.1.2.2. Database Module

The database module provides the software to store data which can be referred to as passive context. The passive context provides data that do not change for a long time period. The database module enables the use of stored such data recursively.

3.1.1.2.3. Video Module

The video module provides the software to capture video using mobile smart deviceœs camera component and store it in an external storage. This module also provides the means for accessing the captured video from the external storage component for replay purposes.

3.1.1.2.4. Picture Module

The picture module provides the software to capture photos using the mobile smart deviceœs camera component and store it in an external storage. This module also provides the means for accessing the captured photo from the external storage component and for making drawings on the photo by the touch-based user interface.

3.1.1.2.5. Voice Module

The voice module provides the software to record voice using mobile smart deviceœs microphone component and store it in an external storage. This module also provides the means for accessing recorded voice from the external storage component and for listening to it by using the mobile smart deviceâs loudspeakers.

3.1.1.2.6. Property Module

The property module provides the capability for acquiring information about the smart mobile device that the software is running on. This information may include the unique device identification number (ID), mobile country or network code of the provider of the subscriber identity module (SIM), or service provider name.

3.1.1.2.7. Network Module

The network module provides the software to reach settings of the network service of mobile smart device in order to turn on Wi-Fi or wide area mobile network access.

3.1.1.2.8. Integrity Module

The integrity module provides the software to compute the hash value of the acquired data such as captured photos or recorded voice, by using the Message Digest 5 (MD5) algorithm. The MD5 algorithm is a cryptographic hash function which produces a 128 bit hash value. An intentional or accidental change on the data causes the hash value to change. Hence the hash value is used for checking data integrity.

3.1.1.2.9. Communication Module

The communication module provides the software to manage sending operations of the acquired data. The module is capable of sending the data through three different communication technologies: Wi-Fi referring to the Wireless Local Area Network (WLAN), the mobile network including GPRS, EDGE and 3G, and the short messaging service (SMS). The communication module provides a prioritization mechanism. If all these three communication technologies are available, the module prefers to send data using Wi-Fi. If the only unavailable one is Wi-Fi, the module prefers to send data using the mobile network. And finally, when both Wi-Fi and the mobile network are unavailable, the data are sent using SMS which is more restrictive, since this mode of operation disallows the sending of multimedia data.

3.1.1.2.10. Map Module

The map module provides the software to reach a digital map in street view mode. This module also provides zoom in or out capabilities in order to acquire detailed information.

3.1.1.2.11. Text Module

The text module provides the software to insert textual information describing the situation.

3.1.1.2.12. Screen Module

The screen module provides a substructure of the user interface screen. This module outlines the base screen of the software allowing construction through this substructure.

3.1.2. Central Processor

The central processor component provides the capability for the proposed system to create meaningful and useful information.

According to Sorber et al (2005), mobile devices are poor in terms of battery life. Hence, operation power cost should be decreased for mobile devices. Roy et al. (2011) describes peripheral components as high power consuming for mobile devices. According to an experimental evaluation performed by Abukmail et al. (2007), outsourcing the processes of central processor unit (CPU) of mobile device to the network provides less energy consumption and long battery life.

The user interface component is responsible for acquiring raw data and this task is done by using mostly peripheral components such as camera and microphone. Since this acquisition task occurs on a mobile smart device for the proposed system, processing of raw data is provided by central processor for energy management.

The central processor component runs on a computer acting as a server so that it provides not only energy savings but also advanced processing capabilities.

The central processor consists of six modules as described next.

3.1.2.1. Location Module

The location module provides meaningful and useful location information for the system. The location data acquired from the user interface component includes longitude and latitude data. Latitude describes the angular distance in degrees, minutes and seconds to the equator from south or north. Latitude describes the angular distance in degrees, minutes and seconds but to the Greenwich the prime meridian from west or east. These numeric longitude and latitude location raw data do not make sense when used alone.

The location module is responsible for converting longitude and latitude location raw data into meaningful and useful addresses in terms of country name, city name, street name and postal code.

For a given area, it may be too large to manage defined tasks. Hence, this area can be divided into pieces in order to provide a better management similar to the local government system. The location module also provides the means for determining the area of responsibility by comparing acquired longitude and latitude data with pre-defined address information.

3.1.2.2. Storage Module

The storage module provides the capability to store all the multimedia data (video, voice records and captured images) acquired by the user interface component.

3.1.2.3. Database Module

The database module provides the system to store both the data acquired by the user interface component and the information created by the central processor component allowing the construction of meaningful mappings. Communication between components of the system is carried out by the database module. If one component needs information stored in the database or a component creates new data or information, it uses the database module to get access to the related area, data or information.

3.1.2.4. Verification Module

The integrity module of the user interface component calculates the hash value of recorded multimedia data, which are video, image and voice, by using the MD5 cryptographic hash function. Similar to the raw longitude and latitude location data, the hash value of a recorded multimedia data is not useful by itself.

The verification module also calculates the hash value of related data, which is stored by the storage module, by using the MD5 cryptographic hash function. Then it compares the resulting hash value with the value calculated by the user interface component on the mobile device. If the two hash values are equal, data integrity is validated.

3.1.2.5. Statistics Module

The statistics module provides the system to create statistical inference by using the database and storage modules which include raw data and information. This module aims to show meaningful information which can be used in management tasks such as planning of resource sharing.

3.1.2.6. External Context Module

The external context module provides the system to acquire supplementary information, not about the emergency event itself, but related to it for the purpose of enhancing the planning or response efforts. For an emergency situation, it is very important to reach the emergency location in time and start the rescue effort. If responders cannot reach an emergency location in time because of a traffic jam on route, it may result in failure. Hence, the external context module provides the means for acquiring information such as road and weather conditions.

3.1.3. Management Interface

The management interface helps with not only the management of both hierarchical domains according to locations and tasks and flow of information, but also the use of meaningful and useful information.

According to Laudon (2007) information systems can help both managers to superintend larger number of employees and lower-level employees to get a decision making authority. By this way, an organization can reduce the number of levels in hierarchy. Such kind of an organization is called as flattened. Ledbetter (2003) indicates that reduced number of layers in hierarchy increases the emphasis of cross-functional teams and coordination.

Since the user interface module provides raw data and the central processor creates meaningful information for usage, the proposed system suggests a flattened organization for emergency response management.

The management interface component includes three different hierarchical sites of user in terms of organization. Central site is located at the top of the hierarchy and is mainly responsible for superintending tasks of lower-layer sites and planning the resources. Secondary site is called as the behavior site and is responsible for making decisions about using resources. Responder site is located at the bottom of the hierarchy and is responsible for making decisions about situations and intervening them. Figure 3.3 illustrates the organizational structure of the management interface user.

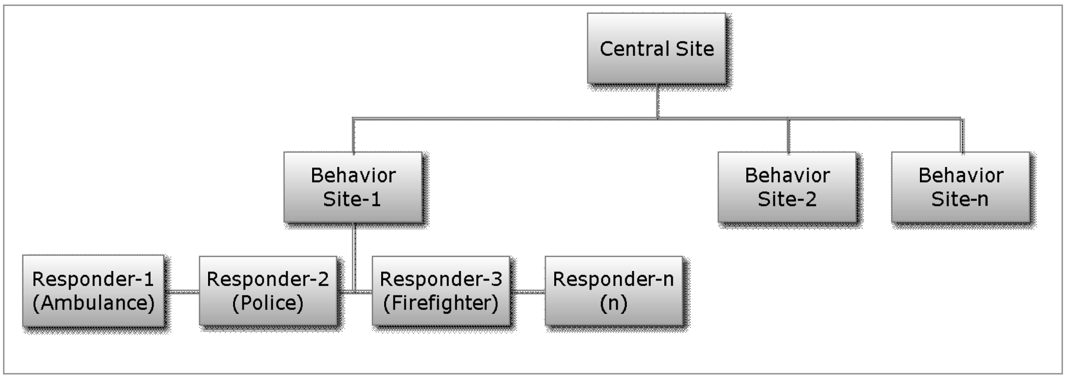

Figure 3.3 Organizational Structure of the Management Interface User

Since the central site is at the top of the hierarchy, the management interface provides it to access all the transactions, decisions which are taken by the lower-level sites, inventory and intervening tasks. It also allows the central site to plan sharing of the inventory between lower level sites according to the statistics module data. The area of the responsibility of behavior sites is also determined by the central site by using the management interface. Decisions that are taken by different behavior sites, their inventory usage manner, and intervening information are provided by the management interface to the central site for better supervision.

The behavior site makes decisions about an emergency situation by analyzing the information provided by the management interface. Better decision is made by seeing not only available but also unavailable inventory data provided by the management interface. The management interface provides the behavior site to only see the emergency situations related with their area of responsibility. One behavior site is unaware about an emergency situation which occurs in another behavior sitesôresponsibility area.

The responder site is only responsible for the task of responding to an emergency situation. The management interface provides the responder site to see the details about an emergency situation for a better response. The responder site is only allowed to be aware of an emergency situation which is assigned to them by the behavior site. To provide better decision making for the behavior site and improved supervision by the central site, the responder site informs about its task via the management interface.

The management interface component provides same modules for all three levels of sites in the hierarchy. According to tasks of these sites, site specific modules are provided by this component.

The management interface is accessed via a web browser over Hyper-Text Transfer Protocol (HTTP). Each member of the organization is defined by the central site and information about members is stored by the database module of the central management component. All members of the central site access site specific management interface by entering user name and password data. After that, they are navigated to related modules.

The management interface provides the three sites all the information about an emergency reporting. This information becomes available by several modules.

3.1.3.1. Multimedia Module

The multimedia module provides the sites the capability to watch video or listen to the voice recording about the emergency situation as captured by the user interface component. The multimedia module plays video or voice by retrieving data from the storage module of the central processor.

3.1.3.2. Image & Size Module

The image & size module provides the sites the capability to access the images about the emergency situation if they are captured. Zoom in or out on the image is also provided for the sites so that they can make better decisions and respond better to the emergency situation. The image and size module shows images by gathering data from the storage module of the central processor.

3.1.3.3. Digital Map Module

The digital map module provides the sites the location and address information regarding the emergency situation on a digital map. It has the ability of locating the point-of-interest on a digital map according to acquired longitude and latitude location information. The digital map provides the capability to switch between map and satellite interfaces, which allows seeing nearby building and objects. The digital map also has zooming in or out capability.

3.1.3.4. Textual Module

The textual module provides the sites any textual information about the emergency situation. The textual information may include not only raw data acquired by the user interface component but also information created by the central processor.

3.2. Use Cases of the Proposed System

The proposed system provides different types of components to create an emergency response framework. These components also provide different types of modules. Since, different types of emergency situations require different types of intervening processes, components and modules can be coupled together according to the requirements. Different use cases are created.

3.2.1. Use Case Scenario – Emergency Situation of Heart Attack

A heart attack situation can be categorized as a health risk emergency which may be about individuals or a number of people needing immediate help. Heart attack may occur anytime and anywhere. According to Babalık (Memorial, 2009), half of the deaths occur within first hour after the beginning of the heart attack. Hence, it is very important to get the patient to a hospital as soon as possible.

After an emergency responder reaches the patient, it may be useful to know the blood type of the patient or allergic sensitivity of the patient to drugs, if any.

In order to provide a successful emergency response to a heart attack emergency situation, the proposed system can be used by combining different types of modules.

To create the user interface component for an emergency situation of heart attack, the database module is used for saving the blood type of the user. In order to record additional information, the text module is used. The location module is used for location determination of the patient. The network module is used for enabling the data connection, and the communication module makes sending the location and blood type data to the related site possible.

To create the central processor component for the related situation, the location module is used for converting raw longitude and latitude to useful address information. The location module also helps determine the area of responsibility according to the address information. The database module stores the blood type, textual data, location data and address information.

To create the management component, the digital map module is used for seeing address information by all the sites. In order to see the textual data or information, the textual module is used.

First, the smart mobile device user saves his/her blood type to the software database. In the event of a heart attack emergency situation, the application is activated by the user. If the patient is him/herself, he/she selects blood type information from the database. If the patient is another person, user writes his/her blood type if it can be determined. The network connection is checked, if it is not on, the network connection is enabled. Then the user determines his location via an available source which may be Wi-Fi, GPS or mobile network. Then related information is sent to the central processor.

While the central processor converts longitude and latitude data into the corresponding address information, the blood type or additional information and address information are stored in the database. The area of responsibility is also calculated and then added to the database.

As the responsible region unit is warned about the emergency situation, the information about the situation is represented on the web. The region unit makes some decisions about the situation, and accordingly a responder is assigned for intervention. Then the responder is warned about the emergency situation. The same information becomes available for him on the web. As a result, the intervention tasks are started. Figure 3.4, 3.5, and 3.6 describe the activity flow of this use case scenario.

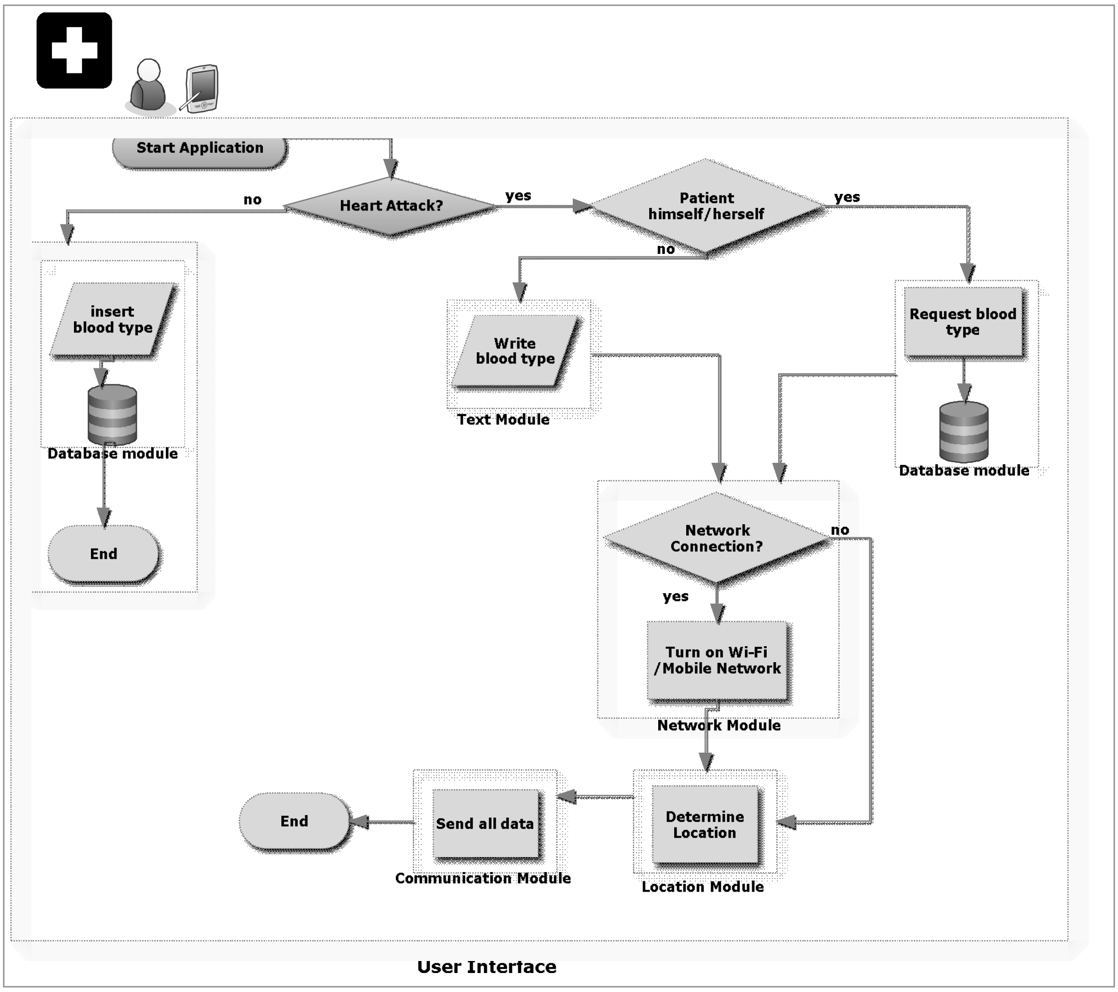

Figure 3.4 Activity Flow of User Interface Component for Heart Attack Scenario

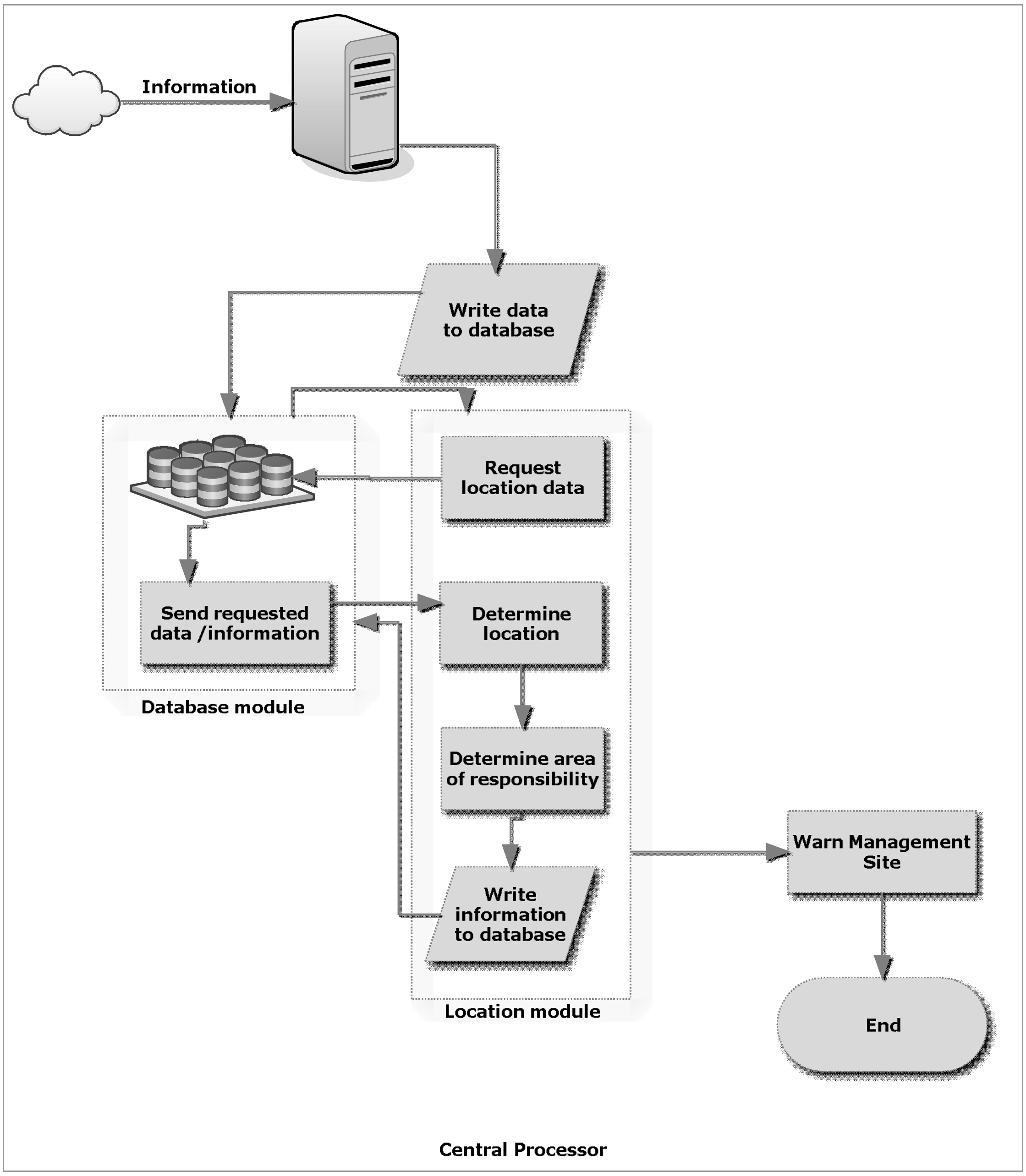

Figure 3.5 Activity Flow of Central Processor Component for Heart Attack Scenario

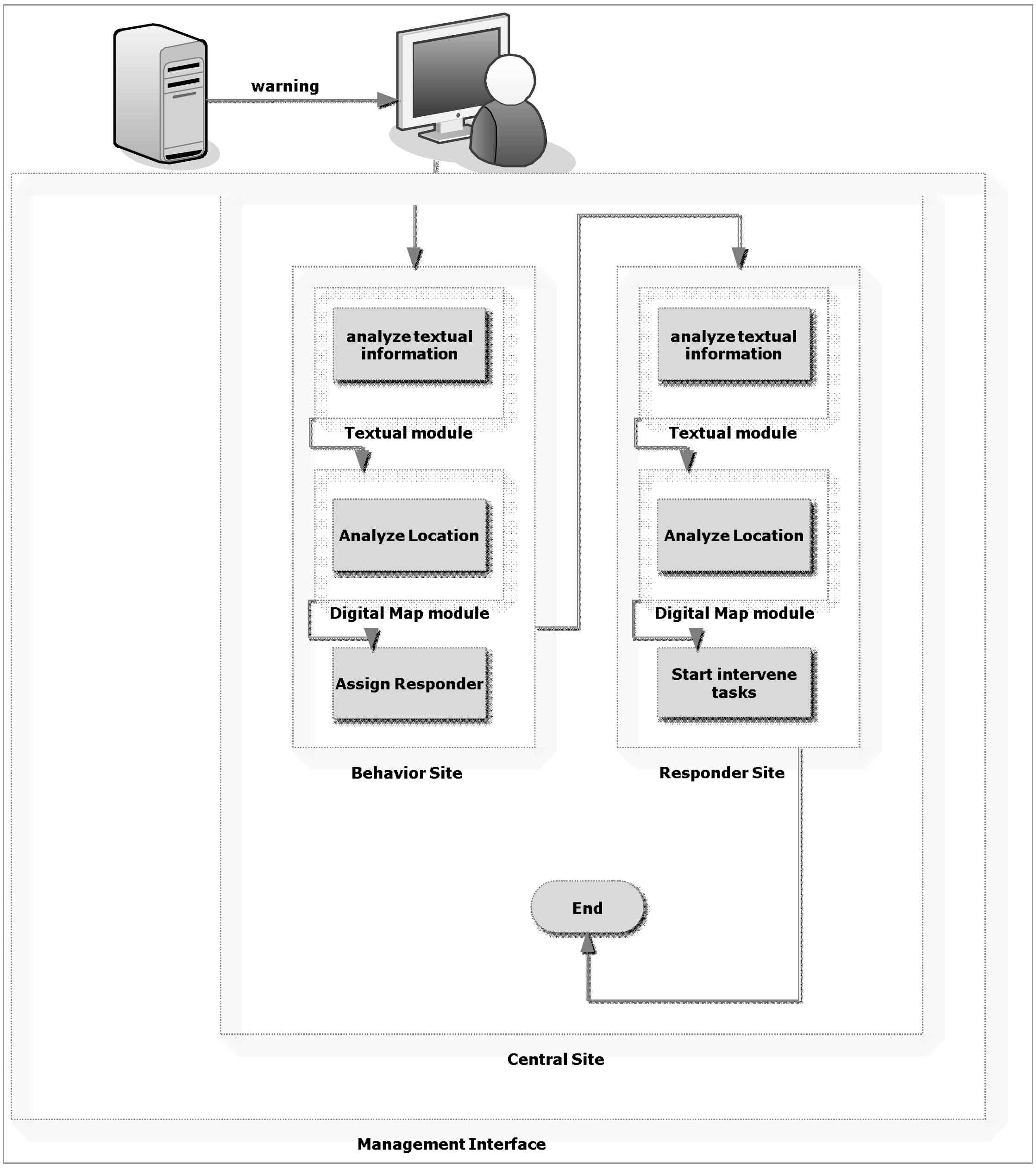

Figure 3.6 Activity Flow of Management Interface Component for Heart Attack Scenario

CHAPTER 4

PROTOTYPE IMPLEMENTATION

Following the conceptual description of the proposed system, the prototype implementation of the emergency management system using mobile computing is described, and the real prototype domains and applications are presented in this chapter.

4.1. Description of the Prototype Implementation

In order to show the feasibility and applicability of the proposed system, a working system is constructed according to its conceptual description. The prototype mainly consists of an application running on the Android operating system on a mobile device, processing software that works on a remote server and a web application enabling interactions of the users.

In the prototype, while the mobile application represents the user interface component of the proposed system, the processing software represents the central processing component of proposed system and the web application is used for the management interface component of proposed system.

The public safety system M-urgency (Krishnamoorthy& Argawala, 2011) offers an implementation including three components as caller application, dispatcher console application and emergency responder application. The caller application runs on a smart mobile device and provides to send video stream with real time location information to PSAP. The dispatcher console application runs on a desktop computer and is used by PSAP. It provides dispatcher to view incoming emergency calls, location information of the caller via a digital map, and available responders. It also enables to assign a responder to an incoming call. The emergency responder application runs on a mobile computing platform generally on a laptop and provides the responder to receive video stream assigned by PSAP with location information. Conceptually, all the tasks about m-urgency activity flow are fulfilled in a real time manner requiring continuous network connectivity.

In our study, the prototype offers an implementation including three components for activity flow. However, main focus and major contribution of our study are; unlike the system offered by Krishnamoorthy et al (2011), technically to report any type of emergency situation even if there is no network connectivity at that time, provide additional information by using different techniques such by writing a comment or by recording voice according to the situation and conceptually to guide a reporter for better information delivery, manage emergency response activity flow and plan about inventory.

The prototype is implemented by gathering different modules of the proposed system according to emergency situations aiming not only to reduce the handicaps of traditional reporting processes but also adding value to these processes. In the end, the prototype system will be used by a group of users for an experimental case in order to analyze contributions compared to traditional reporting.

The prototype system is named as CerAndroid, and involves three different emergency situations which are ñSuspicious Packetò, ñFire Warningò and ñStranger at Homeò. For the different situations, different modules are used to show the applicability of the implementation. The reporting activities start with determining the location by using GPS, Wi-Fi, mobile network or digital map. For the suspicious packet case, users capture a photo of suspicious packet and also highlight the suspicious packet on the captured photo by drawing manually on the smart phone surface. For the fire warning case, users record a video of a fire event. At the end, reporting is finished with commenting about the situation for additional information. This process may be performed by writing a comment or voice recording for this purpose. All the data about a case is sent to a remote server to be processed by using Wi-Fi or mobile network. If there is no internet connection available required data can be sent via SMS.

All the processed data are viewed by the system administrator at the management department. The management department is not actively involved in emergency responding tasks but it plays the managing role in the system. The region department acting as public safety answering point is allowed to see the emergency situations according to its area of responsibility. It plays the role of assigning and planning activity of responders. Responders are allowed to view only the assigned emergency situation and inform the region department about their task.

These implementation steps are described in detail next.

4.2. Components of the Prototype

The prototype implementation includes three main components according to the proposed system. These components are mobile application running on a mobile device, processing software and web application. Figure 4.1 illustrates these three components.

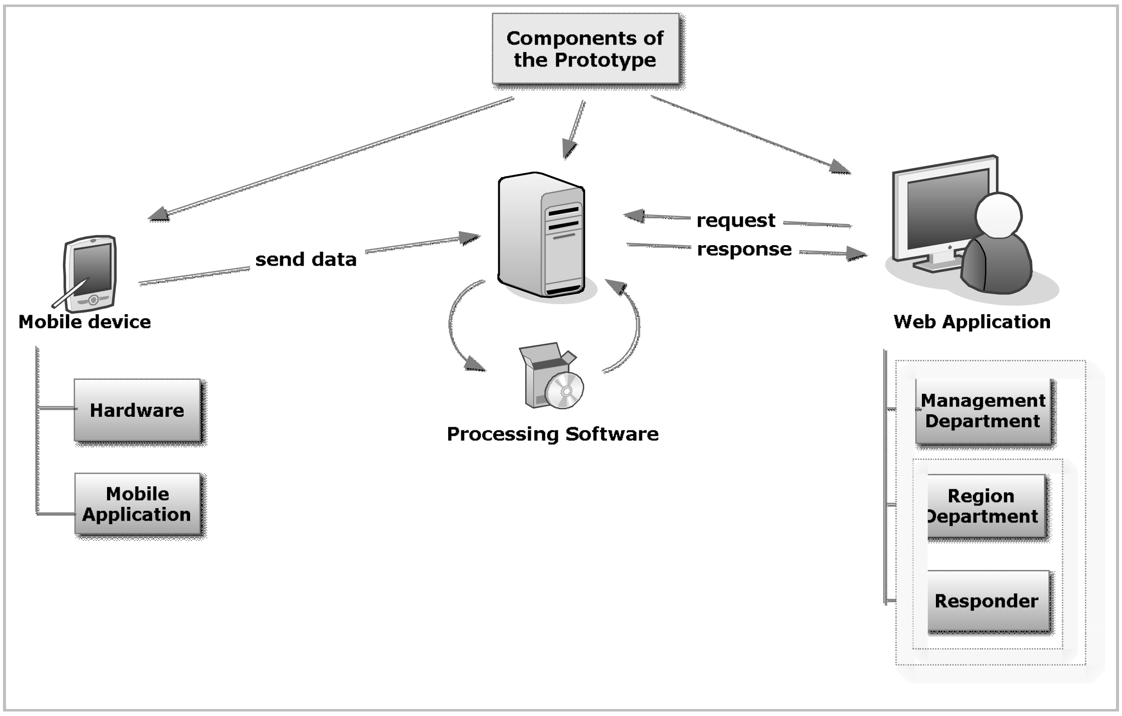

Figure 4.1 Components of the Prototype

4.2.1. Mobile Device

A mobile device is used for reporting an emergency situation for the prototype implementation. All data are acquired by the mobile device which contains GPS and A-GPS for location determination, Wi-Fi, GPRS, EDGE, and 3G for both location determination and data transmission, capacitive touchscreen for activity flow and user interaction, camera for capturing video and photo, microphone and loudspeakers for inputting and outputting voice data and external storage for storing data.

The mobile device runs the Android operating system, as it provides some advantages as a mobile computing environment.

4.2.1.1. Android Operating System

Android, developed by Google Inc., is an open source and linux-based operating system designed for running on mobile devices (Önder & Mermerkaya, 2011). In 2005, Google Inc. purchased Android Inc. and led the constitution of the Open Handset Alliance (OHA) in 2007 with a consortium of 34 mobile operators, handset manufacturers, software, commercialization and semiconductor companies for creating and defining open standards for mobile devices (Taç, 2011). In 2008, the first version of the operating system ñAndroid 1.0ò was released with the efforts of Google and the other firms in OHA. Today there are various versions of the Android operating system running on mobile devices.

According to Taç (2011), it is possible to manufacture both a traditional mobile phone and smart phone supporting different kinds of hardware and sensors by using the Android operating system. Specification of the Android operating system and why Android is chosen for the prototype can be explained as follows;

- It supports different size of screens.
- The support for SQLite database provides applications the capability to store relational data.

- It supports the communication technologies of GSM/EDGE, CDMA, UMTS, Bluetooth, Wi-Fi and WiMAX.
- It supports both SMS and Multimedia Messaging Service (MMS).
- Applications can be developed by using Java programming language.
- To run applications, Android uses Dalvik virtual machine which is optimized for running with limited resources in terms of CPU and memory.
- It supports different kinds of multimedia components.
- It supports hardware for GPS, touchscreen, accelerometer, gyroscope, pressure meter.
- It supports multi touch and multi-tasking.
- It supports the developers to use open source libraries and reach all the resources of the mobile device.
- It provides developers the capability to reach important Google services like Google Maps or Gmail by using provided APIs.

4.2.1.2. Android Application Development Basics

An Android application consists of six components which are activities, services, content providers, intents, broadcast receivers, widgets and notifications. These components are bound by an application manifest file, ñAndroidManifest.xmlò, which describes each component, interaction between them, structure and metadata of the application. The application name, the first screen which is shown on start-up of application, the permissions about resources that application wants to reach are defined in the manifest file. An example manifest file defining access to vibration hardware of the phone can be shown as;

Example:

```
<manifest>
<application>
…
</application>
<uses-permission android:name=”android.permission.VIBRATE”/>
</manifest>
```

Activity component controls the viewsô visibility on the user interface and how to react according to user interactions and data entries. Each interface shown on the screen of mobile device is controlled by an activity. View defines all the graphical components like button or text that are viewed on the device screen. These graphical components are defined in an Extensible Markup Language (XML) file. An example of defining a button in an XML file can be shown as;

Example:

```
<Button
android:id="@+id/button_id"
android:layout_width="wrap_content"
android:layout_height="wrap_content"
android:textStyle="bold"
android:text="Button 1"
/>
```

Service component provides an application the capability to run an activity in the background even if it is not active or visible. Content provider component provides for application to get shared data over the databases. Using contact details of records on the phonebook for another application can be an example of content provider work. Intent component provides broadcasting messages to defined components of application like activities to perform required actions. Dialing a number after pressing a button can be an example of intent work. Broadcast receiver component provides to create event-driven applications with automatically responding a broadcasting intent. Widget component can be described as shortcut form of mobile application stated on the home screen. Notification component is used for warning or informing the application user without interrupting current activity. Vibration of the mobile device in the event of an incoming call can be an example of notification.

In order to install an android application into a mobile device after development, application has to be exported as an Android Packet File (APK). APK file includes all the source codes, images, XML files, manifest etc. about the application.

4.2.1.3. Mobile Application: CerAndroid

A mobile application named CerAndroid is developed by using Android application basics for the prototype implementation. The mobile application provides the user to report an emergency situation using capabilities of the smart mobile devices. Development is done using Java programming language and API level 10 is chosen for the minimum Software Development Kit (SDK) level. Android SDK is a set of development tools which includes required libraries and some other components for developing android applications. With the release of every version of Android OS, a corresponding SDK is also released in order to provide application development with the latest features.

The application is developed for three different types of situation which are ñSuspicious Packetò, ñFire Warningò and ñStranger at Homeò. For the different situations, different modules are used to show applicability of the implementation.

The application starts by showing four buttons. Three of them are about types of emergency situations and one of them is about creating pre-defined location information. Figure 4.2 illustrates the startup screen of the application. Conformably to main classes of application, the user interfaces are created by making use of inheritance capabilities of java programming language. To create the user interface, graphical components are not defined in an XML file for % 90 percent of the application. The main layout, which holds all the elements that appear to the user, is created programmatically in the class and the other user interfaces created by extending that class:

Base screen class:

```
//new layout is created
main_lay = new LinearLayout(this);


//layout parameters are defined
main_lay.setLayoutParams(new LinearLayout.LayoutParams(
    LinearLayout.LayoutParams.FILL_PARENT,
    LinearLayout.LayoutParams.FILL_PARENT));
main_lay.setOrientation(LinearLayout.VERTICAL);
```

Class extending Base screen:

```
//new button is created
bookmarks = new Button(this);
  bookmarks.setId(20000);
  bookmarks.setText("Pre-defined Locations");
  bookmarks.setLayoutParams(new LinearLayout.LayoutParams(
  LinearLayout.LayoutParams.FILL_PARENT, LinearLayout.LayoutParams.WRAP_CONTENT));
```

//the new button added to layout using inheritance

View layout = ((ViewGroup)findViewById(android.R.id.content)).getChildAt(0);

((ViewGroup) layout).addView(bookmarks);

Figure 4.2 Startup Screen of Mobile Application of Prototype

Three of the buttons related to the emergency situations help the user to be navigated in order to make a reporting. The other button named as ñPre-defined Locationsò guides the user to create, edit or delete location information by combining address information with longitude and latitude data.

The application provides user to determine location in four ways which are described in detail in this chapter. Four types of location determination techniques acquire longitude and latitude data of the location. Each technique requires time and power for determination process and none of them provides address information like name of an apartment, floor number or door number of a place. Many people sleep at the same house and go to the same building for work. ñPre-defined locationsò is created in order to make a more value added reporting, decreasing reporting time and processing power for emergency situations occuring at those locations. In ñstranger at homeò emergency situation, it senses nothing to give the longitude and latitude data of the building without informing responders with the floor and door number information for intervening tasks. ñPre-defined locationsò combines longitude and latitude data, which is also acquired by using the four types of techniques provided by the application, with address information input by the user. Combined location information is stored on the database of the application and provides an alternative way of determining location information in the event of an emergency situation reporting. User determines location from a dropdown menu, which is called as spinner in android programming, with the name of the pre-defined location. Figure 4.3 illustrates ñPre-defined Locationsò screens of the application and figure 4.4 illustrates ñPre-defined Locationsò activity flow.

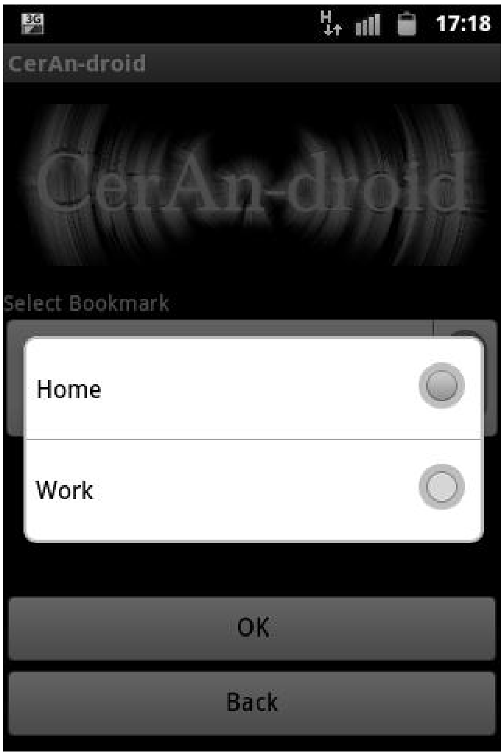

Figure 4.3 Screen of ñPre-defined Locationsò

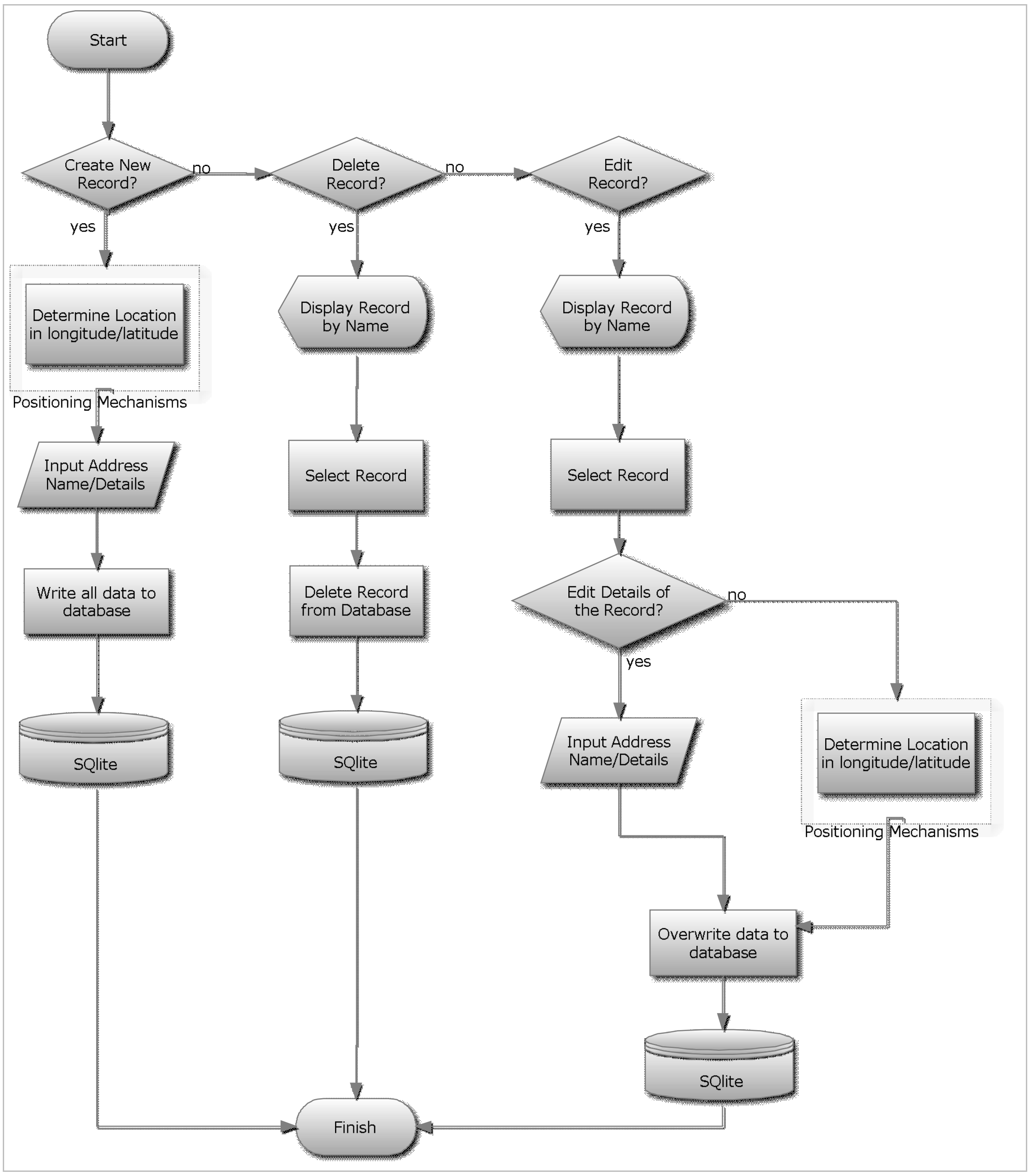

Figure 4.4 Activity Flow of Creating/Editing/Deleting Pre-defined Location

The application is developed for three different types of situations which are ñStranger at Homeò, ñFire Warningò and ñSuspicious Packetò. ñStranger at Homeò case is about reporting the event of a stranger being in a residence with the aim of theft, robbery, without alerting him/her about the reporting activity. ñFire Warningò case is about reporting a fire event which started or has the probability of starting soon somewhere. ñSuspicious Packetò case is about reporting an object located somewhere and appears suspicious. The reason for choosing these cases is to analyze and show the applicability of different modules according to the proposed model. However, these three cases include common modules within the activity flows which are ñdetermining locationò and ñfinishing reportingò. Two common modules within activity flows will be described in detail and then three of the cases will be described separately in detail.

4.2.1.3.1. Determining Location

Determining the location in the event of an emergency situation is provided by positioning mechanisms of GPS-based, Wi-Fi based and Mobile Network Based mechanisms and making use of the Android environment. All these mechanisms provide different capabilities in terms of accuracy, power consumption or time. Positioning mechanisms are made available by location-based services of Google Inc. Google is one of the companies providing location-based services in order to estimate user location ("Location-based services," 2012).

Android application development environment provides location-based application development using the classes of the android.location package. The Location Manager class which is located in android.location package provides developer to access to the location services of the system. It also includes constants returning the name of location provider. One of the providers is GPS and the other one is network provider. Location listener class implements callback methods for location manager class in the event of a change in user location.

GPS-based positioning mechanism determines location by using satellites. Location updates are requested by defining the provider with location manager. Code sample may be described;

Example:

```
...
LocationListener Gpslistener = new LocationListener() {
...
}
lm = (LocationManager) context.getSystemService(Context.LOCATION_SERVICE);
lm.requestLocationUpdates(LocationManager.GPS_PROVIDER, 0, 0, Gpslistener);
...
```

The permission of ñACCESS_FINE_LOCATIONò must be added into AndroidManifest.xml file for accessing GPS location service.

Wi-Fi based and Mobile Network Based positioning mechanisms are both available with network provider. Wi-Fi based positioning mechanism uses Google Location Server (GLS) data. Google, like other companies, uses publicly broadcast Wi-Fi data from wireless access points to store on GLS ("Location-based services," 2012). The collection of information is done with the permission of users and can be done even when no applications are running. Figure 4.5 illustrates the location service permission screen.

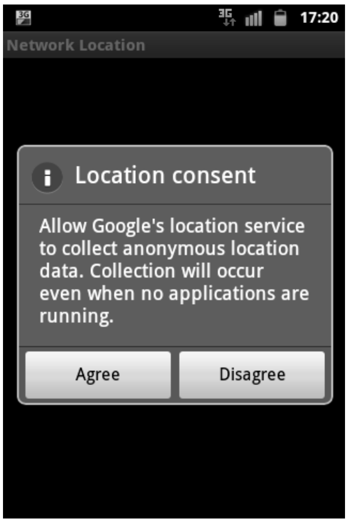

Figure 4.5 The Location Service Permission Screen.

Mobile Network Based positioning mechanism uses cell-tower location data comparing with the data in cell tower location database of Google Inc. to estimate user location. Accuracy of acquired location data may be differed up to thousand meters ("Location source and," 2012).

For network-based positioning code sample may be described;

Example:

```
…
LocationListener Gpslistener = new LocationListener() {
...
}
lm = (LocationManager) context.getSystemService(Context.LOCATION_SERVICE);
lm.requestLocationUpdates(LocationManager.NETWORK_PROVIDER, 0, 0, Gpslistener);
…
```

The permissions of ñACCESS_FINE_LOCATIONò and ñACCESS_COARSE_LOCATIONò must be added into AndroidManifest.xml file for accessing network location service.

The fourth mechanism to determine location is using Google Maps. If GPS is unavailable and there is no data acquired from databases of Google, user is asked to determine his/her place by using Google digital map by analyzing nearby constructions or addresses. com.google.android.maps package is provided by Maps external library. This package includes classes to enable downloading and rendering a digital map. User is asked to determine his/her location by touching on the screen over the digital map. Figure 4.6 illustrates the Google Maps screen with a pinpoint marker.

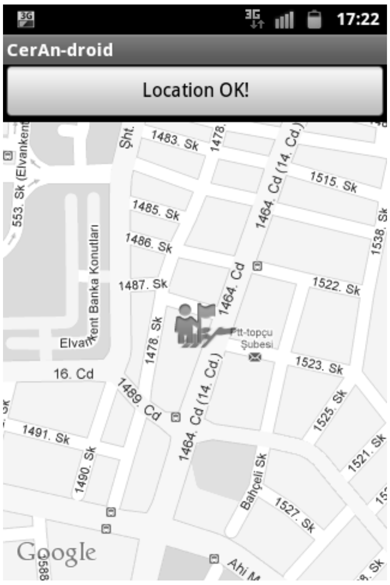

Figure 4.6 Google Maps Screen with a Pinpoint Marker.

The permissions of ñINTERNETò must be added into AndroidManifest.xml file for downloading and rendering map data from the internet.

The four mechanisms provide user to acquire a longitude and latitude location data to be processed. Pre-defined location information creates an alternative for these four positioning mechanism including both longitude/latitude data and address information.

In the event of emergency situation user may determine his/her location by using any of these five positioning mechanism. To determine location, two choices are shown to user. One of them navigates user to use one of the pre-defined location from the database; the other one navigates user to use any of four positioning mechanisms. Second choice also includes two choices of ñfinding location by using GPSò or ñfinding location by using mapò. In the event of choosing any of two choices, application triggers some conditional statement comparisons. If user prefers to determine his/her location by using map, application checks the availability of network connection by either Wi-Fi or mobile network to warn user to turn-on any of them. If application can acquire data from Google databasesô, Google maps screen is viewed with a pinpoint marker placed on the related location. If not, Google maps screen is viewed with a pinpoint marker placed on programmatically-defined location. If the user prefers to determine his/her location by using GPS, application checks whether GPS is available to warn user turn it on. If GPS data can be acquired in one minute duration, Google maps screen is viewed with a pinpoint marker placed on the related location. If not, tasks of first choice, which are about finding location by using map, are triggered automatically. Activity flow of location determination is described in figure 4.7.

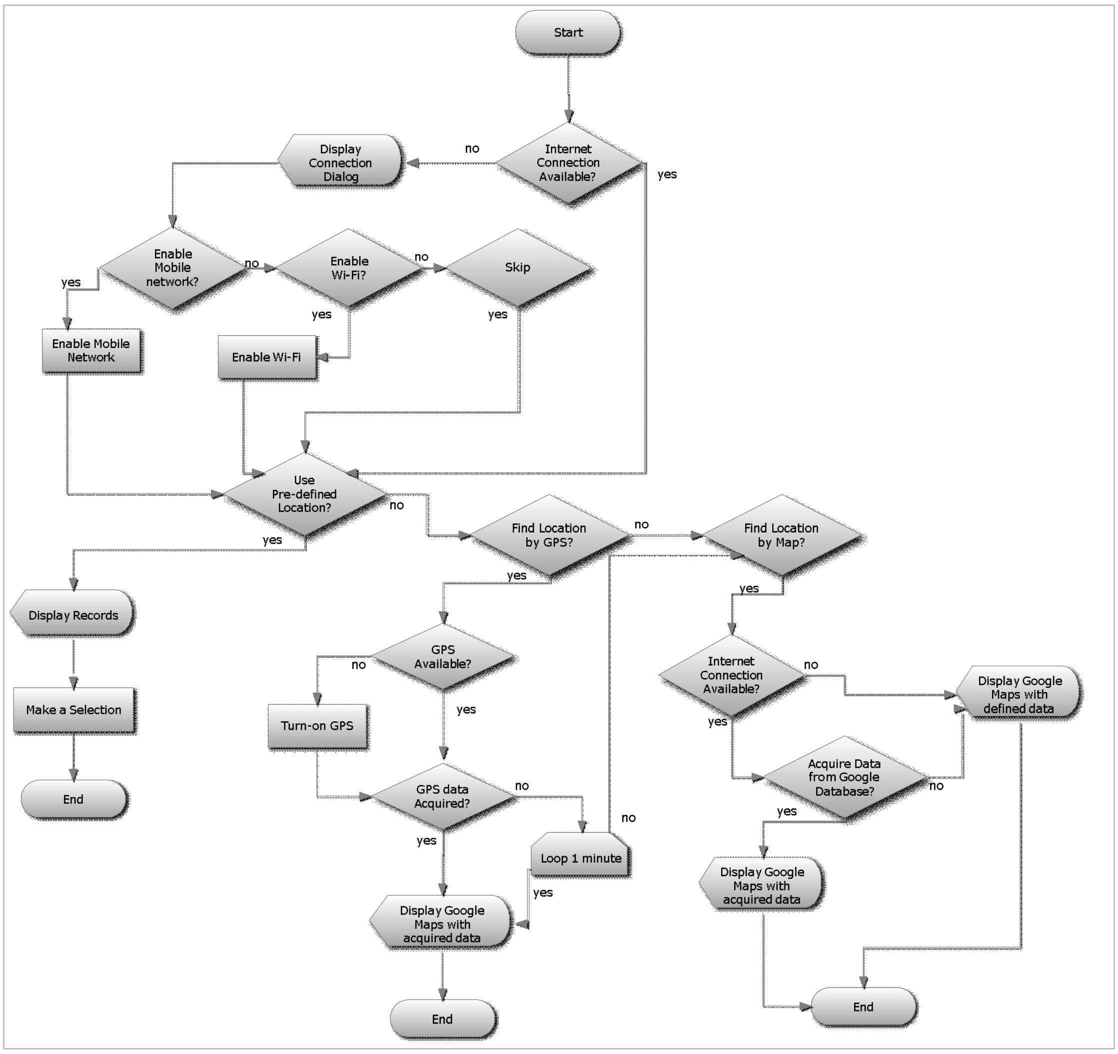

Figure 4.7 Activity Flow of Determining Location Module with Positioning Mechanisms.

4.2.1.3.2. Finishing Reporting

Finishing the reporting process for an emergency situation combines two tasks which are sending all gathered data within the application to a remote server and using two types of commenting options which are ñwriting a commentò and ñrecording a voice commentò. Commenting options are provided for the user to give additional information about the emergency situation which is not acquired by the application directly. For instance, in the event of an emergency situation of ñstranger at homeò; if the user did not create ñpre-defined locationò information indicating his/her address information, it would be expected from user to tell the address information by using any of the commenting options.

Two types of commenting options are created to be used for different situations. To write a comment may be more acceptable and useful than recording a voice comment in the event of a traffic accident where there is much noise because of the traffic which can lower the level of understanding by PASP or responder. Writing a comment is provided user with input dialog box which is a kind of alert dialog box provides user for inputting data.

According to a research report (Matthews, Pierce & Tang, 2009), people read e-mail messages using their smart phone and they reply e-mail messages with short answers. They also postpone writing e-mail messages in order to do the job with their computer. Bao et al. (2011) indicates that since screen of smart phones are small, it is hard to type on it and people prefer reading than writing on their phone. In order to make user give more additional information, other option of commenting with voice record is added to the implementation. Since recording a voice has some handicaps in terms of noise in the environment, it is provided user to listen recorded comment and re-record a voice comment if the first record has lower understanding level. Figure 4.8 illustrates the writing comment and recording voice comment screens.

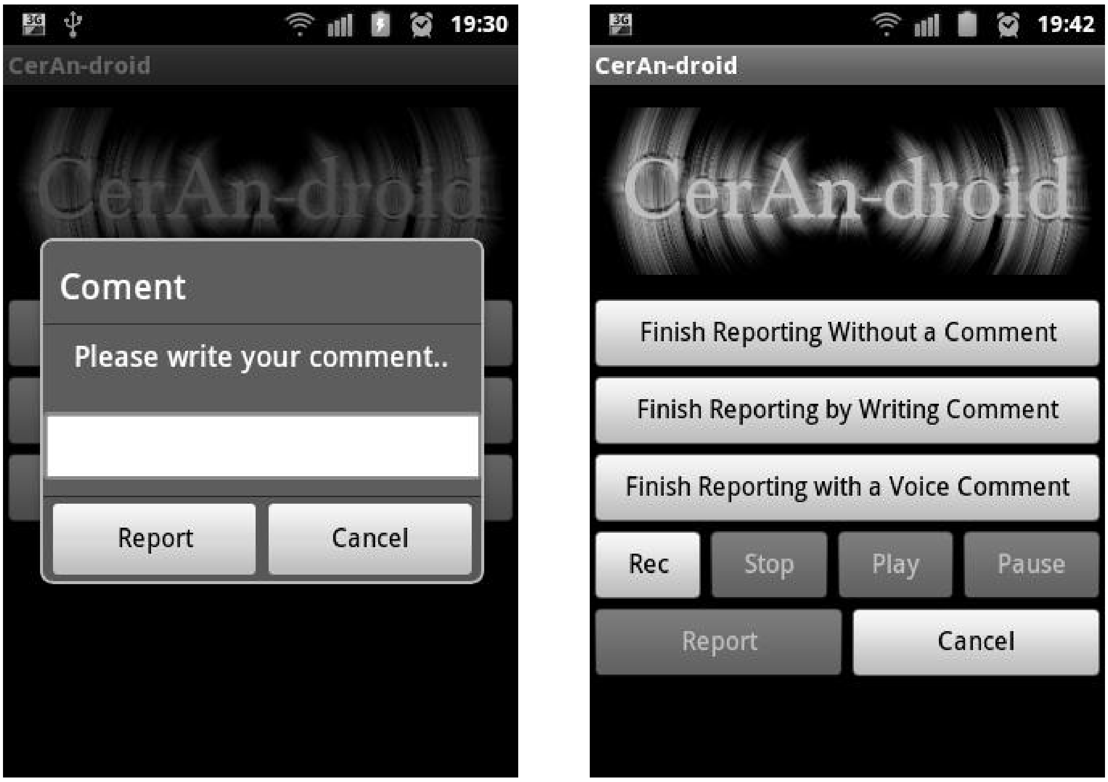

Figure 4.8 Screens of ñWriting Commentò and ñRecording Voice Commentò

Second task of finishing the reporting process for an emergency situation is sending all gathered data within the application to a remote server. All the data or paths of files are kept in variables after creation. To keep a variable value across all android activities, a global class is created. So the data which will be sent is accessed via this global class. To give an example; the IMEI number is acquired programmatically with the start of the application. And then the data is kept in a variable named ñphone_imeiò using function of global class. The source code for keeping this variable can be described:

Global_class function:

//function for keeping phone_imei data

public void set_phone_imei(String phone_imei) {

```
    this.phone_imei = phone_imei; }
```

Using this function in any class:

```
//keeping phone_imei data in variable
Global_class.getInstance().set_phone_imei(phone_imei);
```

The data of phone_imei is accessed by using another function of global class while sending task.

Global_class function:

```
//function for acquiring phone_imei data
 public String get_phone_imei() {
    return phone_imei; }
```

Using this function in sending task:

```
//accessing phone_imei data within variable
Global_class.getInstance().get_phone_imei(phone_imei);
```

The data is selected according to emergency situation and accessed by using this function. Sending the selected data task can be completed via two different channels. Sending information via internet is the first channel and the second channel is short messaging service. Before the sending task, application checks the internet connection again. If internet connection is available, all the data is sent to remote server automatically. If not, the user is provided to send the data via SMS. Since only textual data is available to be sent via SMS, it is preferred to send all the data via internet. For any emergency situation; type of the emergency situation, longitude and latitude location data, details if exists, IMEI number, phone number and the user comment form the SMS message. In comparison with M-Urgency project (Krishnamoorthy& Argawala, 2011), reporting via SMS creates contribution in terms of availability while there is no internet connection.

Sending the data over internet includes two different tasks. The first task is sending the textual data (string, integer etc. variables) to remote server and the second task is uploading multimedia data, if exists, to remote server.

Sending textual data is provided by using ñhttppostò class. Httppost class is provided with org.apache.http package. The post method which is used to request a remote server to accept the entity provides application posting a block of data. NameValuePair class which provides to encapsulate an attribute or value pair is used for gathering data which will be sent. Selected data is then handed to request by SetEntitiy method of httppost class. For the implementation ñhttp://www.onurceran.com/onur/insert.phpò is used for remote server address to which all the textual data is sent.

The second task which is uploading multimedia data to remote server is provided by using InputStream/OutputStream classes. By using FileInputStream class, the multimedia data is read as bytes by accessing the existing file name. A Uniform Resource Locator (URL) connection to "http://www.onurceran.com/onur/upload.php" is created for HTTP to send data over the internet by using HttpURLConnection class for the implementation. writeBytes method of DataOutputStream class provides to write the bytes of selected data to remote server in 8-bits order.

Figure 4.9 illustrates the activity flow of finishing reporting for an emergency situation. Determining location and finishing reporting modules include same tasks in three of the emergency situation cases. Three of the cases for the implementation will be described separately in detail with activity flows. It will be described how different modules may be used according to the proposed model.

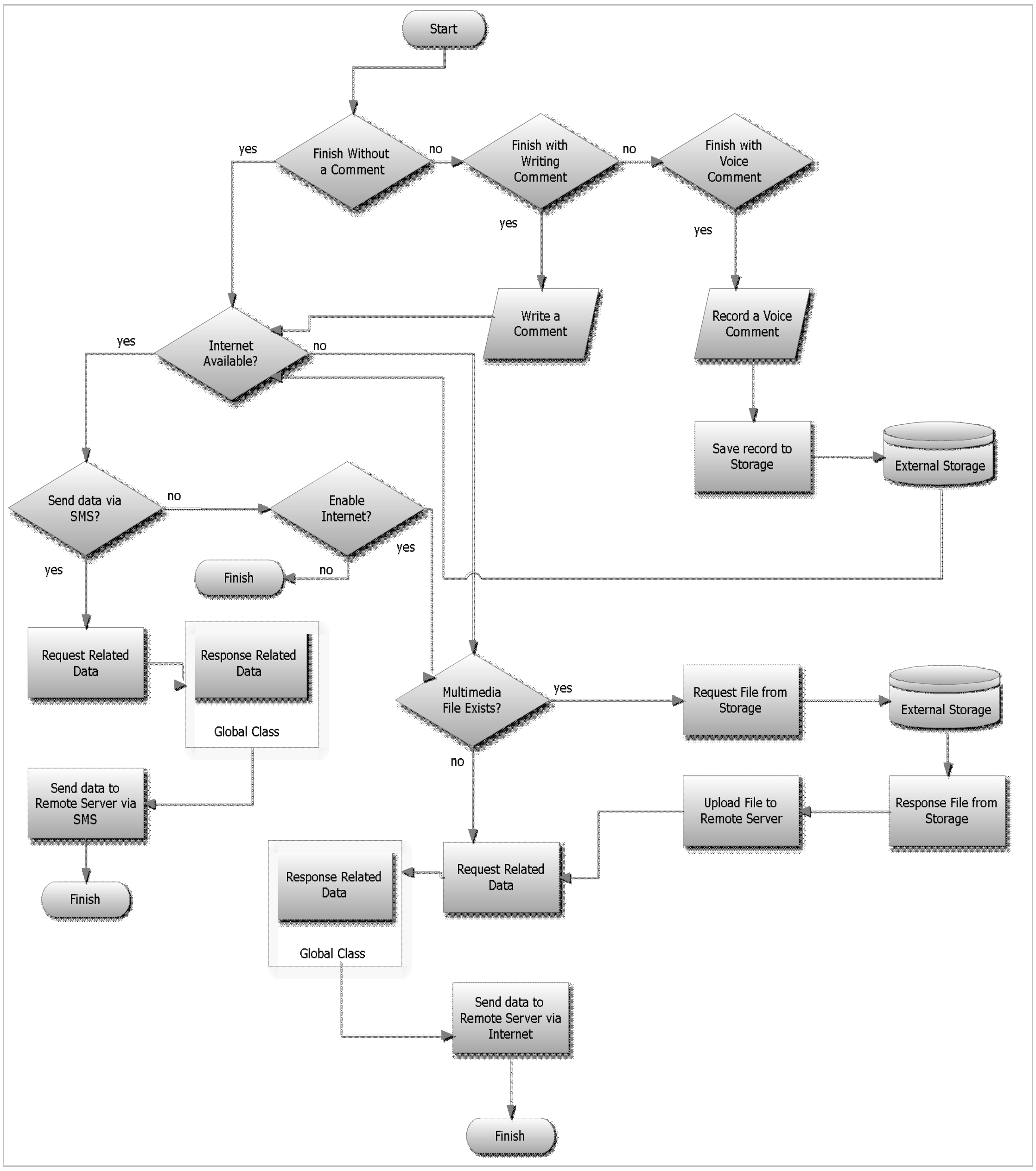

Figure 4.9 Activity Flow of Finishing Reporting Module

4.2.1.3.3. Emergency Case ñStranger at Homeò

Emergency case of ñStranger at Homeò creates the cornerstone of the implementation. The implementation of the case consists of only common two modules which are determining location and finishing reporting. It is aimed to show the applicability of implementation for emergency situations in which it is not necessary for responders to get additional information in multimedia type or sensor data provided by a smart mobile device and to show that only two modules of implementation may be enough for intervention.

4.2.1.3.4. Emergency Case ñSuspicious Packetò

ñSuspicious Packetò case is about reporting an object located somewhere and appearing suspicious. Similar to ñStranger at homeò case, determining location and finishing reporting modules are also used in ñSuspicious Packetò case. However; according to proposed model, picture module is used in addition to that case. It is aimed to show the applicability of implementation for emergency situations in which it may help responders to get additional information for a better intervene or help region department to make more efficient plans by analyzing captured image provided by the smart mobile device.

In the implementation, after location is determined, user needs to capture a photo of suspicious packet and also compelled for specifying the suspicious packet on the captured photo by drawing on the smart device surface using fingers. Screen of capturing and drawing on captured photo for the prototype is shown in figure 4.10.

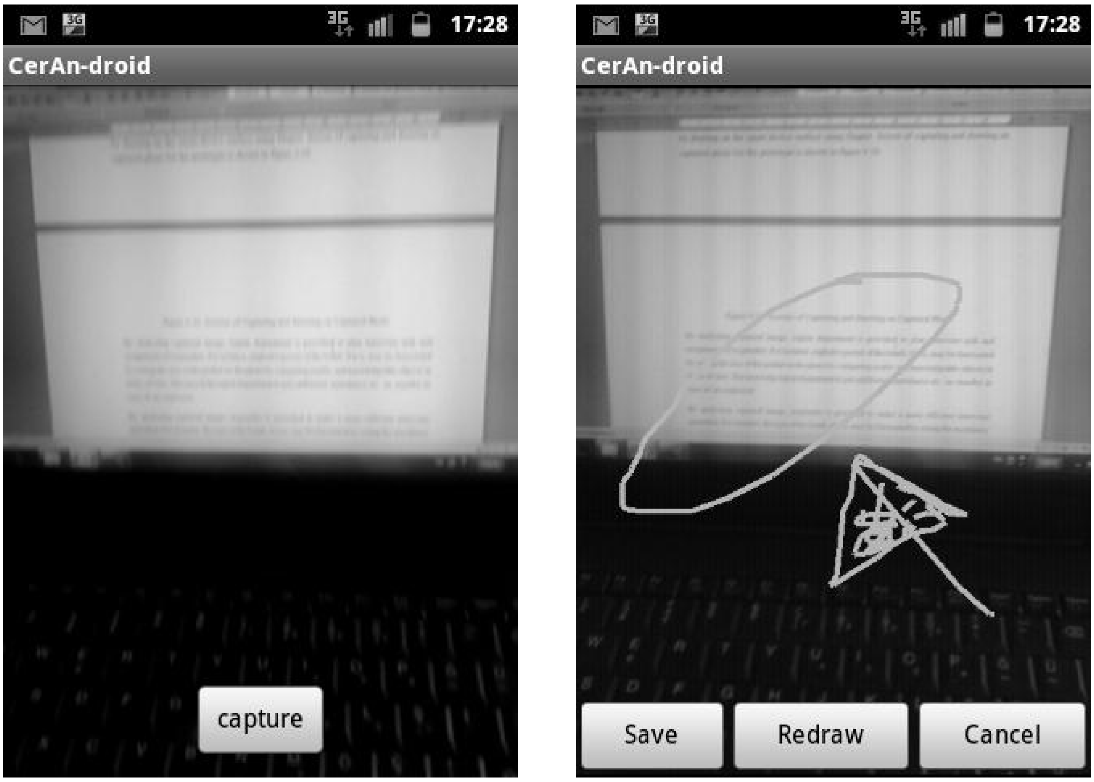

Figure 4.10: Screens of Capturing and Drawing on Captured Photo

By analyzing captured image, region department is provided to plan intervene task and assignment of responders. For instance, explosive power may be forecasted by seeing the size of the packet on the photo by comparing nearby and knowledgeable objects in terms of size. This may help region department to put additional ambulance on standby in case of an explosion.

By analyzing captured image, responder is provided to make a more efficient intervention operation. For instance, the type of the packet may be determined by seeing the machinery of the packet by analyzing the photo. If a wireless communication device like a cellphone or radio-set is attached on the packet and can be seen on the photo, responders come close to the suspicious packet to destroy it by using a jammer device to interrupt the communication to prevent the remote control of explosion. Specifying the suspicious packet by drawing on the smart device surface using fingers provides responder to see the packet which is realized as suspicious by the user. It may cause not being able to perceive the suspicious packet on the raw photo. However, even raw photo give additional information about where the suspicious packet is located. Responder reaching the address of reporting looks for a green car parked on the street - that provides gaining time for quicker intervening -, if the photo shows that the suspicious packet is located under a green vehicle.

Capturing a photo is provided by using ñCameraò class for the implementation. Camera class provides developer to set capturing parameters, start and stop actions for preview by using public methods. By calling ñtakePictureò function of Camera class, it is provided to capture a photo. To use camera hardware for the application, the permissions of ñCAMERAò must be added into AndroidManifest.xml.

Drawing on the captured photo by using fingers is provided by using ñCanvasò class. Canvas class provides developer to draw something on the view. Paint class creates an instance which is one of the four parameters of Canvas class. Paint class determines the style and color information of the drawing. OnTouch method, which determines of touching event dispatching to a view, provides the canvas class to use òdrawLineò method in order to draw something over the surface with touching event of the fingers.

4.2.1.3.5. Emergency Case ñFire Warningò

ñFire Warningò case is about reporting a fire event which started or has probability of starting soon on somewhere. Similar to ñStranger at homeò case, determining location and finishing reporting modules are also used in ñFire Warningò case. However, according to the proposed model, the video module is used in addition to that case. It is aimed to show the applicability of the implementation for emergency situations in which it may help responders to get additional information for a better intervene or help region department to make more efficient plans by analyzing captured video provided by the smart mobile device.

In the implementation, after location is determined, user is compelled for capturing video of fire event with its environment. Fire or its probability case may be a vehicle dropping liquid fuel over the road creating a probability of an explosion and right after a fire event, fire on a harvest field which has flames visible outside or a fire inside a building with flames which cannot be seen outside the building. Each of the fire cases may have different environmental states which may affect intervene tasks and planning. According to states indicated by firefighter experts in problem and motivation section, different types of equipment are used for different types of fire cases. In addition, it is important to know about the nearby structures where the fire occurs. To acquire additional information about the event and its state of environment may provide advantages for not only region department but also firefighter. For instance, it may provide region department to make a better planning of assigning a fire truck which has the capabilities of extinguishing a ñflammable liquidò fire, in the event of a fire caused by a vehicle dropping liquid fuel. In the event of a fire on a harvest field, it may provide region department to assign additional and also different type of fire truck for making provision, if it is known that there is a nearby forest which may be affected by the fire because of the wind. In the event of a fire inside a building, it may provide firefighter to prepare equipment in order to reach inside of the building not by using entrance because of flame; instead, by going in from the roof of the building, if there is a nearby building providing firefighter to pass by using its roof and if this information can be acquired.

To provide these advantages for region department or firefighters, capturing image of the event in one screen may not be applicable. Capturing a photo of burning vehicle may provide firefighter to know about the fire type but it does not give about a nearby gas station for making provision if it is not seen on the captured screen. Capturing a video of the fire event and its environment may provide indicated advantages.

It is aimed with the implementation for ñfire warningò case, to show the applicability and advantage of capturing a video for emergency cases in which it is important to get information about not only the event but also state of environment. Screen of recording for the prototype is shown in figure 4.11. A screen created for warning user to start recording video from the fire and turn 360 degrees around for including environment into the video illustrated in figure 4.12.

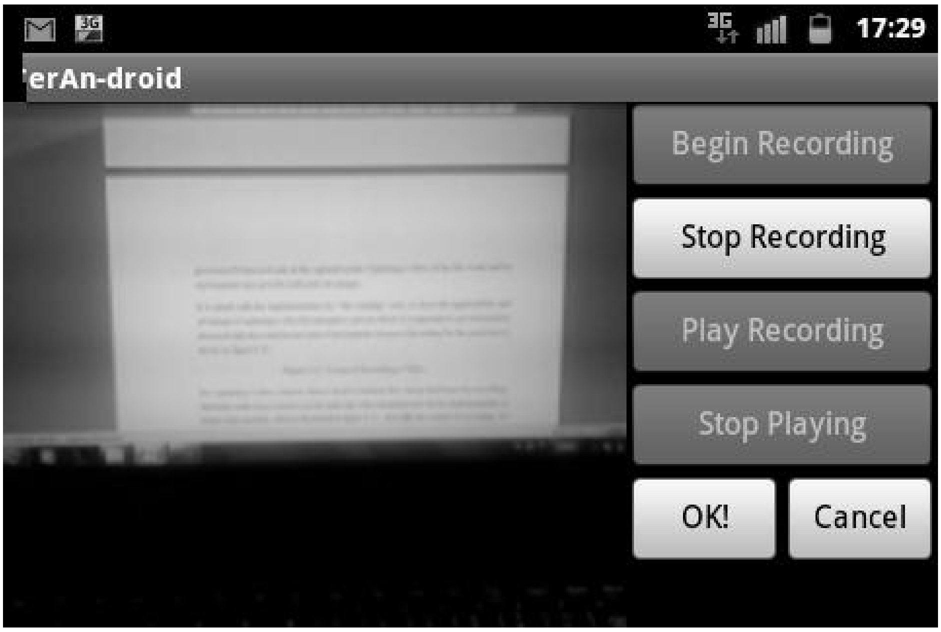

Figure 4.11: Screen of Recording a Video

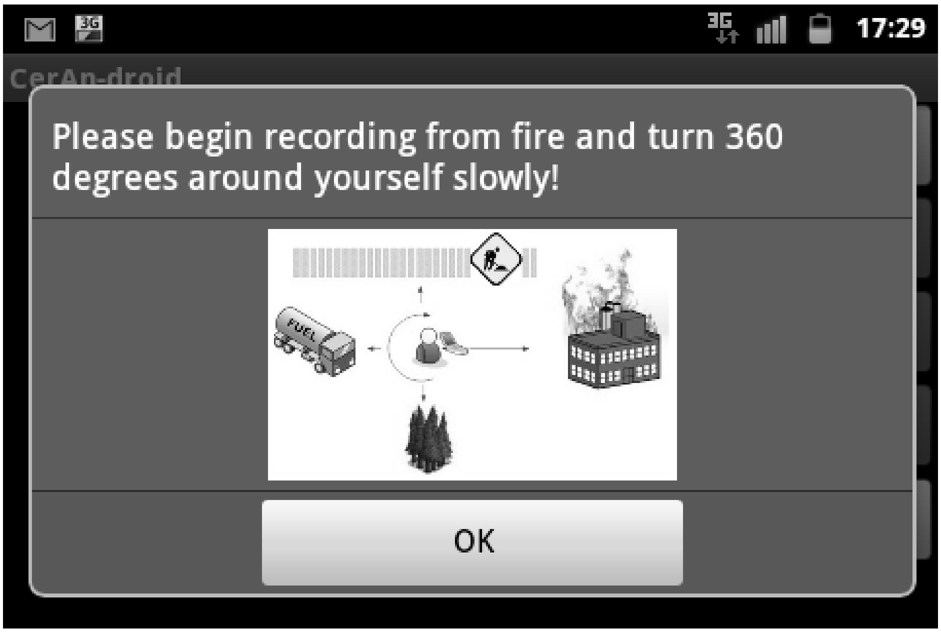

Figure 4.12: Screen of Warning User

For capturing a video, Camera class is used to initialize the camera hardware for recording. MediaRecorder class is used to record audio and video simultaneously for the implementation. A simple state machine, which is illustrated in figure 4.13, describes the control of recording. To use camera hardware for the application, the permissions of ñCAMERAò must be added into AndroidManifest.xml.

After creating an object of MediaRecorder class, the properties are set for the implementation with the source code;

media_recorder = new MediaRecorder();

media_recorder.setAudioSource(MediaRecorder.AudioSource.CAMCORDER);
media_recorder.setVideoSource(MediaRecorder.VideoSource.CAMERA);
media_recorder.setOutputFormat(MediaRecorder.OutputFormat.MPEG_4);

media_recorder.setVideoSize(176, 144);

media_recorder.setVideoFrameRate(15);
media_recorder.setVideoEncoder(MediaRecorder.VideoEncoder.MPEG_4_SP);
media_recorder.setAudioEncoder(MediaRecorder.AudioEncoder.AMR_NB);

media_recorder.setMaxDuration(20000);

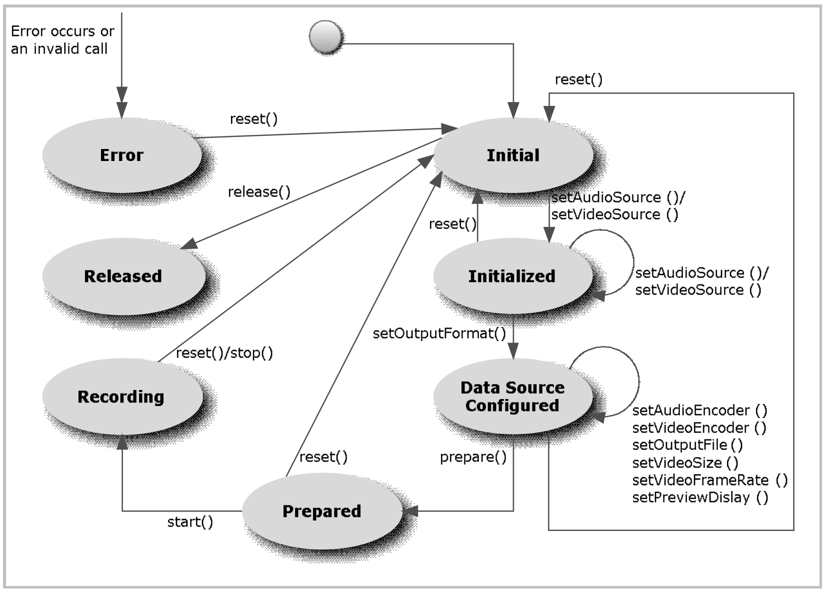

Figure 4.13 State Diagram of MediaRecorder

4.2.2. Processing Software

The processing software, in relation with the proposed system, enables both the management and the responder sites to acquire meaningful information in order to use in intervention efforts. The tasks are done automatically without the interaction of a manager or responder. The processing software runs on a computer acting as a server with the Debian operating system, and Apache web server. The processing software is generated by using PHP which is a general-purpose server-side scripting language originally designed for Web development to produce dynamic Web pages. MySQL is used as the database component.

The data acquired by CerAndroid application are sent to the central processor for processing., and stored on a 5GB of storage area for the prototype.

The longitude and latitude location data are processed to determine the area of responsibility to provide better management efforts. The responsibility areas are created according to postal codes defined by the government. For Turkey, according to the local government; cities are divided into counties and each county is divided into localities. Each locality is defined by borders and has a postal code. The localities, with the related postal code number, are pre-stored on the central processor database. When an emergency situation is reported, the central processor helps determine postal code number of the location according to the acquired longitude and latitude data. Then, the detected postal code number is matched against the postal code number pre-stored on the database so that the area of responsibility is determined.

Postal code number determination by using longitude and latitude is provided by the Google maps API, which helps managers and responders get the meaningful and useful address information in terms of country name, city name, street name and postal code. In order to use the API, an API key is obtained from Google Inc. With this key it is allowed to send longitude and latitude data to location servers of Google. Then, the meaningful address information is parsed in XML format, and stored on the database. The address information is provided for the manager and responders as emergency location information and the extracted postal code information is provided for determination of the area of responsibility.

The longitude and latitude location data are also processed to determine the weather condition of the location of emergency area. The weather condition is an external context for the managers and responders. Knowing about the wind velocity with the direction may help the managers assign sufficient number of responders and may help responders to make a better intervention plan. Determining the weather condition is provided by using the API provided by Weather Underground Inc. In order to use the API, an API key is obtained from www.wunderground.com. By using this API, a request is made to get content about the related longitude and latitude data. The response is provided in JavaScript Object Notation (JSON) format, which is then decoded into PHP objects and arrays in order to be stored on the database. The highest and the lowest temperature, wind velocity and direction, cloud situation are gathered as the weather condition information.

The processing software also provides verification of the integrity of the multimedia data which are sent by CerAndroid mobile application by using the MD5 cryptographic hash function. It compares the resulting hash value with the value acquired from mobile application component. If the two hash values are equal, data integrity is validated.

4.2.3. Web Application: CerAndroid Web

The web application is accessed over the internet at the web address www.onurceran.com. The users are logged in to the application by using a username and password. Based on the proposed system, three types of users are defined according to the organizational structure.

ñAdminò user is the user of the management department. This department is not actively involved in emergency responding tasks but it plays a managing role in the system. The admin user is allowed to see all the information about the reportings. He/she is also able to oversee the efforts made by the lower level users. The admin also organizes inventory planning. Responder teams are subordinated to region departments by the admin user.

The Region department acting as public safety answering point is allowed to see the emergency situations according to its area of responsibility determined by the longitude and latitude information acquired from the reporting. Counties create not only the borders of the area of responsibility but also the region departments by name. The county names are defined as usernames. Region department can see the subordinated responders and assign them for creation of the intervention effort about an emergency situation. Like the admin user, the region department can oversee the intervention efforts.

For the prototype implementation, three types of responders are created which are police, firefighter and ambulance. These types also form the responder site user of the system. The usernames are defined with the type of responder and a number like ñpolice1ò or ñambulance2ò. Responders are allowed to view only the information about assigned emergency situation and inform the region department about their task.

The modules are explained according to user interactions. Figure 4.14 illustrates the web page after logging in as the admin user. This page provides an overall view of the reportings.

Figure 4.14 The Web Page after Logging in

Some of the sections are the same for three types of the user. However, some of the sections are specific. When examining the same sections for both the management and region departments; the top-left corner illustrates the user currently logged in. ñNew messagesò link shows the number of reports which has reached the system as an emergency situation, but no responder are assigned for the intervention efforts by the region department. ñRead messagesò link shows how many of the reports are processed by the region department and assigned responders but not completed yet. ñCompleted messagesò link give how many of the intervention efforts for the reportings are completed by the responders. The statistics module is about showing how much time it takes for a user to make a reporting. The ñNew messagesò link provides the emergency situation type (ñsuspicious packetò), phone number of the reporter (ñ0505XXXXXXXò), the region department responsible for the assignment of responders (ñEtimesgutò), comment options (ñthere is a voice commentò) and integrity options about multimedia data if exists. The green dots indicate that there are multimedia data (photo, video, voice as ordered) validated in terms of integrity. If dots are red in color it shows that multimedia data are not validated in terms of integrity.

ñRead messagesò module includes an additional section, which is illustrated in figure 4.15, showing the responder types that are assigned to an emergency situation. Each picture symbolizes a responder type (police, firefighter and ambulance, respectively).

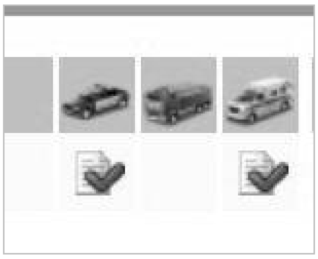

Figure 4.15 Responder Types Assigned to an Emergency Situation

If the assigned responders complete their efforts and inform the region department about that; red checkmarks turn to green. If all the red checkmarks turn to green, the reports are moved to the ñcompleted messagesò section automatically.

The ñEditò section is specific for the admin user and provides management department to change the responsible region department for the reporting which is automatically assigned by the processing software.

The ñSettingsò section is also specific for the admin user and enables the management department to organize and see the inventory about the region departments. It also provides adding new regions or deleting them from the system. Figure 4.16 and Figure 4.17 show the screen about the settings section.

Counties	Inventory
AKYURT	edit
ALTINDAĞ	edit
AYAŞ	edit
BALA	edit
BEYPAZARI	edit
ÇAMLIDERE	edit
ÇANKAYA	edit
ÇUBUK	edit

Figure 4.16 Settings of Counties

Inventory				
TOTAL	21	10	15	
AKYURT	4	2	3	edit
ALTINDAĞ	4	2	3	edit
AYAŞ	0	0	0	edit
BALA	0	0	0	edit
BEYPAZARI	0	0	0	edit
ÇAMLIDERE	0	0	0	edit
ÇANKAYA	10	2	4	edit
ÇUBUK	0	0	0	edit

Figure 4.17 Settings of Inventory

When a reporting is viewed in detail by three of the users some sections are the same for them. However some of them are specific. All three users are allowed to see the reporting time, emergency type, details if created by the reporter, longitude and latitude data and weather condition of the day and night, indepent of the reporting time. Users are also allowed to see the weather condition forecast for three days duration. (Figure 3 in the Appendix). Video, voice and image data are shown together in the page, if they exist. If there is an image related to the emergency situation, it provides the user to zoom in the picture from 3 up to 10 levels (Figure 4 in the Appendix) which provides the user to see the details about the picture. A digital map provided by Google Inc. shows the location of emergency situation according to acquired latitude and longitude. A marker is located on the map showing the address information inside a bubble. The digital map is loaded in street view type which shows the street and road names but it can be switched to satellite view which enables the user to see the structures on the map in addition to the street view. The digital map has the zoom in and out capabilities.

For all three users it is allowed to see which responder teams are assigned for the emergency situation. For only the region department, it is allowed to assign additional responder teams for the emergency situation. In this page, only the responders inform the region department about the completed intervention effort. Viewing the reports provides both same and different sections according to the user logged in (Figure 5, 6, 7 in the Appendix).

4.3. Experiments Performed Using the Prototype

In order to show the applicability of the prototype implementation, an experimental case study is carried out. With this study, it is aimed to show the advantage of the prototype implementation compared to the traditional emergency reporting tasks. It is also aimed to show the comparative advantages of different implementation modules.

Experimental case study includes 15 participants. 8 of the participants are selected among people who use traditional cell phones and 7 of them are selected among people using smart phones in daily life. The participants go through a simulated suspicious packet reporting in two ways for the same suspicious packet event. The first way is reporting of a suspicious packet by using the traditional call center approach, and the second one is reporting of the same suspicious packet by using the CerAndroid mobile application.

For the reporting of the suspicious packet in the traditional manner, there are two groups of call center staff. The first group is called as experienced expert which consists of staffs who have experience of being a call center staff for more than 10 years and who know about locations of Ankara (Turkey) well. The second group is called as inexperienced experts group which consists of the staffs who have minor experience of being a call center staff less for than 2 years and knows little about locations of Ankara.

Expert groups and participant groups are matched against each other for the reporting of the suspicious packet in the traditional manner. The match-ups are formed as follows:

Smart phone user (4 users) ź Experienced expert

Smart phone user (3 users) ź Inexperienced expert

Traditional cell phone user (4 users) ź Experienced expert

Traditional cell phone user (4 users) ź Inexperienced expert

For both reporting types, three different types of locations are determined for simulating the reporting tasks. The first type of location is called as ñknown placeò which refers to a location that the participant knows the address information of by heart and can transmit it to somebody spontaneously. The second type of location is called as ñsemi-known placeò which refers to a location that the participant does not know the address information of by heart, but can transmit it by asking somebody about the address, finding a street sign about the location, or telling about a well-known nearby structure such as a shopping mall or trade center. The last type of location is called as ñunknown placeò which refers to a location that the participant does not know anything about, and there is nobody to ask about the address or no easily recognizable unique structure. For the ñunknown placeò type, the only way for expressing the location information is by depicting the roads passed or describing the structures around the area.

According to the Turkish Statistical Institute (TSI), Ankara is located over a 25.437 km^2 area in terms of square measure ("Turkey in statistics," 2011). The three different types of locations are determined for each participant according to their knowledge about locations of Ankara. For the ñknown placeò, home or work addresses of participants are chosen. In each type of location (known, semi-known and unknown) either of the two types of suspicious packets are located somewhere at that location. After that, the participant is asked to call the matched expert in order to simulate a suspicious packet reporting. By analyzing the conversation between the participant and the expert, information about the call including the description of the packet, the place of the packet, accuracy of the location and call time are recorded.

For each of the location and suspicious packet, participants are asked for making the same reporting by using the CerAndroid application. For each suspicious packet reporting, participants use different modules of application in terms of determination of location and finishing the reporting. In the end, one participant makes nine different reportings for the same suspicious packet and twenty seven different reportings in three location types (Table 1 in Appendix). The results of the reporting are stored at www.onurceran.com website.

After all the results are acquired, the differences between traditional emergency reporting task and reporting via using CerAndroid are compared. Different modules of the CerAndroid application are also compared in order to show the applicability and comparative advantages of them against each other.

4.3.1. Analyses on Experiment of the Prototype

Analyses of the experiments are grouped into 5 different heading which are ñKnown Place Analysisò, ñSemi-Known Place Analysisò, ñUnknown Place Analysisò, ñQuality of Information Analysisò and ñComment Analysisò.

4.3.1.1 Known-Place Analysis

According to descriptive statistics the table created according to ñKnown-Placeò attributes is given in table 4.1;

Table 4.1: Descriptive Statistics Table of Known Place

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
User	15	18.00	1.00	19.00	9.9333	6.19293	38.352	.037	.580	-1.515	1.121
expert	15	1	1	2	1.47	.516	.267	.149	.580	-2.308	1.121
phone_status	15	1	1	2	1.53	.516	.267	-.149	.580	-2.308	1.121
Place	15	0	1	1	1.00	.000	.000	.	.	.	.
traditional	15	56	29	85	52.73	15.378	236.495	.289	.580	-.001	1.121
by_Map_No_comment	15	103	32	135	80.93	33.433	1.118E3	.269	.580	-.949	1.121
by_GPS_No_comment	15	145	23	168	52.00	38.049	1.448E3	2.501	.580	6.370	1.121
Predefined_No_comment	15	36	14	50	28.00	10.275	105.571	1.059	.580	.546	1.121
by_Map_write_comment	15	42	25	67	38.07	12.384	153.352	1.052	.580	.399	1.121
by_GPS_write_comment	15	23	22	45	29.20	6.657	44.314	.985	.580	.535	1.121
Predefined_write_ commant	14	22	13	35	21.43	6.060	36.725	.734	.597	.766	1.154
by_Map_voice_comment	15	93	21	114	41.53	26.354	694.552	1.991	.580	3.741	1.121
by_GPS_voice_comment	15	26	18	44	26.93	7.941	63.067	.956	.580	.244	1.121
Predefined_voice_ comment	15	21	14	35	22.13	5.604	31.410	1.441	.580	2.085	1.121
By_Map	15	65.33	27.00	92.33	53.5111	18.19378	331.014	.511	.580	-.046	1.121
By_GPS	15	54.00	22.67	76.67	36.0444	14.85211	220.585	1.823	.580	3.184	1.121
Predefined	14	25.00	13.67	38.67	24.0476	6.13364	37.621	.895	.597	1.651	1.154
Valid N (listwise)	14										

For results of number of the participants (N) = 15; it is determined for traditional reporting task that the elapsed time differs between 29 seconds (s) and 85 s.; the range is calculated as 56 s and mean value is determined as 52.73 s. The variance value of reporting time is determined as 236.494 and standard deviation is calculated as 15.378.

The analysis of data acquired from traditional reporting by comparing expertise types is described in table 4.2;

Table 4.2 Group Statistics According to Expert Type

	expert	N	Mean	Std. Deviation	Std. Error Mean
traditional	Experienced	8	46.12	13.174	4.658
	Inexperienced	7	60.29	14.986	5.664

The reporting calls of N_1 = 8 are responded by an experienced expert and N_2=7 are responded by an inexperienced expert. According to the analysis on the reporting times of experienced or inexperienced experts, the mean value of reporting call time for experienced experts are calculated as 46.12 s and 60.29 s for inexperienced experts.

According to the analysis for determining whether there is a difference between reporting call times of experienced and inexperienced experts; two hypotheses are created:

Null hypothesis (H_0) = There is no difference between reporting time of experts according to their experience level.

Alternative hypothesis (H_a) = There is difference between reporting time of experts according to their experience level.

Table 4.3: Independent Sample Test According to Experience level of Experts

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
traditional	Equal variances assumed	,031	,863	-1,949	13	,073	-14,161	7,266	-29,858	1,537
	Equal variances not assumed			-1,931	12,111	,077	-14,161	7,333	-30,122	1,801

According to inpependent sample test decribed in table 4.3 for 2 hypothesis;

Since probability value (p) =0.073 > error margin (Ŭ) = 0.05, the hypothesis cannot be refuted. It means that; for reporting about known places, there is no statistical difference between reporting times of experts according to their experience level.

Because it is analyzed that there is no importance of being experienced or inexperienced expert in the event of a reporting for a known place, the comparison can be made between traditional reporting and reporting by CerAndroid application.

First, the traditional reporting is compared with then CerAndroid application, in terms of reporting times, when determining location by map is used. It is not important to select any of finishing reporting types because the mean time value of three finishing reporting type are calculated. This approach provides both eliminating the effect of finishing reporting type and creating robust results.

The analysis of data acquired from traditional reporting and CerAndroid application when determining location by map is described in table 4.4;

Table 4.4: Paired Samples Statistics of Traditional Reporting and CerAndroid Application When Determining Location by Map

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	traditional	52.73	15	15.378	3.971
	By_Map	53.5111	15	18.19378	4.69761

The mean value of reporting call time for traditional reporting is calculated 52.73 s and 53.51 s for CerAndroid Application when determining location by map.

As part of the analysis for determining whether there is a difference between reporting call times of traditional type and CerAndroid Application when determining location by map; two hypotheses are created:

Null hypothesis (H_0) = There is no difference between reporting mean time of traditional type and CerAndroid Application when determining location by map.Alternative hypothesis (H_a) = There is difference between reporting mean time of traditional type and CerAndroid Application when determining location by map.

Table 4.5: Paired Sample Test Between Traditional Reporting And CerAndroid Application When Determining Location by Map

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	traditional - By_Map	-.77778	20.78754	5.36732	-12.28953	10.73398	-.145	14	.887

According to paired sample test decribed in table 4.5 for 2 hypothesis, since p =0.877 > Ŭ= 0.05, the hypothesis cannot be refuted. It means that; there is no difference between traditional reporting and CerAndroid application when determining location by map in terms of reporting mean times.

Similarly, traditional reporting is compared with CerAndroid application when determining location by GPS is used in terms of reporting times.The analysis of data acquired from traditional reporting and CerAndroid application when determining location by GPS is described in table 4.6;

Table 4.6: Paired Samples Statistics of Traditional Reporting and CerAndroid Application When Determining Location by GPS

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	traditional	52.73	15	15.378	3.971
	By_GPS	36.0444	15	14.85211	3.83480

The mean value of reporting call time for traditional reporting is calculated as 52.73 s and 36.04 s for CerAndroid Application when determining location by GPS.

As part of the analysis for determining whether there is a difference between reporting call times of traditional type and CerAndroid Application when determining location by GPS; two hypotheses are created:

Null hypothesis (H_0) = There is no difference between reporting mean time of traditional type and CerAndroid Application when determining location by GPS.

Alternative hypothesis (H_a) = There is difference between reporting mean time of traditional type and CerAndroid Application when determining location by GPS.

Table 4.7: Paired Sample Test Between Traditional Reporting And CerAndroid Application When Determining Location by GPS

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	traditional - By_GPS	16.68889	21.68514	5.59908	4.68006	28.69772	2.981	14	.010

According to paired sample test decribed in table 4.7 for 2 hypothesis;

Since p =0.010 < Ŭ = 0.05, the hypothesis is refuted. It means that; there is a significant difference between traditional reporting and CerAndroid application when determining location by GPS in terms of reporting mean times. It takes shorter amount of time to report by using CerAndroid application when determining location by GPS than the traditional type.

Lastly, traditional reporting is compared with CerAndroid application, in terms of reporting times, when determining location by pre-defined records is used.

The analysis of data acquired from traditional reporting and CerAndroid application when determining location by pre-defined records is given in table 4.8;

Table 4.8: Paired Samples Statistics of Traditional Reporting and CerAndroid Application When Determining Location by pre-defined records

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	traditional	54.07	14	15.025	4.016
	Predefined	24.0476	14	6.13364	1.63928

The mean value of reporting call time for traditional reporting is calculated as 54.07 s and 24.04 s for CerAndroid Application when determining location by pre-defined records

As part of the analysis for determining whether there is a difference between reporting call times of traditional type and CerAndroid Application when determining location by pre-defined records; two hypotheses are created:

Null hypothesis (H_0) = There is no difference between reporting mean time of traditional type and CerAndroid Application when determining location by pre-defined records.

Alternative hypothesis (H_a) = There is difference between reporting mean time of traditional type and CerAndroid Application when determining location by pre-defined records.

Table 4.9: Paired Sample Test Between Traditional Reporting And CerAndroid Application When Determining Location by pre-defined records

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			

Table 4.9 (continued)

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	traditional - Predefined	30.02381	15.42751	4.12317	21.11623	38.93139	7.282	13	.000

According to paired sample test decribed in table 4.9 for 2 hypothesis;

Since p =0.000 < Ŭ = 0.05, the hypothesis is refuted. It means that; there is a significant difference between traditional reporting and CerAndroid application when determining location by pre-defined records in terms of reporting mean times. Reporting by using CerAndroid application when determining location by pre-defined records is faster than the traditional type.

4.3.1.1. Semi-known Place Analysis

According to descriptive statistics table created according to ñSemi-known Placeò attributes described in table 4.10;

For results of N = 14; it is determined for traditional reporting task that the elapsed time differs between 118 s and 226 s. The range is calculated as 108 s and mean value is determined as 161.50 s. The variance value of reporting time is determined as 939.962 and standard deviation is calculated as 30.659.

Table 4.10: Descriptive Statistics Table of Semi-known Place

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
User	15	18,00	1,00	19,00	9,9333	6,19293	38,352	,037	,580	-1,515	1,121
expert	15	1	1	2	1,47	,516	,267	,149	,580	-2,308	1,121
phone_status	15	1	1	2	1,53	,516	,267	-,149	,580	-2,308	1,121
Place	15	0	2	2	2,00	,000	,000	.	.	.	.
traditional	14	108	118	226	161,50	30,659	939,962	1,064	,597	,460	1,154
by_Map_No_comment	14	134	33	167	77,93	44,437	1,975E3	1,097	,597	,050	1,154
by_GPS_No_comment	14	23	26	49	34,57	8,455	71,495	,616	,597	-1,170	1,154
Predefined_No_comment	12	59	16	75	28,00	16,954	287,455	2,242	,637	5,518	1,232
by_Map_write_comment	14	63	19	82	42,71	17,895	320,220	,748	,597	,228	1,154
by_GPS_write_comment	14	48	18	66	30,57	14,648	214,571	1,719	,597	2,040	1,154
Predefined_write_ commant	14	38	11	49	19,93	10,521	110,687	2,211	,597	4,490	1,154
by_Map_voice_comment	14	36	18	54	30,36	11,167	124,709	1,136	,597	,307	1,154
by_GPS_voice_comment	14	36	17	53	28,57	9,693	93,956	1,158	,597	1,910	1,154
Predefined_voice_ comment	14	26	12	38	19,50	6,607	43,654	1,777	,597	4,202	1,154
By_Map	14	66,33	27,00	93,33	50,3333	22,40536	502,000	,945	,597	-,121	1,154
By_GPS	14	33,33	20,67	54,00	31,2381	9,53216	90,862	1,339	,597	1,131	1,154
Predefined	12	31,00	13,67	44,67	21,9444	9,67224	93,552	1,711	,637	2,175	1,232
Valid N (listwise)	12										

The analysis of data acquired from traditional reporting by comparing expertise types is described in table 4.11;

Table 4.11 Group Statistics According to Expert Type

	expert	N	Mean	Std. Deviation	Std. Error Mean
traditional	Experienced	7	159.00	29.103	11.000
	Inexperienced	7	164.00	34.278	12.956

The reporting calls of $N_1 = 7$ are responded by experienced experts and $N_2=7$ are responded by inexperienced experts. According to the analysis on the reporting times of experienced or inexperienced experts, the mean value of reporting call time for experienced experts are calculated as 159 s and 164 s for inexperienced expert.

As part of the analysis for determining whether there is a difference between reporting call times of experienced and inexperienced experts; two hypotheses are created:

Null hypothesis (H_0) = There is no difference between reporting time of experts according to their experience level.

Alternative hypothesis (H_a) = There is difference between reporting time of experts according to their experience level.

Table 4.12: Independent Sample Test According to Experience level of Experts

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
traditional	Equal variances assumed	.705	.418	-.294	12	.774	-5.000	16.996	-42.031	32.031
	Equal variances not assumed			-.294	11.692	.774	-5.000	16.996	-42.139	32.139

According to inpependent sample test decribed in table 4.12 for 2 hypothesis;

Since probability value p =0.774 > error margin Ŭ = 0.05, the hypothesis cannot be refuted. It means that; for reporting about known places, there is no statistical difference between reporting times of experts according to their experience level.

Because it is analyzed that there is no importance of being experienced or inexperienced expert in the event of a reporting for a known place, the comparison can be made between traditional reporting and reporting by CerAndroid application.

First, traditional reporting is compared with CerAndroid application when determining location by map is used in terms of reporting times. It is not important to select any of finishing reporting types because the mean time value of three finishing reporting type are calculated. This approach provides both eliminating the effect of finishing reporting type and creating robust results.

The analysis of data acquired from traditional reporting and CerAndroid application when determining location by map is described in table 4.13;

Table 4.13: Paired Samples Statistics of Traditional Reporting and CerAndroid Application When Determining Location by Map

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	traditional	161.50	14	30.659	8.194
	By_Map	50.3333	14	22.40536	5.98808

The mean value of reporting call time for traditional reporting is calculated as 161.50 s and 50.333 s for CerAndroid Application when determining location by map.

As part of the analysis for determining whether there is a difference between reporting call times of traditional type and CerAndroid Application when determining location by map; two hypotheses are created:

Null hypothesis (H_0) = There is no difference between reporting mean time of traditional type and CerAndroid Application when determining location by map.

Alternative hypothesis (H_a) = There is difference between reporting mean time of traditional type and CerAndroid Application when determining location by map.

Table 4.14: Paired Sample Test Between Traditional Reporting And CerAndroid Application When Determining Location by Map

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper			
Pair 1 traditional - By_Map	111.16667	33.71316	9.01022	91.70127	130.63206	12.338	13	.000

According to paired sample test decribed in table 4.14 for 2 hypothesis, since p =0.000 < Ŭ = 0.05, the hypothesis is refuted. It means that; there is a significant difference between traditional reporting and CerAndroid application when determining location by map in terms of reporting mean times.

Similarly, traditional reporting is compared with CerAndroid application when determining location by GPS is used in terms of reporting times.

According to analysis of data acquired from traditional reporting and CerAndroid application when determining location by GPS which is described in table 4.15;

Table 4.15: Paired Samples Statistics of Traditional Reporting and CerAndroid Application When Determining Location by GPS

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	traditional	161.50	14	30.659	8.194
	By_GPS	31.2381	14	9.53216	2.54758

The mean value of reporting call time for traditional reporting is calculated as 161.50 s and 31.23 s for CerAndroid Application when determining location by GPS.

As part of the analysis for determining whether there is a difference between reporting call times of traditional type and CerAndroid Application when determining location by GPS; two hypotheses are created:

Null hypothesis (H_0) = There is no difference between reporting mean time of traditional type and CerAndroid Application when determining location by GPS

Alternative hypothesis (H_a) = There is difference between reporting mean time of traditional type and CerAndroid Application when determining location by GPS.

Table 4.16: Paired Sample Test Between Traditional Reporting And CerAndroid Application When Determining Location by GPS

		Paired Differences				t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	traditional - By_GPS	130.26190	31.77409	8.49198	111.91609	148.60772	15.339	13	.000

According to paired sample test decribed in table 4.16 for 2 hypothesis;

Since p =0.000 < Ǔ = 0.05, the hypothesis is refuted. It means that; there is a significant difference between traditional reporting and CerAndroid application when determining location by GPS in terms of reporting mean times. It takes shorter amount of time to report by using CerAndroid application when determining location by GPS than traditional type.

Lastly, traditional reporting is compared with CerAndroid application when determining location by pre-defined records is used in terms of reporting times.

The analysis of data acquired from traditional reporting and CerAndroid application when determining location by pre-defined records is described in table 4.17;

Table 4.17: Paired Samples Statistics of Traditional Reporting and CerAndroid Application When Determining Location by pre-defined records

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	traditional	161.50	14	30.659	8.194
	Predefined	22.3095	14	9.11790	2.43686

The mean value of reporting call time for traditional reporting is calculated as 161.50 s and 22.30 s for CerAndroid Application when determining location by pre-defined records.

As part of the analysis for determining whether there is a difference between reporting call times of traditional type and CerAndroid Application when determining location by pre-defined records; two hypotheses are created:

Null hypothesis (H_0) = There is no difference between reporting mean time of traditional type and CerAndroid Application when determining location by pre-defined records.

Alternative hypothesis (H_a) = There is difference between reporting mean time of traditional type and CerAndroid Application when determining location by pre-defined records.

Table 4.18: Paired Sample Test Between Traditional Reporting And CerAndroid Application When Determining Location by pre-defined records

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	traditional - Predefined	139.1904	29.17226	7.79661	122.34691	156.03404	17.853	13	.000

According to paired sample test decribed in table 4.18 for 2 hypothesis;

Since p =0.000 < Ǔ = 0.05, the hypothesis is refuted. It means that; there is a significant difference between traditional reporting and CerAndroid application when determining location by pre-defined records in terms of reporting mean times. Reporting by using CerAndroid application when determining location by pre-defined records works faster than traditional type.

4.3.1.2. Unknown Place Analysis

Descriptive statistics table created according to ñUnknown Placeò attributes is described in table 4.19;

Table 4.19: Descriptive Statistics Table of Unknown Place

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
User	15	18,00	1,00	19,00	9,9333	6,19293	38,352	,037	,580	-1,515	1,121
expert	15	1	1	2	1,47	,516	,267	,149	,580	-2,308	1,121
phone_status	15	1	1	2	1,53	,516	,267	-,149	,580	-2,308	1,121
Place	15	0	3	3	3,00	,000	,000	.	.	.	.
traditional	15	424	163	587	327,40	118,802	14113,829	,801	,580	,236	1,121
by_Map_No_comment	14	244	19	263	85,21	59,440	3533,104	2,147	,597	6,320	1,154
by_GPS_No_comment	15	70	19	89	42,67	16,220	263,095	1,499	,580	4,335	1,121
Predefined_No_comment	15	27	13	40	20,93	7,421	55,067	1,489	,580	1,843	1,121
by_Map_write_comment	15	183	15	198	46,60	49,166	2417,257	2,532	,580	6,629	1,121
by_GPS_write_comment	15	18	18	36	26,93	5,910	34,924	-,048	,580	-1,286	1,121
Predefined_write_commant	15	29	12	41	19,07	7,977	63,638	1,751	,580	3,084	1,121
by_Map_voice_comment	15	37	16	53	28,33	9,700	94,095	1,143	,580	1,747	1,121
by_GPS_voice_comment	15	24	17	41	24,87	5,963	35,552	1,418	,580	2,760	1,121
Predefined_voice_comment	15	26	11	37	19,20	7,599	57,743	1,271	,580	1,126	1,121
By_Map	15	94,67	23,67	118,33	52,0667	30,51286	931,035	1,340	,580	,946	1,121
By_GPS	15	33,67	20,00	53,67	31,4889	8,09749	65,569	1,302	,580	3,287	1,121
Predefined	15	23,00	12,00	35,00	19,7333	6,83386	46,702	1,272	,580	,716	1,121
Valid N (listwise)	14										

For results of N = 15; it is determined for traditional reporting task that the elapsed time differs between 163 s and 587 s. The range is calculated as 424 s and mean value is determined as 327.40 s. The variance value of reporting time is determined as 14113.8 and standard deviation is calculated as 118.8.

As part of the analysis of data acquired from traditional reporting by comparing expertise types (table 2, 3 in the Appendix);

Two hypotheses are created to determine whether there is a difference between expert types according to experience level for acquiring accurate address of emergency situation:

Null hypothesis (H_0) = There is no difference between expert types according to experience level for acquiring accurate address information of emergency situation.

Alternative hypothesis (H_a) = There is difference between expert types according to experience level for acquiring accurate address information of emergency situation.

Table 4.20: Chi-Square Tests for Unknown Location

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.964[a]	2	.031
Likelihood Ratio	9.270	2	.010
Linear-by-Linear Association	1.049	1	.306
N of Valid Cases	15		

a. 6 cells (100,0%) have expected count less than 5. The minimum expected count is, 47.

When the chi-square test illustrated in table 4.20 is examined; since 6 cells (100,0%) have expected count less than 5, likelihood ratio is used for analysis. Hypothesis is refuted because of the equation of $p = 0.010 <$ Ŭ = 0.05. it means that the expereince level affects determining location of the emergency address information and its accuracy. Experienced expert determines address information of emergency situation accurately. However, inexperienced expert has difficulty for determining address information and address information is not determined accurately.

According to measurements, %62.5 percent of address information is determined exactly and %37.5 percent of the address information is determined approximately by experienced expert. Although there is no experienced expert who cannot determine any of address information, %14.3 percent of address information cannot be determined by inexperienced experts. Inexperienced experts determine %85.7 percent of address information approximately but the number of address information determined exactly is 0.

So, it is not applicable to compare elapsed times of traditional type of reporting according to experience level of experts.

When the CerAndroid application is examined in terms of accuracy of determined location by using map or GPS module for emergency situation reporting; it is shown that determining address for unknown location case by using map module provides mean value of 511 meters for accuracy. The calculation is made by using median methodology since arithmetic mean methodology is affected by the edge values excessively. Table 4.21 illustrates the measured values of distances between actual and determined locations. Distances between actual locations and measured values acquired by CerAndroid application by using GPS module are not measured, universal consent values are accepted.

Table 4.21: Distance and Median Values

Distances to Actual Locations										
511	54	934	1965	243	7081	552	122	383	164	1991
Median of Measured Distances										511 m

Federal Communications Commission (FCC) which is an U.S. government agency regulating interstate and international communications by radio, television, wire, satellite and cable ("Wireless 911 services," 2012) obligates wireless service providers to determine location information of 911 callers in an accuracy level of 50 to 300 meter in order to improve public safety efforts.

For Turkey, where the experiment of the prototype is made, there is not an obligation or enforcement of low created for wireless service providers to provide location information within a level. However, 511 meters of accuracy level provided by CerAndroid application using map module provides an approximate value close to the FCC rules.

Despite the fact that there is a difference on determining location information between expert types, when comparing traditional reporting effort with reporting by using CerAndroid application in terms of elapsed time, the results are provided.

At first, traditional reporting is compared with CerAndroid application when determining location by map is used in terms of reporting times. It is not important to select any of finishing reporting types because the mean time value of three finishing reporting type are calculated. This approach provides both eliminating the effect of finishing reporting type and creating robust results.

The analysis of data acquired from traditional reporting and CerAndroid application when determining location by map is described in table 4.22;

Table 4.22: Paired Samples Statistics of Traditional Reporting and CerAndroid Application When Determining Location by Map

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	traditional	327.40	15	118.802	30.674
	By_Map	52.0667	15	30.51286	7.87839

The mean value of reporting call time for traditional reporting is calculated 327.40 s and 52.06 s for CerAndroid Application when determining location by map.

As part of the analysis for determining whether there is a difference between reporting call times of traditional type and CerAndroid Application when determining location by map; two hypotheses are created:

Null hypothesis (H_0) = There is no difference between reporting mean time of traditional type and CerAndroid Application when determining location by map.

Alternative hypothesis (H_a) = There is difference between reporting mean time of traditional type and CerAndroid Application when determining location by map.

Table 4.23: Paired Sample Test Between Traditional Reporting And CerAndroid Application When Determining Location by Map

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper			
Pair 1 traditional - By_Map	275.33333	114.09902	29.46024	212.14740	338.51927	9.346	14	.000

According to paired sample test decribed in table 4.23 for 2 hypothesis;

Since p =0.000 < Ŭ= 0.05; the hypothesis is refuted. It means that; there is significant difference between traditional reporting and CerAndroid application when determining location by map in terms of reporting mean times.

Similarly, traditional reporting is compared with CerAndroid application when determining location by GPS is used in terms of reporting times.

The analysis of data acquired from traditional reporting and CerAndroid application when determining location by GPS is described in table 4.24;

Table 4.24: Paired Samples Statistics of Traditional Reporting and CerAndroid Application When Determining Location by GPS

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	traditional	327.40	15	118.802	30.674
	By_GPS	31.4889	15	8.09749	2.09076

The mean value of reporting call time for traditional reporting is calculated as 327.40 s and 31.48 s for CerAndroid Application when determining location by GPS.

As part of the analysis for determining whether there is a difference between reporting call times of traditional type and CerAndroid Application when determining location by GPS; two hypotheses are created:

Null hypothesis (H_0) = There is no difference between reporting mean time of traditional type and CerAndroid Application when determining location by GPS

Alternative hypothesis (H_a) = There is difference between reporting mean time of traditional type and CerAndroid Application when determining location by GPS.

Table 4.25: Paired Sample Test Between Traditional Reporting And CerAndroid Application When Determining Location by GPS

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper			
Pair 1 traditional - By_GPS	295.91111	116.37484	30.04785	231.46487	360.35735	9.848	14	.000

According to paired sample test decribed in table 4.25 for 2 hypothesis;

Since p =0.000 < Ŭ = 0.05, the hypothesis is refuted. It means that; there is a significant difference between traditional reporting and CerAndroid application when determining location by GPS in terms of reporting mean times. It takes shorter amount of time to report by using CerAndroid application when determining location by GPS than traditional type.

4.3.1.3. Quality of the Information Analysis

For suspicious packet emergency situation, CerAndroid application provides acquiring additional information about the packet. The information is categorized into two varieties: First variety is called as ñPacket descriptionò which is about describing the suspicious packet in terms of appearance and visible property. Second variety is called as ñplace of the packetò which is about describing where the packet is specifically located at the related address.

For the experiment case, two types of suspicious looking packets are prepared. First packet is about 30 cm x 30 cm in size and there are some cables covering the packet. Second packet is about 15 cm x 25 cm in size and there is a cell phone attached to the packet. (Figure 8 in Appendix).

For analysis, information quality about packet description is graded with 3 degrees. According to recorded information about reporting cases of participants, information qualities of their packet descriptions are graded. If the participant tells about suspicious packet describing both the size and visual property (cable covering the packet or cell phone attached to the packet) information quality of packet description is graded as ñexactò. If the participant tells about suspicious packet describing either the size or visual property, information quality of packet description is graded as ñhalfò. If the participant does not tell or expert does not ask for about describing the packet, information quality of packet description is graded as ñno descriptionò.

For analysis, information quality about place of the packet is also graded with 3 degrees. According to recorded information about reporting cases of participants, information qualities of their packet descriptions are graded. If the participant tells about place of the packet that provides responder to turn into a specific place or provides responder to decrease the possibilities in terms of finding the packet in shorter time (like ñunder the green carò or ñin front of the trash binò), information quality of place of the packet is graded ñexactò. If the participant does not tell about place of the packet or expert does not asks about it, information quality of place of the packet is graded as ñno descriptionò.

According to statistic tables created according to ñpacket descriptionò and ñplace of the packetò grades described in table 4.26 and 4.27;

Table 4.26: Grades for Packet Description

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No Description	19	42.2	43.2	43.2
	Exact	23	51.1	52.3	95.5
	Half	2	4.4	4.5	100.0
	Total	44	97.8	100.0	
Missing	System	1	2.2		
Total		45	100.0		

Table 4.27: Grades for Place of the Packet

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No Description	29	64.4	65.9	65.9
	Exact	15	33.3	34.1	100.0
	Total	44	97.8	100.0	
Missing	System	1	2.2		
Total		45	100.0		

% 51.1 percent of the packet is described exactly, %42.2 percent of them are not described at all and %33.3 percent of the place that the packet is located is described exactly, %64 of them are not described at all. Unlike traditional reporting, CerAndroid provides %100 percent of accuracy about describing both packet itself and place about it. This is provided by capturing a photo of the suspicious packet together with its place.

According to analysis of packet description grades related to location types acquired from traditional reporting described in table 4.28;

Table 4.28: Packet Description Grades Related to Location Types

Count

		Packet_description			Total
		No Description	Exact	Half	
Place	Known	4	9	2	15
	Semi Known	4	10	0	14
	Unknown	11	4	0	15
Total		19	23	2	44

Two hypotheses are created:

Null hypothesis (H_0) = There is no relationship between describing the suspicious packet and location type.

Alternative hypothesis (H_a) = There is a relationship between describing the suspicious packet and location type.

Table 4.29: Chi-Square Test Related with Location type and Packet Description

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.700[a]	4	.020
Likelihood Ratio	12.137	4	.016
Linear-by-Linear Association	8.045	1	.005
N of Valid Cases	44		

a. 3 cells (33.3%) have expected count less than 5. The minimum expected count is .64.

According to chi-square test decribed in table 4.29 for 2 hypothesis;

Since p =0.016 < Ŭ = 0.05, the hypothesis is refuted. It means that; there is a relationship between describing the suspicious packet and location type. (Likelihood Ratio is used because 3 cells (33,3%) have expected count less than 5 and the minimum expected count is 64)

The analysis of place of the packet grades related to location types acquired from traditional reporting is described in table 4.30;

Table 4.30: Place of the Packet Grades Related to Location Types

Count

		Place_of_packet		
		No Description	Exact	Total
Place	Known	7	8	15
	Semi Known	8	6	14
	Unknown	14	1	15
Total		29	15	44

Two hypotheses are created:

Null hypothesis (H_0) = There is no relationship between having place of the packet information and location type.

Alternative hypothesis (H_a) = There is a relationship between having place of the packet information and location type.

Table 4.31: Chi-Square Test Related with Location type and Place of Packet

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.972[a]	2	.019
Likelihood Ratio	9,267	2	.010
Linear-by-Linear Association	7.104	1	.008
N of Valid Cases	44		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is 4.77.

According to chi-square test decribed in table 4.31; for 2 hypothesis;

Since p =0.010 < Ŭ = 0.05, the hypothesis is refuted. There is a relationship between having place of the packet information and location type. (Likelihood Ratio is used because 1 cell (16,7%) has expected count less than 5 and the minimum expected count is 4,77)

According to analyses for quality of information, it is determined that when address information gets closer for an unknown place, experts focus on determining the address information and they push aside getting information about packet description and place of the packet. In addition, many of the experts have no effort for getting this additional information.

Unlike traditional reporting, acquiring information about packet description or place of the packet is not dependent on the expert or reporter. By taking photos of the suspicious packets, which is asked from the reporter, provide responder to acquire both packet description and place of the packet information. For the experiment cases, all the photos of suspicious packets are acquired without any damage because of shaking of the hands or any other problem. So it is assumed that CerAndroid mobile application provides %100 success in terms of quality of information.

4.3.1.4. Comment Analysis

CerAndroid mobile application provides participants two different types of commenting options which are ñwritten commentò and ñvoice commentò. Commenting options are provided for the user to tell additional information about the emergency situation which is not acquired by the application optionally.

The analysis of data acquired from CerAndroid mobile application about mean times related to finishing the reporting by writing or recording voice is described in table 4.32;

Table 4.32: Paired Samples Statistics of Mean Time Related to Two Options of Finishing the Reporting

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	write_comment	30.5573	131	21.22885	1.85477
	voice_comment	26.8931	131	13.16771	1.15047

The mean value of elapsed time of reporting related to finishing task by writing is calculated as 30.55 s and 26.89 s for finishing task by recording voice.

As part of the analysis for determining whether there is a difference between elapsed times of reporting related to finishing the tasks by writing or recording; two hypotheses are created:

Null hypothesis (H_0) = There is no difference between reporting mean time of finishing task by writing and recording voice.

Alternative hypothesis (H_a) = There is difference between reporting time of finishing task by writing and recording voice.

Table 4.33 Paired Sample Test Between Reporting Mean Time of Writing and Recording Voice

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	write_comment - voice_comment	3.66412	19.00065	1.66009	.37982	6.94842	2.207	130	.029

According to paired sample test decribed in table 4.33 for 2 hypothesis;

Since p =0.029 < Ŭ = 0.05, the hypothesis is refuted. It means that; there is difference between reporting time of finishing task by writing and recording voice. Recording voice for finishing the reporting takes shorter of time than writing and it is more useful.

According to the analysis about content of the comments, it is determined that for both 131 voice and written comment records;

- 309 words and 1783 characters are used by writing comment. 878 words and 5240 characters are used by recording voice for comment.
- 8 of the 131 written comments and 18 of the 131 voice comments are not comprehensible.
- 20 of the 131 written comments and 31 of 131 voice comments include additional information.
- 44 of the 131 written comments and 75 of the 131 voice comments include the ñsuspicious packetò discourse which is unnecessary to indicate.
- 40 of the 131 written comments and 35 of the 131 voice comments include the ñbe quickò discourse which is also unnecessary to indicate.

CHAPTER 5

CONCLUSION

In this chapter conclusion of this thesis is provided. First, summary and contribution of the study are analyzed and then future work is described.

5.1. Summary

In this thesis, a context aware emergency management system framework using mobile computing is offered. The framework includes three main components which are user interface describing processes running on a smart mobile device, central processor processing raw data to create meaningful and useful information and management interface describing not only management of both hierarchical domains according to locations and tasks and flow of information but also usage of meaningful and useful information.

A real implementation based on the proposed framework is developed as a prototype. In the prototype, an Android based mobile application is developed for representing user interface component of the proposed system. The processing software represents the central processing component and web application represents the management interface component of proposed system.

In the event of an emergency situation, a person creates a report using the mobile application which provides determining location of emergency. The mobile application also supplies environmental data by using mobile device capabilities such as taking a picture or recording a video. All these data are sent to processing software to enable converting raw data into value-added information. This information is used in emergency management phases by all the management personnel.

5.2. Contribution and Discussion

The major contribution of this study is using a variety of sensing capabilities of smart mobile devices for reporting an emergency situation and helping first responders be aware of the situation more clearly and make better decisions about response activities.

The analyzes about comparison between traditional reporting and using CerAndroid System shows that CerAndroid mobile application enables a user to include more and accurate context as well as to report in shorter amount of time. Some of the information acquired by the CerAndroid mobile application in implementation cases may be forecasted or foreseen by the region department or responder personnel. For the fire warning case, the information about a forest located nearby the fire event which requires additional planning or intervening equipment may be forecasted or foreseen by the region department or responder personnel. But this forecast is only related to the knowledge of the personnel about the location. According to the analysis in the study; it is shown that the descriptions of a human, either a reporter or personnel, do not provide %100 percent of success.

This study is not the first in the literature using smart mobile devices for reporting an emergency situation for context aware emergency management. But it is the first study using smart mobile devices for reporting of an emergency situation which does not require direct involvement of PSAP personnel one-to-one, and works even if there is no internet connection.

The advantage of not requiring one-to-one PSAP personnel involvement is to decrease wait times for a reporting. It also helps shorten the time about planning and assigning a responder team which is longer for systems requiring one-to-one PSAP personnel, because of the delays caused by human originated reasons as indicated in problem and motivation section.

According to the results related to the collected data through the questionnaires from a group of participants, it is shown that the ratio for reaching an emergency service (police is the emergency service for the questionnaire) gets closer to %100 percent when the situation is somehow related with the user. In addition, a user wants to overcome the situation as soon as possible when it is related with him/her. That proves the applicability of recording locations to be predefined on the CerAndroid mobile application for use in reporting of an emergency event. According to the analysis, it is shown that reporting by using CerAndroid application when determining location by pre-defined records works better than the traditional approach.

For the experiment about suspicious packet reporting, it is shown that the application users are allowed to see their location on the digital map by street view appearance when they are to determine the location using the map. It is found out that allowing the user only to see the street view appearance of the map restricts his/her to determine the location by examining routing or cross-roads. Because of this, the expected value for accuracy of the location information for an emergency situation determined by FCC is exceeded.

It is determined that the experienced experts use geographical formations, well-known or specific constructions to determine a location. Allowing users to see their locations on the map by satellite view appearance, which provides the visualization of geographical formations and all the constructions, may help improve the accuracy level of determining a location by using the map.

5.3. Future Work

In this study, implicit and explicit data about an emergency situation are acquired and demonstrated for use in planning the emergency response tasks. The raw data are sent to the processing software to be converted into value-added information. As future work; in addition to raw data, value added information that cannot be acquired by the processing of the software can be acquired. The distance of a reporter to the emergency situation can be calculated. The size of an object in the captured image by the mobile application can be calculated. These types of information may improve the planning and response tasks.

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APPENDIX A: FIGURES

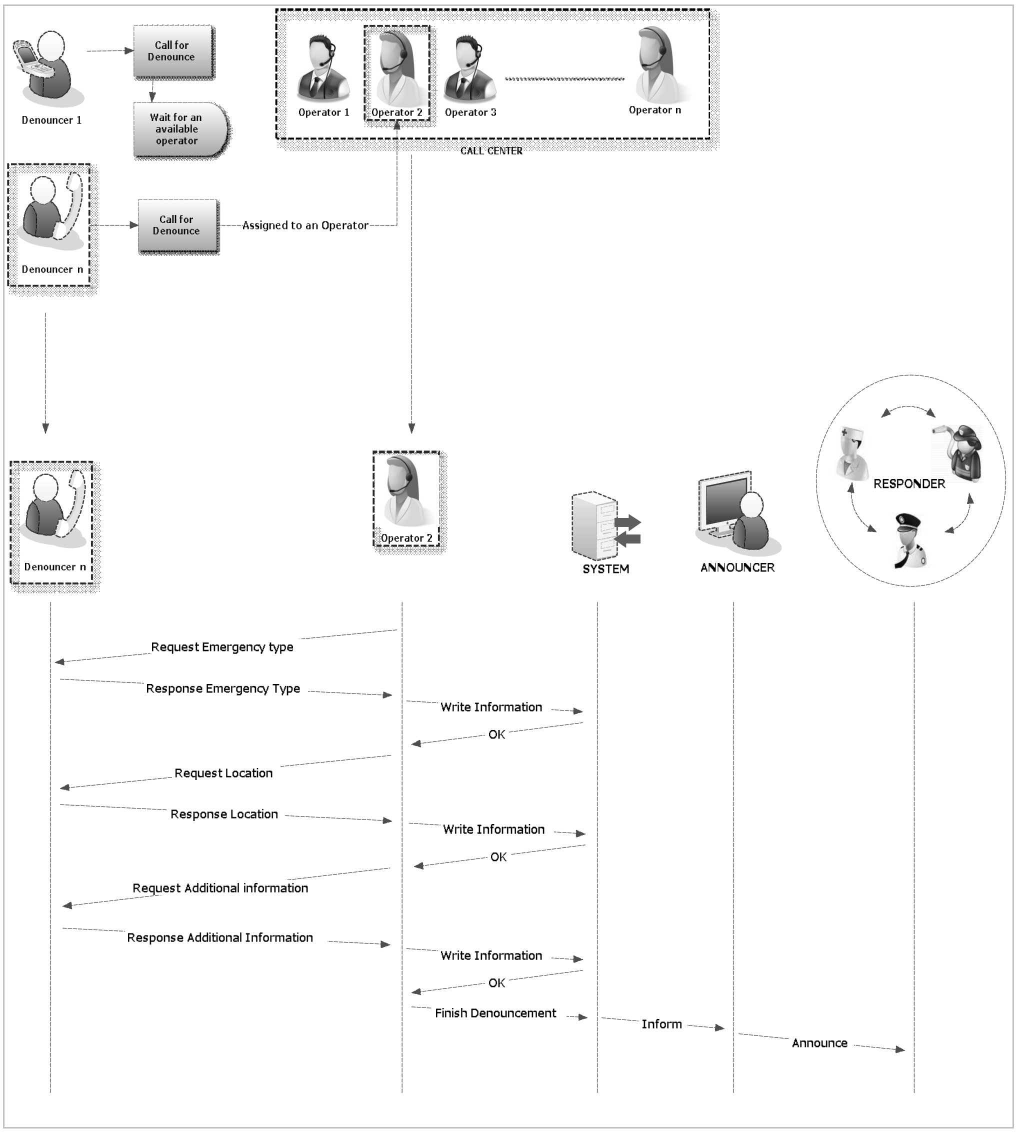


Figure 1: Traditional Call Center Working Order

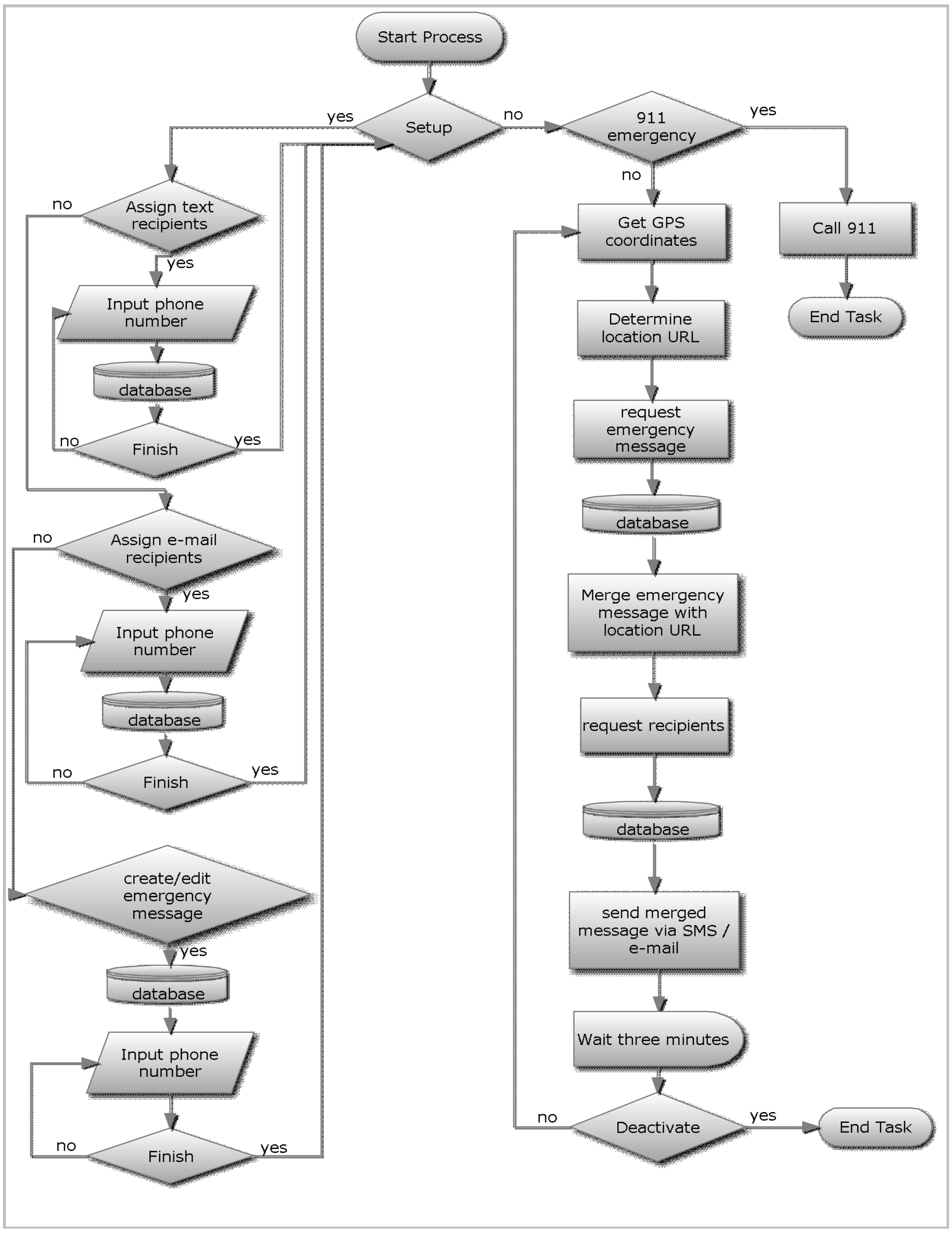


Figure 2: Activity Flow of MyFlare

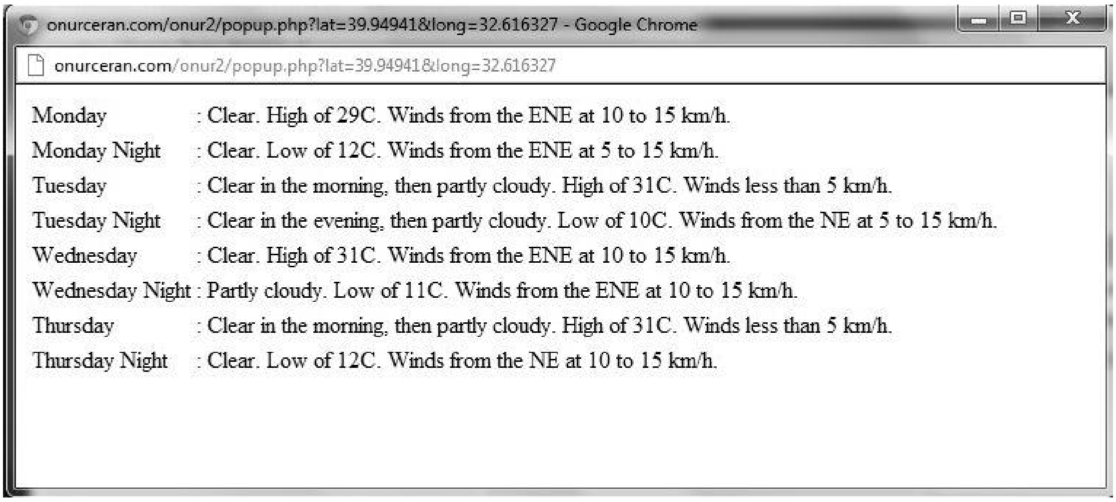
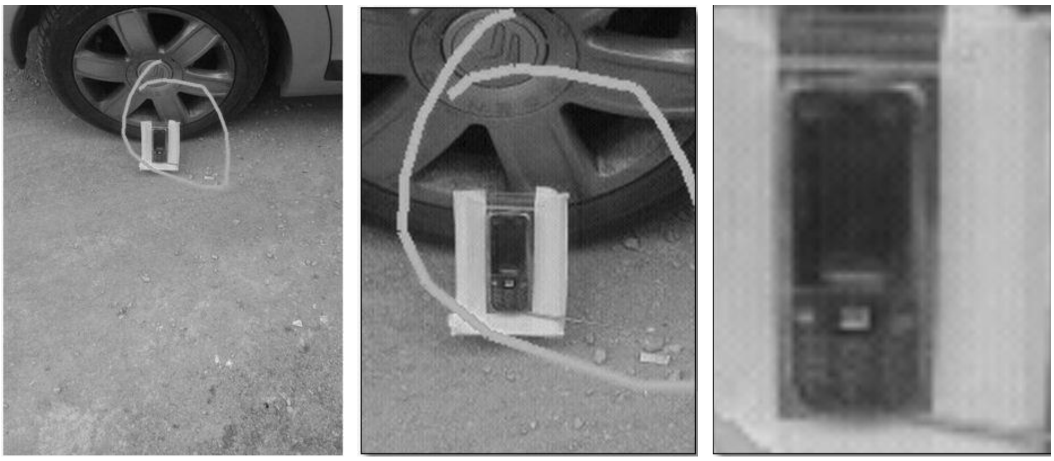


Figure 3: Screen of Forecast of the Weather



Level 0 Level 3 Level 10

Figure 4: Zoom Levels for Captured Image

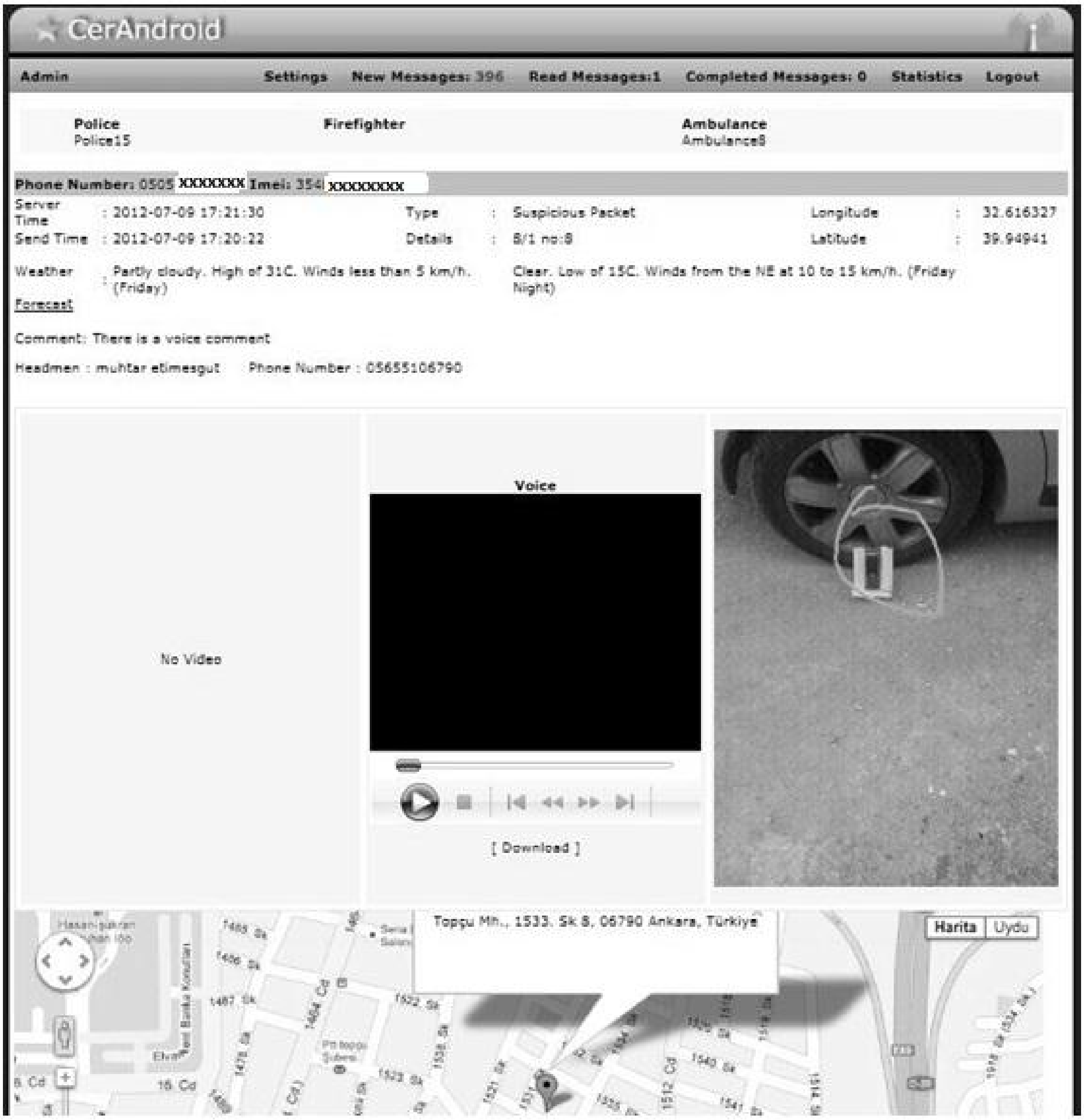


Figure 5: Detailed Reporting Screen of Admin

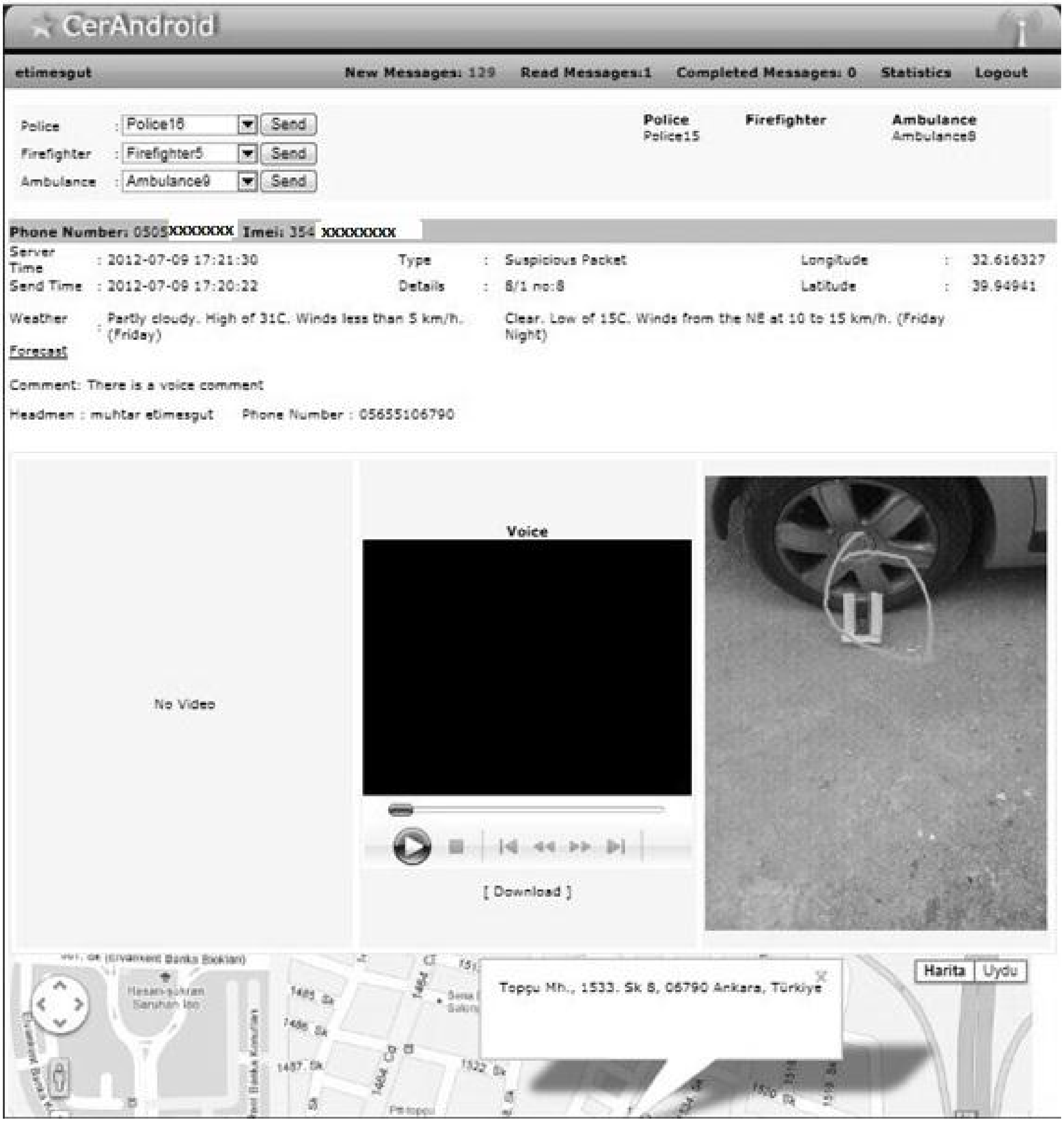


Figure 6: Detailed Reporting Screen of Region Department

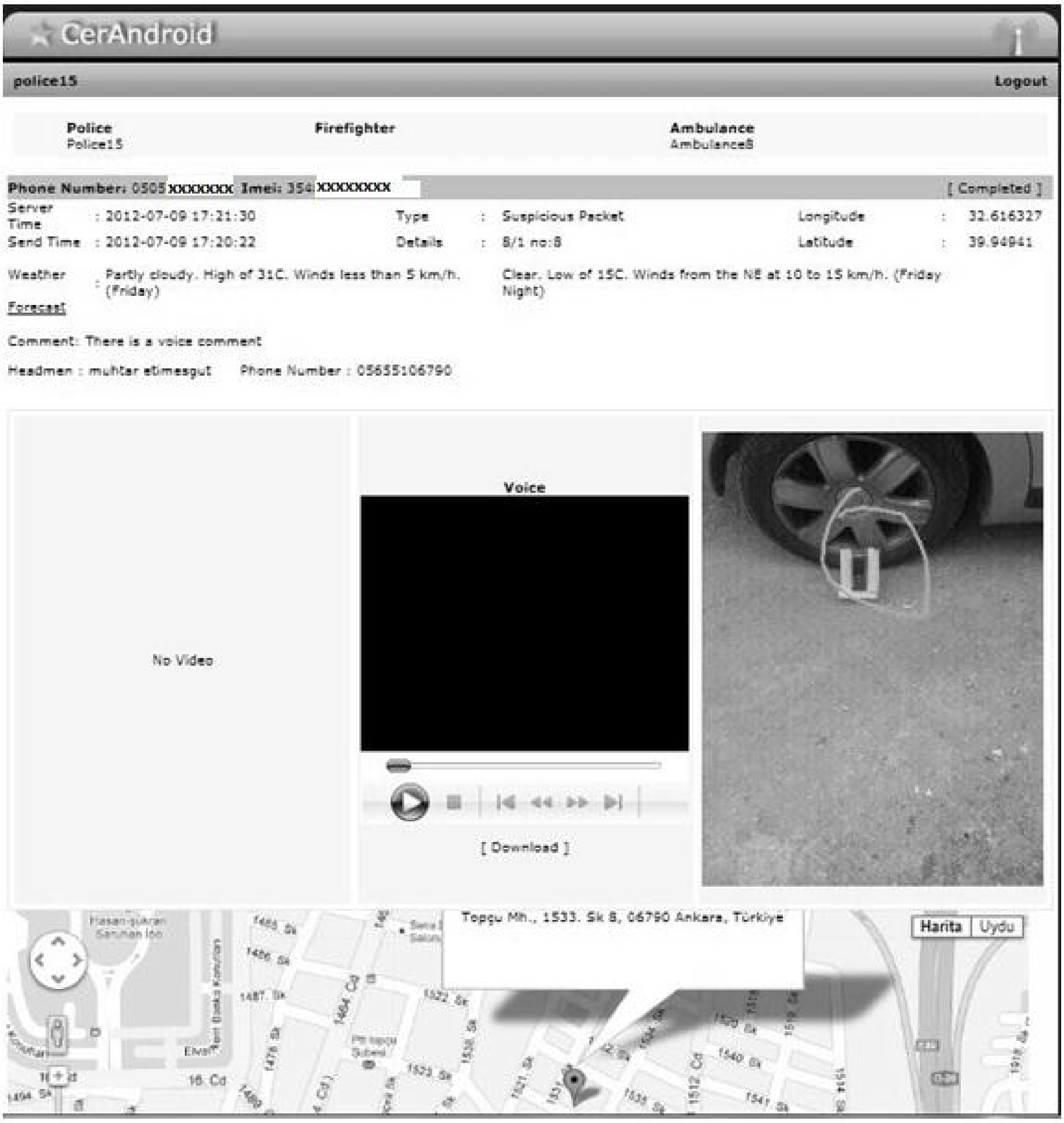


Figure 7: Detailed Reporting Screen of Responder

Figure 8: Suspicious Packets

APPENDIX B: TABLES

Table 1: Combination of Reporting Attributes

USER: Smart Phone User or Traditional Cell Phone User **- Expert :** Experienced or Inexperienced				
	Place:	**Known Place**	**Semi-known place**	**Unknown Place**
Types of Reportings:		**Elapsed Time**	**Elapsed Time**	**Elapsed Time**
Traditional				
CerAndroid Mobile Application				
Location determination	**Finishing Reporting**			
By Map	No Comment			
By Map	Write Comment			
By Map	Voice Comment			
By GPS	No Comment			
By GPS	Write Comment			
By GPS	Voice Comment			
Pre-defined location	No Comment			
Pre-defined location	Write Comment			
Pre-defined location	Voice Comment			

Table 2: Cross Tabulation for Expert Type and Location Accuracy

			Location Accuracy			Total
			Not Found	Exact	Half	
Expert	Experienced	Count	0	5	3	8
		Expected Count	.5	2.7	4.8	8.0
		% within VAR00001	.0%	62.5%	37.5%	100.0%
		% within VAR00003	.0%	100.0%	33.3%	53.3%
		% of Total	.0%	33.3%	20.0%	53.3%
	Inexperienced	Count	1	0	6	7
		Expected Count	.5	2.3	4.2	7.0
		% within VAR00001	14.3%	.0%	85.7%	100.0%
		% within VAR00003	100.0%	.0%	66.7%	46.7%
		% of Total	6.7%	.0%	40.0%	46.7%
Total		Count	1	5	9	15
		Expected Count	1.0	5.0	9.0	15.0
		% within VAR00001	6.7%	33.3%	60.0%	100.0%
		% within VAR00003	100.0%	100.0%	100.0%	100.0%
		% of Total	6.7%	33.3%	60.0%	100.0%

Table 3: Symmetric Measures Expert Type and Location Accuracy

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Nominal by Nominal	Phi	.681			.031
	Cramer's V	.681			.031
	Contingency Coefficient	.563			.031
Ordinal by Ordinal	Gamma	.579	.370	1.508	.132
	Spearman Correlation	.393	.266	1.540	.147[c]
Interval by Interval	Pearson's R	.274	.294	1.026	.323[c]
N of Valid Cases		15			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.