Palestine Polytechnic University

College of Engineering &Technology

Electrical and Computer Engineering Department

Graduation Project

GPS-Based Mobile Silencing at Holy Places

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Hebron – Palestine

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Submitted to
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According to the direction of the project supervisor and by the agreement form the entire committee's members. This project was submitted to department of electrical engineering in College of Engineering and Technology to partially fulfill of the B.Sc requirements.

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2010 - 2011

Abstract

The overall objective of this project is to overcome the disturbance caused by the mobiles ringing during praying time in holy places.

Many mosques are currently using Jammer systems. Jammers generate a signal within the same frequency band of GSM system. Jammer's signals cause GSM signals to diminish. Though jammer signal cancel GSM signals coming to the mobile from base stations, this technique may not be efficient, especially when jammer is in off state.

In this work our aim is to develop a new system for Mobile Silencing at mosques during praying times.

It is expected that such a system will be more efficient and highly appreciated in comparison with the jammer based approach.

Dedication

To my dearest mom who supported me and encourage me all the time, I say I love you as much as flowers in the world, To my dad , I say thank you, To my brothers and to my lovely sister, I say I love you, To my lovely Palestine, I say I love you so much , To my friends…. I thank you

Saleh

To my lovely dad and mom who supported me and encourage me all the time, to all my brothers and sisters, to my teachers and friends, to my lovely relative and to my future wife…. I dedicated this project to them.

Abed-alrahman

To my mother and my father and my brother and sisters and to my best friends, I say I love you too much, I say I thank you.

Hassan

To my lovely mom, to the spirit of my beloved father, to my sisters and brothers, I greatly appreciate what you did for me, to all my teachers and friends specially Subha, I say I'll miss you so much, to someone…

Ala'

To my mother and my father and my brother and sisters , I say I thank you.

Taghreed

Acknowledgment

This project is the fruit of effort and hard work. Therefore we wish to extend our heart-felt thanks and appreciation to all who helped in advancing our project. Never will we forget their ready assistance and continuous cooperation. We would like to thank our supervisor

Dr. Murad Abusubaih & Dr. RadwanTahboub

To

Palestine Polytechnic University

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Jawwal company

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- *All staff of our faculty*

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Abbreviations

AOA	Angle Of Arrival.
AUC	Authentication Center
BSC	Base Station Controller
BSS	Base Station Subsystem
BTS	Base Transceiver Station
BCC	Base Transceiver Station Color Code
BSIC	Base Transceiver Station Identity Code
BCCH	Broadcast Control Channel
CA	Cell Allocation
CI	Cell Identifier
CC	Country Code
EIR	Equipment Identity Register
FAC	Final Assembly Code
FDMA	Frequency Division Multiple Access
GMSC	Gateway Mobile Switching Center
GPS	Global Positioning System
GSM	Global System For Mobile Communication
HLR	Home Location Register
IMEI	International Mobile Station Equipment Identity
IMSI	International Mobile Subscriber Identity
LMSI	Local Mobile Station Identity
LA	Location Area
LAC	Location Area Code
LAI	Location Area Identifier

MCC	Mobile Country Code
MNC	Mobile Network Code
MSRN	Mobile Station Roaming Number
MSIN	Mobile Subscriber Identification Number
MSISDN	Mobile Subscriber ISDN Number
MSC	Mobile Switching Center
MTM	Modified Transverse Mercator
NDC	National Destination Code
NCC	Network Color Code
NMC	Network Management Centers
OMC	Operation and Maintenance Center
OMSS	Operation and Maintenance Subsystem
PLMN	Public Land Mobile Network
SNR	Serial Number
SPC	Signaling Point Code
SP	Spare
SIM	Subscriber Identity Module
SN	Subscriber Number
SMSS	Switching and Management Subsystem
TMN	Telecommunication Management Network
TMSI	Temporary Mobile Subscriber Identity
TDMA	Time Division Multiple Access
TDOA	Time Difference Of Arrival.
TAC	Type Approval Code
UTM	Universal Transverse Mercator
VLR	Visited Location Register

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CHAPTER ONE 1

Introduction

1.1 Overview
1.2 Project objectives
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1.1 Overview

Today, GSM (*Global System For Mobile Communication*) and mobile technology has become ordinary and much widespread. Moreover, the greatest applications depend on it nowadays.

It is clear that mobile devices become necessities of convenience in the daily life of many people. But, at the same time, these devices caused sometimes disturbance especially in holy places during prayer times.

If you are in a holy place and you forgot to turn your mobile to the silent mode, suddenly your mobile started ringing. It directly causes annoyance and discontent to the prayers. The GPS system could be used to mitigate this problem by auto switching of mobile from the normal mode to the silent mode within the area of the mosque with some acceptable accuracy during worship times. In a situation like this, the user will benefit from an application that supports these services, and this is the key idea of this work.

In this project, we will design and implement a system that combines GPS, GSM and mobile phone to achieve the idea of GPS-based switching to silent mode during worship times at holy places.

1.2 Project Objectives

The overall objective of this project is: to overcome the disturbance caused by mobile ringing during the prayer times in holy places.

Many mosques are currently using a jammer system which is an instrument to prevent cellular phones from receiving signals from base stations by transmitting signal on the same radio frequencies as the cell phone[1].

However, signals from jammers will affect both uplink and downlink GSM signals. Consequently, subscribers will not even notified about incoming calls.

Accordingly, we intend in this project to switch any mobile that use this service to silent mode at the mosque during praying times without using the jammer by

Programming a new profile for cell phones which named SALAH, this profile will be activated automatically in the mosque at times of praying.

And finally, Design a website to promote the service.

1.3 Project importance

switching mobile to the silent mode through this system aims to reduce the complexity of some techniques such as jammer, and to reduce the cost with less effort and less human work.

The project team would like to highlight that the topic of this project presents a new idea which, consequently, introduces social benefits.

1.4 Requirements

Hardware:

- ❖ Mobile phone.
- ❖ GSM network specially.
- ❖ GPS measurements devices.
- ❖ GPS and measurement devices.

Software :

- ❖ Mobile programming language as (Java ME ,Qt).

1.5 Related works

There are some previous studies with some relationship and relevance to this work. For instance:

- The study of [2] provides a description of some techniques to the mobile localization and wireless position technologies and location services in mobile networks.

- The paper of [3] shows an approach that gives a precise location and tracking of mobile terminals by exploiting advanced propagation models for mobile radio network design.

- The project published in [4] develops a system to determine the location of the user using GPS, GSM and mobile phones.

1.6 Challenges:

There may be some potential difficulties that may occur in the course of the project work involving hardware and software. The following lists some of these difficulties:

- **Positioning technologies:**
  - The available positioning techniques do not provide the required accuracy.

- **Hardware:**
  - Limited work on cellular base stations, especially access and configuration of parameters.
  - Device failure.
  - Lack of measurement devices.

- **Software:**
  - The software may be not allowed to use in the base station, and may not be compatible with used devices.
  - Operating system crash

1.7 Project plan:

The project plan will be divided into the following phases:

Phase 1: Preparing the Project

The aim of this phase is to choose the project (to identify the idea), and to identify its content, followed by information collection, discussion and evaluation of the tasks between the group.

Phase 2: Analysis Overview

In this phase, deep study performed for all possible design options of the project.

Phase 3: Project analysis identification

In phase 3, we determined the most appropriate option for this work and what necessary to undertake it and what steps required and resources needed.

Phase 4: Study of the principles

As shown in the (table 1.1), during this phase, the study of the GSM, GPS, and other techniques for localization performed.

Phase 5: Documentation and writing

Documentation of the project findings and writing of its document was from the first phase to the last one.

Phase 6: measurements

This stage for taking measurements of GPS and GSM to determine the accuracy in each one and to make combination between them.

Phase 7: Programming the mobile

In this stage of project, the programming of the project code started and downloaded to the mobile.

Phase 8: System Testing

In this stage, the testing started by taking more than one value for longitude and latitude, and calculated the distance in real case and compare it with mobile's results.

Phase 9: Writing Documentation

The documentation will continue from the first stage to the last one in parallel.

Table 1.1: Summary of the project plan for first semester

Task	Week													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15
P1														
P2														
P3														
P4														
P5														

Table 1.2: Summary of the project plan for the second semester

Task	Week													
	16	17	18	19	20	21	22	23	24	25	26	27	28	29
P6														
P7														
P8														
P9														

1.8 Estimated cost and budget

Tentatively, the project cost is estimated at US$ 710. Table 1.2 shows the breakdown of the project budget:

Table 1.3: Estimated cost

Item No.	Component	Price ($)
1	Mobile	500
2	SIM Card	10
3	Java supported ID (Net Beans)	10
	Total	**520**

1.9 Report Contents

Documentation of this project is divided by four chapters each of them describes specific part of the project. In short, the project chapters are divided as follows:

Chapter One: Introduction

This chapter includes a general overview and introduction about the project, the project objectives, its importance, related works, challenges that may face; project plan, estimated cost, and, finally, the report contents are listed.

Chapter Tow: Theoretical Back ground

In this chapter, we introduce the theoretical background of the main idea of the project.

Chapter Three: Project Design

This chapter introduces the design and discusses the ways and constituents of this design. Also the software and hardware to be implemented will be described.

Chapter Four: Software System Design

This chapter talks about the implementing the system from the programming point of view. This will include the methods that are used in the program.

Chapter Five: System Implementing and Testing

This chapter discuss the actual implementation of the project, and the various testing stages of the system.

Chapter Sex: Conclusion and Future Work

This chapter provides the conclusion that will be discussed after completing the project, and exploring suggestion for future works.

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1.10 System Modeling.

In modeling we can notice the services provided by the system and the interactions between other systems or humans.

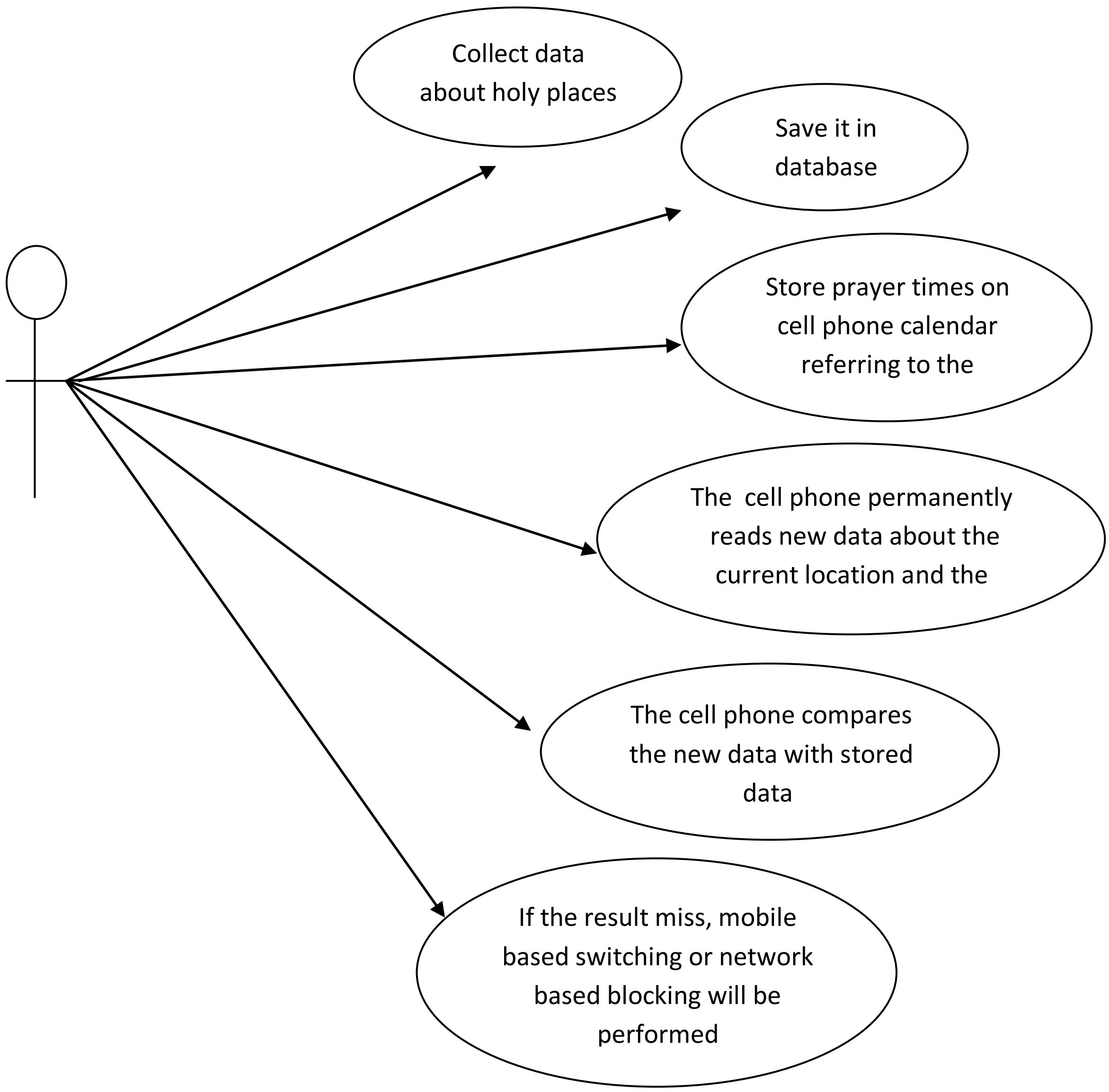


Figure 1.1: Services provided by the system.

CHAPTER TWO 2

Theoretical Background

2.1 GSM Architecture and addressing

2.2 Cellular System

2.3 Determining the subscriber location

2.4 The Mobile Phone

2.5 Summary

2.1 GSM Architecture and addressing

2.1.1 Evolution of GSM system:

Throughout the evolution of cellular telecommunications, various systems have been developed without the benefit of standardized specifications. This presented many problems directly related to compatibility, especially with the development of digital radio technology. The GSM standard is intended to address these problems.

From 1982 to 1985 discussions were held to decide between building an analog or digital system. After multiple field tests, a digital system was adopted for *Global System For Mobile Communication* (GSM) and problems like standardization, incompatibility etc were overcame. The next task was to decide between a narrow or broadband solution. In May 1987, the narrowband time division multiple access (TDMA) solution was chosen.

2.1.2 GSM Network Description

GSM networks are structured hierarchically (Figure 2.1). They substantially consist of at least one administrative region, which is assigned to a *Mobile Switching Center* (MSC). Each administrative region is made up of at least one *Location Area* (LA). Sometimes the LA is also called the visited area. An LA consists of several cell groups. Each cell group is assigned to a *Base Station Controller* (BSC). Therefore for each LA there exists at least one BSC, but cells of one BSC may belong to different LAs

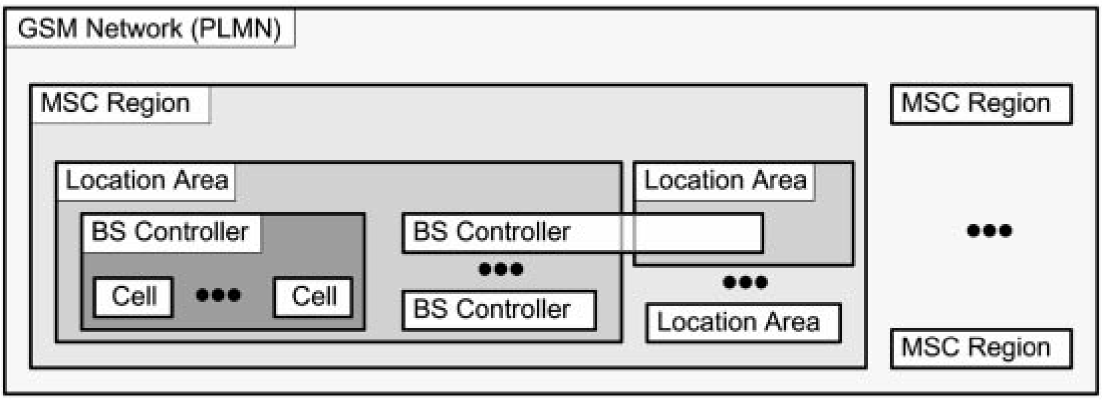


Figure 2.1 GSM system hierarchy [5]

The exact partitioning of the service area into cells and their organization or administration with regard to LAs, BSCs, and MSCs is, however, not uniquely determined and is left to the respective network operator who thus has many possibilities for optimization. (Figure 2.2) shows the system architecture of a GSM *Public Land Mobile Network* (PLMN) with essential components. The hierarchical construction of the GSM infrastructure becomes evident again. The cell is formed by the radio area coverage of a *Base Transceiver Station* (BTS). Several base stations together are controlled by one BSC. The combined traffic of the mobile stations in their respective cells is routed through a switch, the *Mobile Switching Center* (MSC). Calls originating from or terminating in the fixed network (e.g. the Integrated Services Digital Network, ISDN [6]) are handled by a dedicated *Gateway Mobile Switching Center* (GMSC).

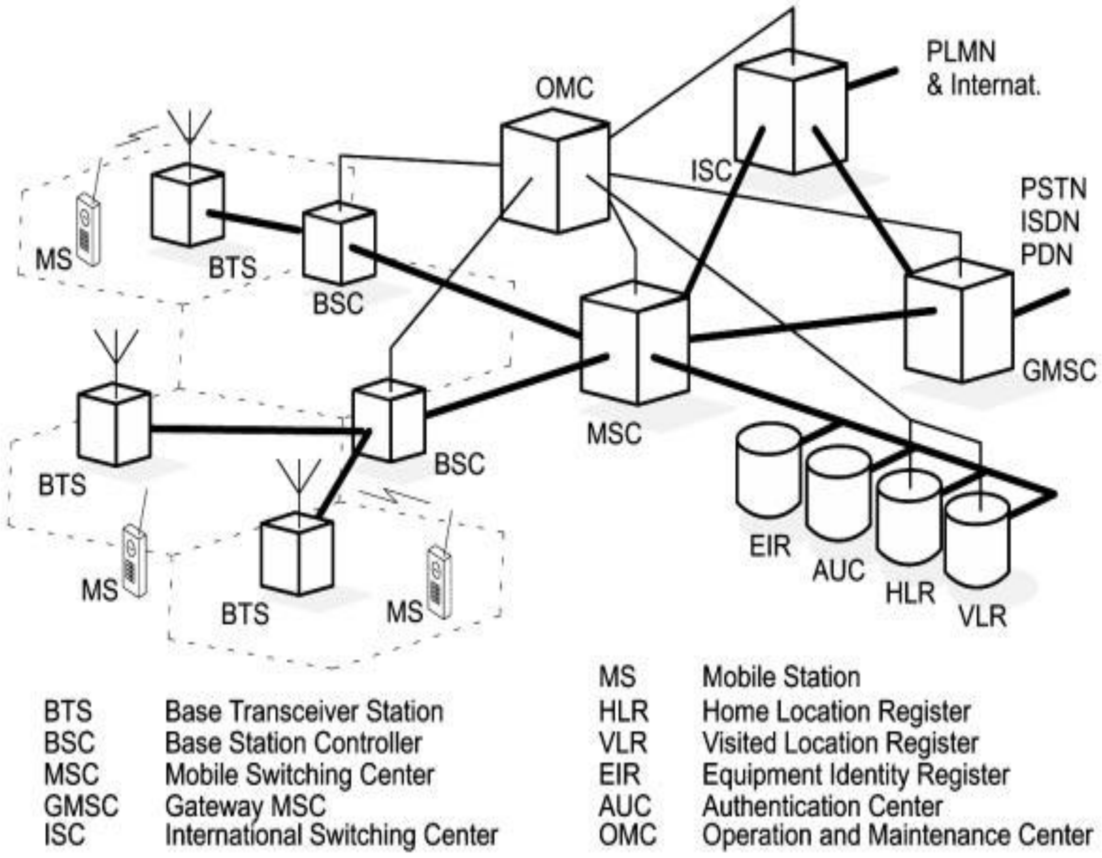


Figure 2.2 GSM system architecture with essential components [5]

Operation and maintenance are organized from a central place, the *Operation and Maintenance Center* (OMC). Several databases are available for call control and network management:

- ✓ Home Location Register (HLR)
- ✓ Visited Location Register (VLR)
- ✓ Authentication Center (AUC)
- ✓ Equipment Identity Register (EIR)

For all subscribers registered with a network operator, permanent data (such as the user's service profile) as well as temporary data (such as the user's current location) are stored in the HLR. In case of a call to a user, the HLR is always first queried, to determine the user's current location. A VLR is responsible for a group of LAs and stores the data of subscribers who are currently in its area of responsibility. This includes parts of the permanent subscriber data which have been transmitted from the HLR to the VLR for faster access. But the VLR may also assign and store local data such as a temporary identification. The AUC generates and stores security-related data such as keys used for authentication and encryption, whereas the EIR registers equipment data rather than subscriber data.

2.1.3 Addresses and Identifiers

GSM distinguishes explicitly between user and equipment and deals with them separately. According to this concept, which was introduced with digital mobile networks, mobile equipment and users each receive their own internationally unique identifiers. The user identity is associated with a mobile station by means of a personal chip card, the *Subscriber Identity Module* (SIM). This SIM usually comes in the form of a chip card, which is transferable between mobile stations. It allows to distinguish between equipment mobility and subscriber mobility. The subscriber can register to the locally available network with his or her SIM card on different mobile stations, or the SIM card could be used as a normal telephone card in the fixed telephone network. However, he or she cannot receive calls on fixed network ports, but further development of the fixed networks as well as convergence of fixed and mobile networks could make this possible, too. In that case, a mobile subscriber could register at an arbitrary ISDN telephone and would be able to receive calls.

In addition, GSM distinguishes between subscriber identity and telephone number. This leaves some scope for development of future services when each subscriber may be called personally, independent of reach ability or type of connection (mobile or fixed). Besides the personal identifier, each GSM subscriber is assigned one or several ISDN numbers.

Besides telephone numbers and subscriber and equipment identifiers, several other identifiers have been defined; they are needed for the management of subscriber mobility and for addressing all the remaining network elements. The most important addresses and identifiers are presented in the following.

2.1.3.1 International Mobile Station Equipment Identity (IMEI)

The *International Mobile Station Equipment Identity* (IMEI) uniquely identifies mobile stations internationally. It is a kind of serial number. The IMEI is allocated by the equipment manufacturer and registered by the network operator, who stores it in the *Equipment Identity Register* (EIR). By means of the IMEI one recognizes obsolete, stolen, or nonfunctional equipment and, for example, can deny service. For this purpose, the IMEI is assigned to one or more of three categories within the EIR:

- ✓ The **White List** is a register of all equipment.
- ✓ The **Black List** contains all suspended equipment. This list is periodically exchanged among network operators.
- ✓ Optionally, an operator may maintain a **Gray List**, in which malfunctioning equipment or equipment with obsolete software versions is registered. Such equipment has network access, but its use is reported to the operating personnel.

The IMEI is usually requested from the network at registration, but it can be requested repeatedly. It is a hierarchical address, containing of the following parts:

- ✓ *Type Approval Code*(TAC): 6 decimal places, centrally assigned.
- ✓ *Final Assembly Code*(FAC): 6 decimal places, assigned by the manufacturer.
- ✓ *Serial Number*(SNR): 6 decimal places, assigned by the manufacturer.
- ✓ *Spare*(SP): 1 decimal place.

Thus, IMEI = TAC + FAC + SNR + SP. It uniquely characterizes a mobile station and gives clues about the manufacturer and the date of manufacturing.

2.1.3.2 International Mobile Subscriber Identity (IMSI)

When registering for service with a mobile network operator, each subscriber receives a unique identifier, the *International Mobile Subscriber Identity* (IMSI). This IMSI is stored in the SIM; see Section 2.1.3.1 . A mobile station can only be operated if a SIM with a valid IMSI is inserted into equipment with a valid IMEI, since this is the only way to correctly bill the associated subscriber. The IMSI also consists of several parts:

- ✓ *Mobile Country Code*(MCC): 3 decimal places, internationally standardized.
- ✓ *Mobile Network Code*(MNC): 2 decimal places, for unique identification of mobile networks within a country.
- ✓ *Mobile Subscriber Identification Number*(MSIN): maximum 10 decimal places, identification number of the subscriber in his/her mobile home network.

2.1.3.3 Mobile Subscriber ISDN Number (MSISDN)

The ``real telephone number'' of a mobile station is the *Mobile Subscriber ISDN Number* (MSISDN). It is assigned to the subscriber (his or her SIM), such that a mobile station can have several MSISDNs depending on the SIM. With this concept, GSM is the first mobile system to distinguish between subscriber identity and number to call. The separation of call number (MSISDN) and subscriber identity (IMSI) primarily serves to protect the confidentiality of the IMSI. In contrast to the MSISDN, the IMSI need not be made public. With this separation, one cannot derive the subscriber identity from the MSISDN, unless the association of IMSI and MSISDN as stored in the HLR has been made public. It is the rule that the IMSI used for subscriber identification is not known, and thus the faking of a false identity is significantly more difficult.

In addition to this, a subscriber can hold several MSISDNs for selection of different services. Each MSISDN of a subscriber is reserved for specific service (voice, data, fax, etc.). In order to realize this service, service-specific resources have to be activated in the mobile station as well as in the network. The service desired and the resources needed for the specific call can be derived from the MSISDN. Thus, an automatic activation of service-specific resources is already possible during the setup of a connection. The MSISDN categories follow the international ISDN numbering plan and therefore have the following structure:

- ✓ *Country Code*(CC): up to 3 decimal places.
- ✓ *National Destination Code(*NDC): typically 2-3 decimal places.
- ✓ *Subscriber Number*(SN): maximal 10 decimal places.

2.1.3.4 Mobile Station Roaming Number (MSRN)

The *Mobile Station Roaming Number* (MSRN) is a temporary location-dependent ISDN number. It is assigned by the locally responsible VLR to each mobile station in its area. Calls are routed to the MS by using the MSRN. On request, the MSRN is passed from the HLR to the GMSC. The MSRN has the same structure as the MSISDN:

- ✓ *Country Code*(CC) of the visited network.
- ✓ *National Destination Code*(NDC) of the visited network.
- ✓ *Subscriber Number*(SN) in the current mobile network

The components CC and NDC are determined by the visited network and depend on the current location. The SN is assigned by the current VLR and is unique within the mobile network. The assignment of an MSRN is done in such a way that the currently responsible switching node MSC in the visited network (CC+ NDC) can be determined from the subscriber number, which allows routing decisions to be made.

The MSRN can be assigned in two ways by the VLR: either at each registration when the MS enters a new *Location Area* (LA) or each time when the HLR requests it for setting up a connection for incoming calls to the mobile station.

In the first case, the MSRN is also passed on from the VLR to the HLR, where it is stored for routing. In the case of an incoming call, the MSRN is first requested from the HLR of this mobile station. This way the currently responsible MSC can be determined, and the call can be routed to this switching node. Additional localization information can be obtained there from the responsible VLR.

In the second case, the MSRN cannot be stored in the HLR, since it is only assigned at the time of call setup. Therefore the address of the current VLR must be stored in the tables of the HLR. Once routing information is requested from the HLR, the HLR itself goes to the current VLR and uses a unique subscriber identification (IMSI and MSISDN) to request a valid roaming number MSRN. This allows further routing of the call.

2.1.3.5 Location Area Identity (LAI)

Each LA of a PLMN has its own identifier. The *Location Area Identifier* (LAI) is also structured hierarchically and internationally unique (Section 2.1.3.2), with LAI again consisting of an internationally standardized part and an operator-dependent part:

- ✓ Country Code(CC): 3 decimal digits
- ✓ *Mobile Network Code*(MNC): 2 decimal places
- ✓ *Location Area Code*(LAC): maximum 5 decimal places, or maximum twice 8 bits, coded in hexadecimal (LAC < $FFFF_{hex}$)

This LAI is broadcast regularly by the base station on the *Broadcast Control Channel* (BCCH). Thus, each cell is identified uniquely on the radio channel as belonging to an LA, and each MS can determine its current location through the LAI. If the LAI that is ``heard'' by the MS changes, the MS notices this LA change and requests the updating of its location information in the VLR and HLR (location update). The significance for GSM networks is that the mobile station itself rather than the network is responsible for monitoring the local conditions of signal reception, to select the base station that can be received best, and to register with the VLR of that LA which the current base station belongs to. The LAI is requested from the VLR if the connection for an incoming call has been routed to the current MSC using the MSRN. This determines the precise location of the mobile station where the mobile can be subsequently paged. When the mobile station answers, the exact cell and therefore also the base station become known; this information can then be used to switch the call through.

2.1.3.6 Temporary Mobile Subscriber Identity (TMSI)

The VLR being responsible for the current location of a subscriber can assign a *Temporary Mobile Subscriber Identity* (TMSI), which has only local significance in the area handled by the VLR. It is used in place of the IMSI for the definite identification and addressing of the mobile station. This way nobody can determine the identity of the subscriber by listening to the radio channel, since this TMSI is only assigned during the mobile station's presence in the area of one VLR, and can even be changed during this period (ID hopping). The mobile station stores the TMSI on the

SIM card. The TMSI is stored on the network side only in the VLR and is not passed to the HLR. A TMSI may therefore be assigned in an operator-specific way; it can consist of up to 4 × 8 bits, but the value $(\text{FFFF FFFF})_{hex}$ is excluded, because the SIM marks empty fields internally with logical 1.

Together with the current location area, a TMSI allows a subscriber to be identified uniquely, i.e. for the ongoing communication the IMSI is replaced by the 2-tuple (TMSI, LAI).

2.1.3.7 Local Mobile Subscriber Identity (LMSI)

The VLR can assign an additional searching key to each mobile station within its area to accelerate database access; this is the *Local Mobile Station Identity* (LMSI). The LMSI is assigned when the mobile station registers with the VLR and is also sent to the HLR. The LMSI is not used any further by the HLR, but each time messages are sent to the VLR concerning a mobile station, the LMSI is added, so the VLR can use the short searching key for transactions concerning this MS. This kind of additional identification is only used when the MSRN is newly assigned with each call. In this case, fast processing is very important to achieve short times for call setup. Like the TMSI, an LMSI is also assigned in an operator-specific way, and it is only unique within the administrative area of a VLR. An LMSI consists of four octets (4 × 8 bits).

2.1.3.8 Cell Identifier (CI)

Within an LA, the individual cells are uniquely identified with a *Cell Identifier* (CI), maximum 4 × 8 bits. Together with the *Global Cell Identity* (LAI + CI), cells are thus also internationally defined in a unique way.

2.1.3.9 Base Transceiver Station Identity Code (BSIC)

In order to distinguish neighboring base stations, these receive a unique *Base Transceiver Station Identity Code* (BSIC) which consists of two components:

- ✓ *Network Color Code* (NCC): color code within a PLMN (3 bits)
- ✓ *Base Transceiver Station Color Code*(BCC): BTS color code (3 bits)

The BSIC is broadcast periodically by the base station on a Broadcast Channel, the Synchronization Channel. Directly adjacent PLMN (and BS) must have different color codes.

2.1.3.10 Identification of MSCs and Location Registers

MSCs and location registers (HLR, VLR) are addressed with ISDN numbers. In addition, they may have a *Signaling Point Code* (SPC) within a PLMN, which can be used to address them uniquely within the Signaling System Number 7 network (SS#7).

The number of the VLR in whose area a mobile station is currently roaming must be stored in the HLR data for this MS, if the MSRN distribution is on a call-by-call basis (Section 2.1.3.4); thus the MSRN can be requested for incoming calls and the call can be switched through to the MS.

2.1.4 System Architecture

A GSM system has two major components: the fixed installed infrastructure (the network in the proper sense) and the mobile subscribers, which use the services of the network and communicate over the radio interface (air interface). The fixed installed GSM network can again be subdivided into three sub networks: the radio network, the mobile switching network, and the management network. These sub networks are called subsystems in the GSM standard. The respective three subsystems are the *Base Station Subsystem* (BSS), the *Switching and Management Subsystem* (SMSS), and the *Operation and Maintenance Subsystem*(OMSS).

2.1.4.1 Mobile Station (MS)

Mobile stations (MS) are pieces of equipment which are used by mobile service subscribers for access to services. They consist of two major components: the *Mobile Equipment* and the *Subscriber Identity Module(*SIM). Only the SIM of a subscriber turns a piece of mobile equipment into a complete mobile station with network usage privileges, which can be used to make calls or receive calls. The SIM can be a fixed installed chip (*plug-in SIM*) or an exchangeable SIM card. In addition to the equipment identifier IMEI, the mobile station has subscriber identification and call number (IMSI and MSISDN) as subscriber-dependent data. Thus GSM mobile stations are personalized with the SIM card (Figure 2.3).

Figure 2.3 Mobile equipment personalization with SIM [5]

This modern concept of the SIM used consistently for the first time in GSM achieved on one hand the separation of user mobility from equipment mobility. This enables international roaming independent of mobile equipment and network technology, provided the interface between SIM and end terminal is standardized. On the other hand, the SIM can take over substantially more tasks than the personalization of mobile stations with IMSI and MSISDN. All the cryptographic algorithms to be kept confidential are realized on the SIM, which implements important functions for the authentication and user data encryption based on the subscriber identity IMSI and secret keys. Beyond that, the SIM can store short messages and charging information, and it has a telephone book function and short list of call numbers storing names and telephone numbers for efficient and fast number selection. These functions in particular contribute to a genuine personalization of a mobile terminal, since the subscriber can use his or her normal ``environment'' plus telephone list and short message archive with any piece of mobile equipment. Besides subscriber-specific data, the SIM can also store network-specific data, e.g. lists of BCCH carrier frequencies used by the network to broadcast system information periodically, or also the current LAI. Use of the SIM and thus of the whole MS can be protected with a PIN against unauthorized access.

2.1.4.2 Radio Network - Base Station Subsystem (BSS)

Figure 2.4 shows the components of the GSM radio network. A GSM cell is expanded around the radio area of a *Base Transceiver Station* (BTS); *transmitter + receiver = transceiver*. The BTS provides the radio channels for signaling and user data traffic in this cell. Thus, a BTS is the network part of the GSM air interface. Besides the high-frequency part (transmitter and receiver equipment) it contains only a few components for signal and protocol processing. For example, error protection coding is performed in the BTS, and the link level protocol LAPDm for signaling on the radio path is terminated here. In order to keep the base stations small, the essential control and protocol intelligence entities reside in the *Base Station Controller* (BSC). For example, the handover protocol is executed in the BSC. BTS and BSC together form the *Base Station Subsystem* (BSS). Several BTSs can be controlled together by one BSC (Figure 2.1). Each BTS is allocated a set of frequency channels, the *Cell Allocation* (CA).

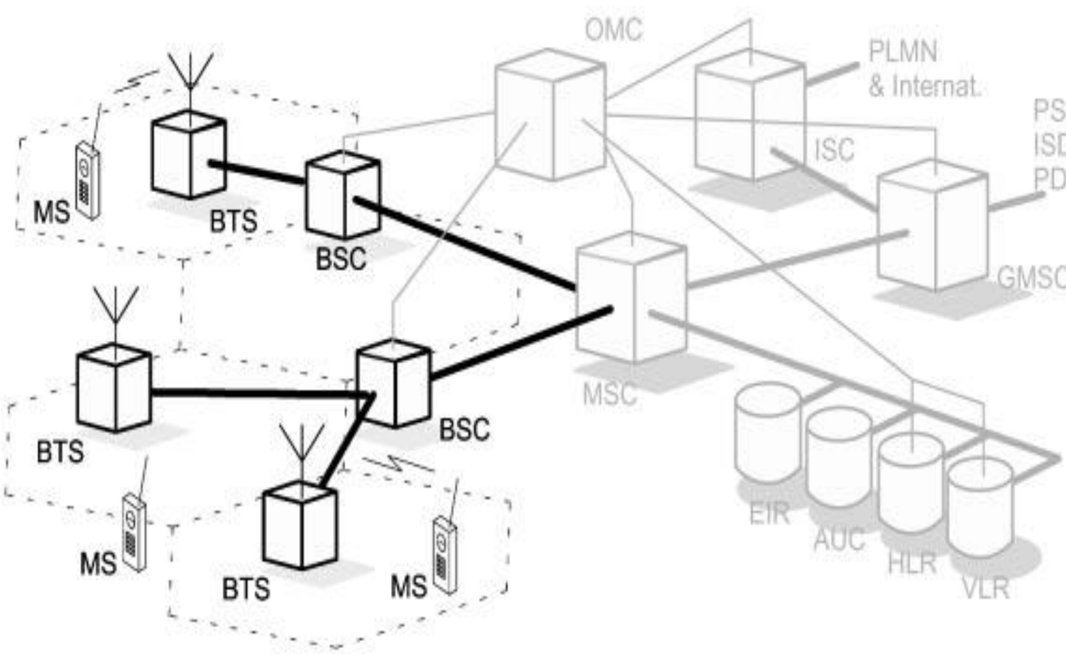


Figure 2.4 Components of the GSM radio network [5]

Two kinds of channels are provided at the radio interface: traffic channels and signaling channels. Traffic channels are further subdivided into full-rate channels and half-rate channels. For the traffic channels, the BSS substantially comprises all the functions of OSI Layer 1.

2.1.4.3 Mobile Switching Network (MSS)

The Mobile *Switching and Management Subsystem* (SMSS) consists of the mobile switching centers and the databases which store the data required for routing and service provision (Figure 2.5). These components and their functions are presented briefly in the following and in more detail in later sections.

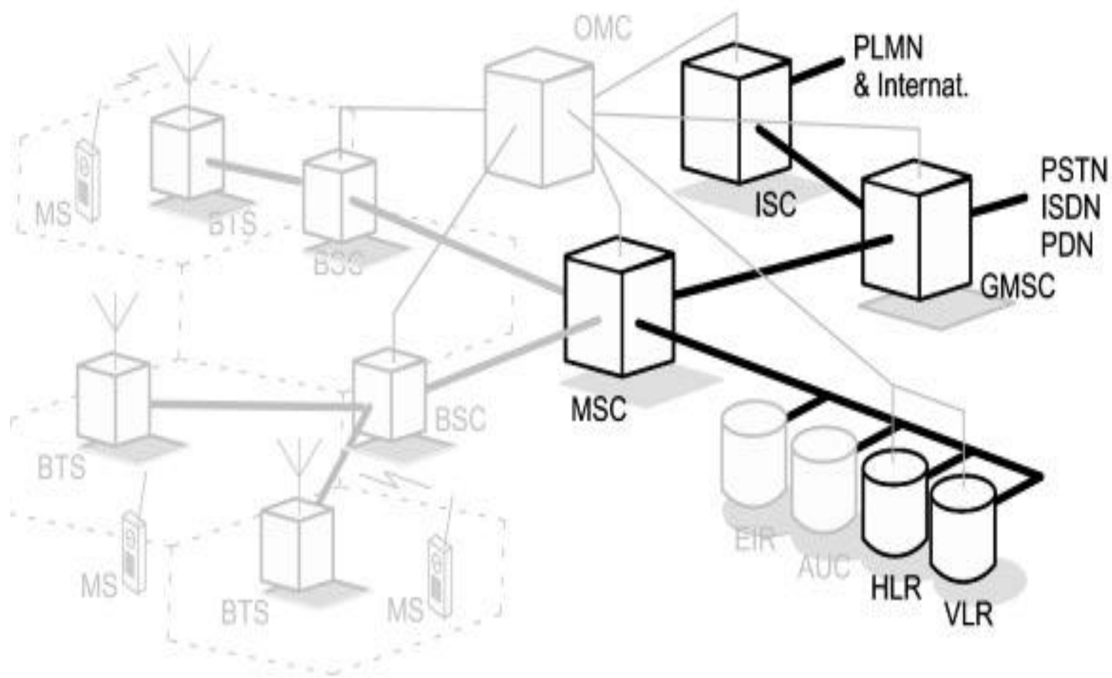


Figure 2.5 Components of the GSM mobile switching network [5]

2.1.4.3.1 Mobile Switching Center (MSC)

The switching node of a GSM PLMN is the *Mobile Switching Center* (MSC). The MSC performs all the switching functions of a fixed-network switching node, e.g. routing path search, signal routing, and service feature processing. The main difference between an ISDN switch and an MSC is that the MSC also has to consider the allocation and administration of radio resources and the mobility of the subscribers. The MSC therefore has to provide additional functions for location registration of subscribers and for the handover of a connection in case of changing from cell to cell. A PLMN can have several MSCs with each being responsible for a part of the Service Area. The BSCs of a BSS are subordinated to a single MSC.

Dedicated *Gateway MSCs* (GMSCs) pass voice traffic between fixed networks and mobile networks. If the fixed network is unable to connect an incoming call to the local MSC (due to the inability to interrogate the HLR), it routes the connection to the next GMSC. This GMSC requests the routing information from the HLR and routes the connection to the local MSC in whose area the mobile station is currently staying. Connections to other mobile or international networks are mostly routed over the *International Switching Center*(ISC) of the respective country.

Associated with an MSC is a functional unit enabling the interworking of a PLMN and the fixed networks (PSTN, ISDN, PDN). This *Interworking Function* (IWF) performs a variety of functions depending on the service and the respective fixed network. It is needed to map the protocols of the PLMN onto those of the respective fixed network. In cases of compatible service implementation in both networks, the IWF has no functions to perform.

2.1.4.3.2 Home and Visitor Registers (HLR and VLR)

A GSM PLMN has several databases. Two functional units are defined for the registration of subscribers and their current location: the *Home Location Register* (HLR) and the *Visited Location Register* (VLR). In general, there is one central HLR per PLMN and one VLR for each MSC. This organization depends on the number of subscribers, the processing and storage capacity of the switches, and the structure of the network.

The HLR has entries for every subscriber and every mobile ISDN number that has his/ her ``home'' in the respective network. It stores all permanent subscriber data and the relevant temporary data of all subscribers permanently registered in the HLR. Besides the fixed entries like service subscriptions and permissions, the stored data also contains a link to the current location of the mobile station (Table 2.1). The HLR is needed as the central register for routing to the subscribers, for which it has administrative responsibility. The HLR has no direct control over an MSC. All administrative activities concerning a subscriber are performed in the databases of the HLR.

The VLR as visitor register stores the data of all mobile stations which are currently staying in the administrative area of the associated MSC. A VLR can be responsible for the areas of one or more MSCs. Mobile stations are roaming freely, and therefore, depending on their current location, they may be registered in one of the VLRs of their home network or in a VLR of a ``foreign'' network (if there is a roaming agreement between both network operators). For this purpose, a mobile station has to start a registration procedure when it enters an LA. The responsible MSC passes the identity of the MS and its current LAI to the VLR, which includes these values into its database and thus registers the MS. If the mobile station has not been registered with this VLR, the HLR is informed about the current location of the MS. This process enables routing of incoming calls to this mobile station.

2.1.4.4 Operation and Maintenance (OMSS)

2.1.4.4.1 Network Monitoring and Maintenance

The ongoing network operation is controlled and maintained by the *Operation and Maintenance Subsystem* (OMSS). Network control functions are monitored and initiated from an *Operation and Maintenance Center* (OMC). Here are some of its functions:

- ✓ Administration and commercial operation (subscribers, end terminals, charging, statistics).
- ✓ Security management.
- ✓ Network configuration, operation, performance management.
- ✓ Maintenance tasks.

Management of the network can be centralized in one or more *Network Management Centers* (NMC). The operation and maintenance functions are based on the concept of the *Telecommunication Management Network* (TMN) which is standardized in the ITU-T series M.30. The OMSS components are shown in Figure 2.6

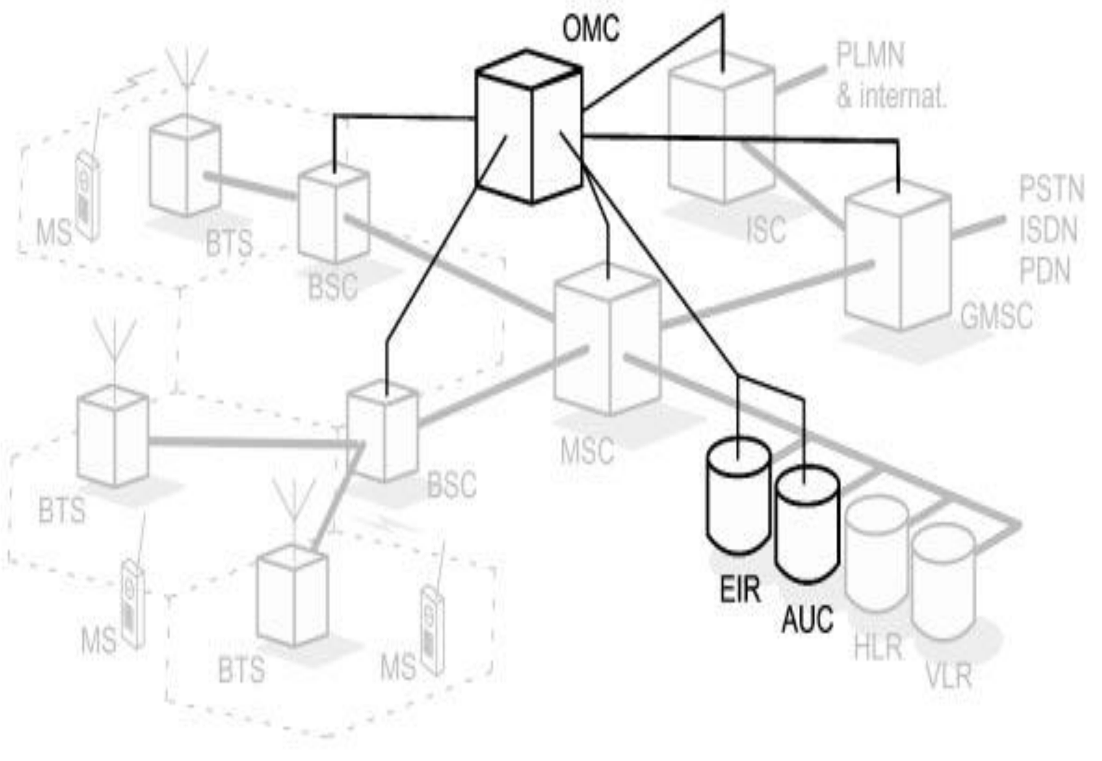


Figure 2.6 Components of the GSM OMSS [5]

2.1.4.4.2 User Authentication and Equipment Registration

Two additional databases are defined in GSM besides the HLR and VLR. They are responsible for various aspects of system security. System security of GSM networks is based primarily on the verification of equipment and subscriber identity; therefore the databases serve for subscriber identification and authentication and for equipment registration. Confidential data and keys are stored or generated in the *Authentication Center* (AUC). The keys serve for user authentication and authorize the respective service access. The *Equipment Identity Register* (EIR) stores the serial numbers (supplied by the manufacturer) of the terminals (IMEI), which makes it possible to check for mobile stations with obsolete software or to block service access for mobile stations reported as stolen.

2.1.5 Subscriber Data in GSM

Besides data of the address type, which is the most important subscriber data of any communication network, a whole series of other service- and contract-specific data exists in GSM networks. Addresses serve to identify, authenticate, and localize subscribers, or switch connections to subscribers. Service-specific data is used to parameterize and personalize supplementary services. Finally, contracts with subscribers can define different service levels, e.g. booking of special supplementary services or subscriptions to data or teleservices. The contents of such contracts are stored in appropriate data structures in order to enable correct realization or provision of these services.

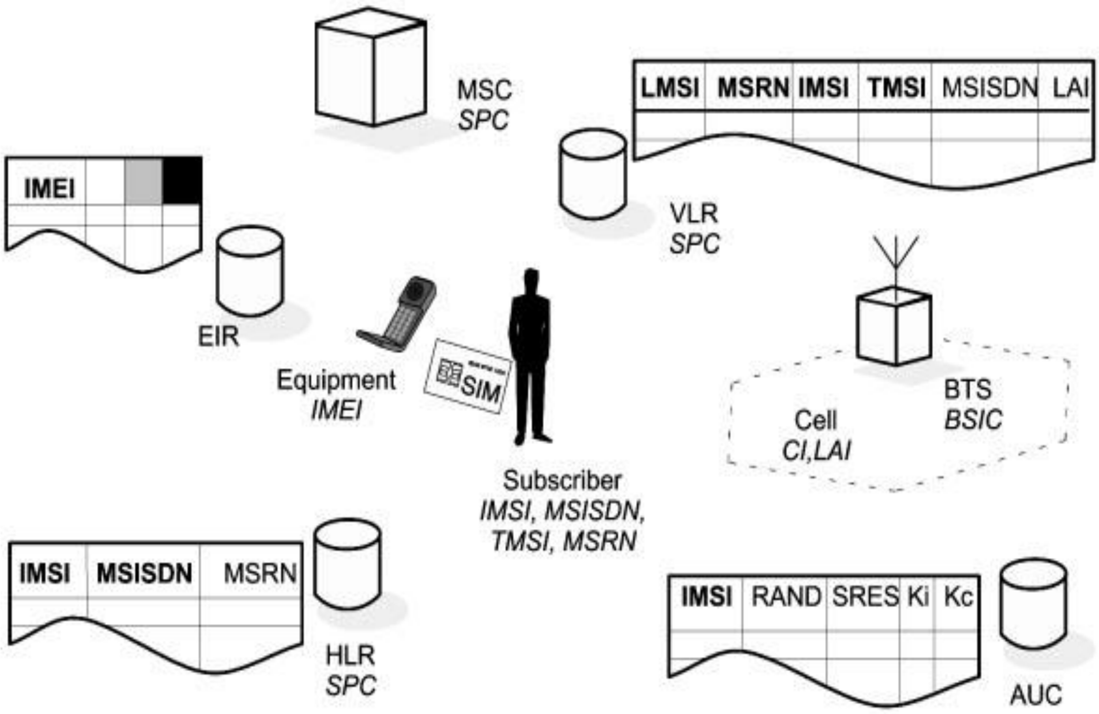


Figure 2.7 Overview of address and pertinent databases [5]

The association of the most important identifiers and their storage locations is summarized in Figure 2.7. Subscriber-related addresses are stored on the SIM and in the HLR and VLR as well. These data (IMSI, MSISDN, TMSI, MSRN) serve to address, identify, and localize a subscriber or a mobile station. Whereas IMSI and

MSISDN are permanent data items, TMSI and MSRN are temporary values, which change according to the current location of the subscriber. Of the other data items defined for user or network equipment elements (like IMEI, LAI, or SPCs), only some are used (LAI, SPC) for localizing or routing. IMEI and BSIC/CI hold a special position by being used only for identification of network elements.

Security-relevant subscriber data is stored in the AUC, which also calculates identifiers and keys for cryptographic processing functions. Each set of data in the AUC contains the IMSI of the subscriber as a search key. For identification and authentication of a subscriber, the AUC stores the subscriber's secret key K_i from which a pair of keys RAND/SRES are pre calculated and stored. Once an authentication request occurs, this pair of keys is queried by the VLR to conduct the identification/authentication process properly. The key K_c for user data encryption on the radio channel is also calculated in advance in the AUC from the secret key K_i and is requested by the VLR at connection setup.

Further data about the subscriber and his or her contractual agreement with the service provider are presented in Tables 2.1 and 2.2. Above all, the HLR contains the permanent data about the subscriber's contractual relationship, e.g. information about subscribed bearer and teleservices (data, fax, etc.), service restrictions, and parameters for supplementary services. Beyond that, the registers also contain information about equipment used by the subscriber (IMEI). Depending on the implementation of the authentication center AUC and the security mechanisms, data and keys used for subscriber authentication and encryption can also be stored there.

Table 2.1 Mobile subscriber data in the HLR

Subscriber and subscription data	***Tracking and routing information***
International Mobile Subscriber Identity (IMSI)	Mobile Station Roaming Number (MSRN)
International Mobile Subscriber ISDN Number (MSISDN)	Current VLR address (if available)
Bearer and teleservice subscriptions	Current MSC address (if available)
Service restrictions, e.g. roaming restrictions	Local Mobile Subscriber Identity (LMSI) (if available)
Parameters for additional services	
Information on the subscriber's equipment (if available)	
Authentication data (subject to implementation)	

The search keys used for retrieving subscriber information (such as IMSI, MSISDN, MSRN, TMSI and LMSI), from a register are indicated either in boldface (Figure 2.7) or in italics (Tables 2.1 and 2.2).

Table 2.2 Mobile subscriber data in the VLR

Subscriber and subscription data	***Tracking and routing information***
International Mobile Subscriber Identity (IMSI)	Mobile Station Roaming Number (MSRN)
International Mobile Subscriber ISDN Number (MSISDN)	Temporary Mobile Station Identity (TMSI)
Parameters for supplementary services	Local Mobile Subscriber Identity (LMSI) (if available)
Service restrictions, e.g. roaming restrictions	Local Area Identity (LAI) of LA, where MS was registered (used for paging and call setup)
Information on the subscriber-used equipment (if available)	
Authentication data (subject to implementation)	

2.2 Cellular System

A cellular mobile communication system uses a large number of low-power wireless transmitters to create cells (the basic geographic service area of a wireless communication system,). Variable power levels allow cells to be sized according to the subscriber density and demand within a particular region. As mobile users travel from cell to cell, their conversations are "handed off" between cells in order to maintain seamless service [7].

Because of the very limited frequency bands, a mobile radio network has only a relatively small number of speech channels available. For example, the GSM system has an allocation of 25 MHz bandwidth in the 900 MHz frequency range, which amounts to a maximum of 125 frequency channels each with a carrier bandwidth of 200 kHz. Within an eightfold time multiplex for each carrier. In order to be able to serve several 100 000 or millions of subscribers in spite of this limitation, frequencies must be spatially reused, i.e. deployed repeatedly in a geographic area. In this way, services can be offered with a cost-effective subscriber density and acceptable blocking probability[5].

2.2.1 Fundamental Definitions

This spatial frequency reuse concept led to the development of cellular technology, which allowed a significant improvement in the economic use of frequencies. The essential characteristics of the cellular network principle are as follows:

- ✓ The area to be covered is subdivided into cells (radio zones). For easier manipulation, these cells are modeled in a simplified way as hexagons (Figure 2.8). Most models show the base station in the middle of the cell.

- ✓ To each cell ***i*** a subset of the frequencies $\boldsymbol{fb_i}$ is assigned from the total set (bundle) assigned to the respective mobile radio network. Two neighboring cells must never use the same frequencies, since this would lead to severe co-channel interference from the adjacent cells.

- ✓ Only at distance *D* (the *frequency reuse distance*) can a frequency from the set $\boldsymbol{fb_i}$ be reused, i.e. cells with distance *D* to cell ***i*** are assigned one or all of the frequencies from the set $\boldsymbol{fb_1}$ belonging to cell ***i***. If *D* is chosen sufficiently large, the co-channel interference remains small enough not to affect speech quality.

  $$D = R\sqrt{3K}$$

  Where: D: the frequency reuse distance
  R: cell radius
  K:number of cells per cluster

The spatial repetition of frequencies is done in a regular systematic way, i.e. each cell with the *frequency allocation* fb_i (or one of its frequencies) sees its neighbors with the same frequencies again at a distance *D* (Figure 2.8). Therefore there exist exactly six such next neighbor cells. Independent of form and size of the cells _ not only in the hexagon model _ the first ring in the frequency set contains six co-channel cells (see also Figure 2.9).

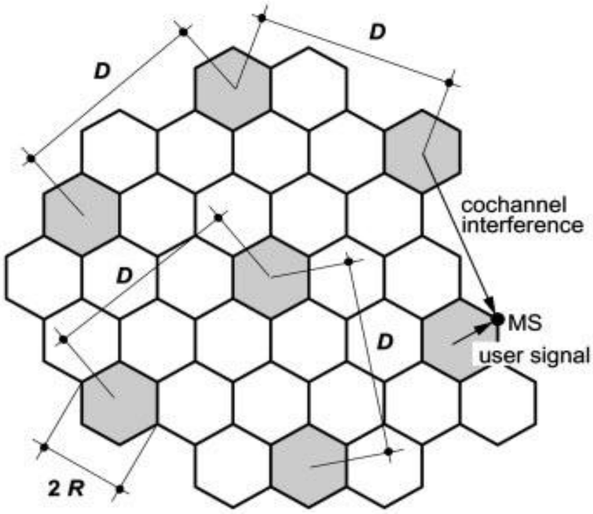


Figure 2.8 Model of cellular network with frequency reuse [5]

- ✓ **Cluster**: The set of cells that use System channels, no channels are reused within a cluster. (figure 2.9)

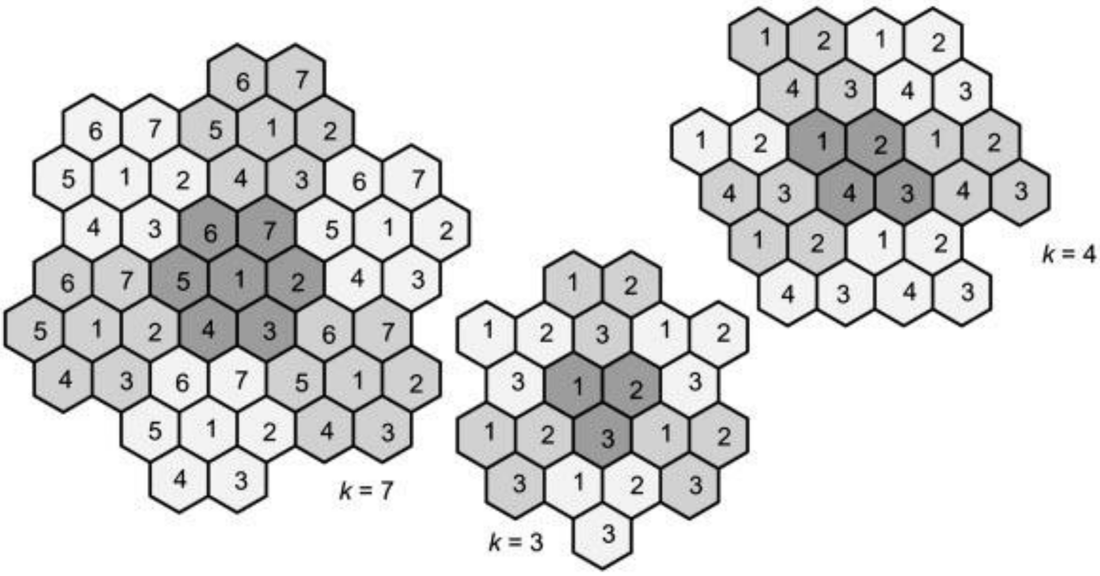


Figure 2.9 Frequency reuse and cluster formation [5]

2.2.2 Handoff:

The final obstacle in the development of the cellular network involved the problem created when a mobile subscriber traveled from one cell to another during a call. As adjacent areas do not use the same radio channels, a call must either be dropped or transferred from one radio channel to another when a user crosses the line between adjacent cells. Because dropping the call is unacceptable, the process of handoff was created . Handoff occurs when the mobile telephone network automatically transfers a call from radio channel to radio channel as a mobile crosses adjacent cells (see Figure 2.10).

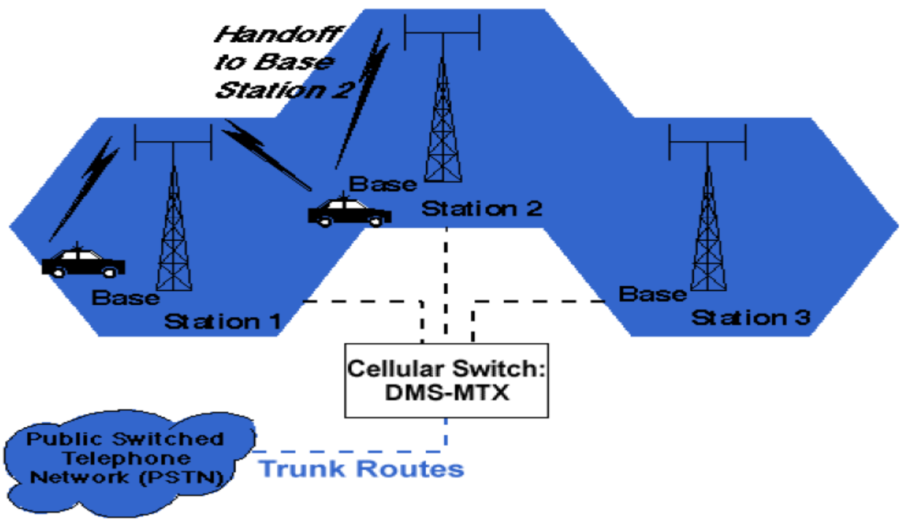


Figure 2.10 Handoff between adjacent cells [7]

During a call, and when the mobile unit moves out of the coverage area of a given cell, the reception becomes weak. At this point, the cell in use requests a handoff. The system switches the call to a stronger frequency channel in a new site without interrupting the call or alerting the user[7] .

2.2.3 Roaming

All cellular systems provide a service called roaming, This allows subscribers to operate in service areas other than the one from which service is subscribed.

When a mobile enters a city or geographic area that is different from its home service area, it is registered as a roamer in the new service area [8].

2.3 Determining the subscriber location:

In the field of mobile networks, the term “localization” is used for denoting a variety of techniques aimed to mobility prediction, which is computing and tracking the position of mobile station.

There are many ways of mobile positioning, which can widely be divided into two major categories – network based and handset based localization methods.

2.3.1 Network-based Mobile localization Technology:

This category is referred to as "network based" because the mobile network, in conjunction with network-based location determination equipment is used to position the mobile device. They are basically the Multilateral (multiple BSs measuring simultaneously), Time Difference of Arrival (TDOA), Angle of Arrival (AOA) approaches, and Localization using wide signal strength Fingerprints.

2.3.1.1 Multilateration (TDOA)

Multilatration is the process of locating an object by accurately computing the time difference of arrival (TDOA) of a signal emitted from that object to three or more receivers. It also refers to the case of locating a receiver by measuring the TDOA of a signal transmitted from three or more synchronised transmitters.

Multilateration is commonly used to accurately locate moving object, and stationary emitter by measuring the time difference of arrival (TDOA) of a signal from the emitter at three or more receiver sites.

If a pulse is emitted from a transmitter, it will arrive at slightly different times at two separated receiver sites, the TDOA being due to the different distances of each receiver from the transmitter. In fact, for given locations of the two receivers, a whole set of emitter locations would give the same measurement of TDOA. Given two receiver locations and a known TDOA, the locus of possible emitter locations is a one half of a two-sheeted hyperboloid as shown in figure 2.11.

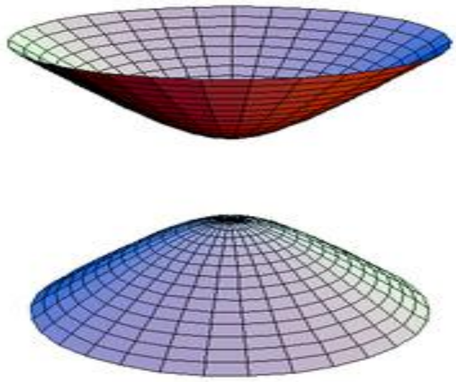


Figure 2.11 two-sheeted hyperboloid

In simple terms, with two receivers at known locations, an emitter can be located onto a hyperboloid. Note that the receivers do not need to know the absolute time at which the pulse was transmitted - only the time difference is needed.

Consider now a third receiver at a third location. This would provide a second TDOA measurement, and hence locate the emitter on a second hyperboloid. The intersection of these two hyperboloids describes a curve on which the emitter lies.

If a fourth receiver is now introduced, a third TDOA measurement is available and the intersection of the resulting third hyperboloid with the curve already found with the other three receivers defines a unique point in space. The emitter's location is therefore fully determined in 3D.

In practice, errors in the measurement of the time of arrival of pulses mean that enhanced accuracy can be obtained with more than four receivers. In general, N receivers provide $N-1$ hyperboloids. When there are $N>4$ receivers, the $N-1$ hyperboloids should, assuming a perfect model and measurements, intersect on a single point. In reality, the surfaces rarely intersect, because of various errors. In this case, the location problem can be considered as an optimization problem.

Additionally, the TDOA of multiple transmitted pulses from the emitter can be averaged to improve accuracy.

** contrast case: locating a receiver from multiple transmitter sites:*

Multilateration can also be used by a single receiver to locate itself, by measuring the TDOA of signals emitted from three or more synchronized transmitters at known locations. This can be used by navigation systems, an example being the British DECCA navigation system, developed during World War II, which used the phase-difference of two transmitters, rather than the TDOA of a pulse, to define the hyperboloids. This allowed the transmitters to broadcast a continuous wave signal. Phase-difference and time-difference can be considered the same for narrow-band transmitters.

** TDOA geometry:*

Consider an transmitter (E in Figure2.12) at an unknown location vector

$$E = (x, y, z)$$

which we wish to locate. The source is within range of N+1 receivers at known locations

$$P0, P1, ..., Pm, ..., PN.$$

The subscript m refers to any one of the receivers:

$$Pm = (xm, ym, zm)$$

$$0 \leq m \leq N$$

The distance (R) from the emitter to one of the receivers in terms of the coordinates is

$$R_m = \left| P_m - E \right| = \sqrt{(x_m - x)^2 - (y_m - y)^2 - (z_m - z)^2} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

The math is made easier by placing the origin at one of the receivers (P0), which makes its distance to the emitter

$$Ro = \sqrt{x^2 + y^2 + z^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

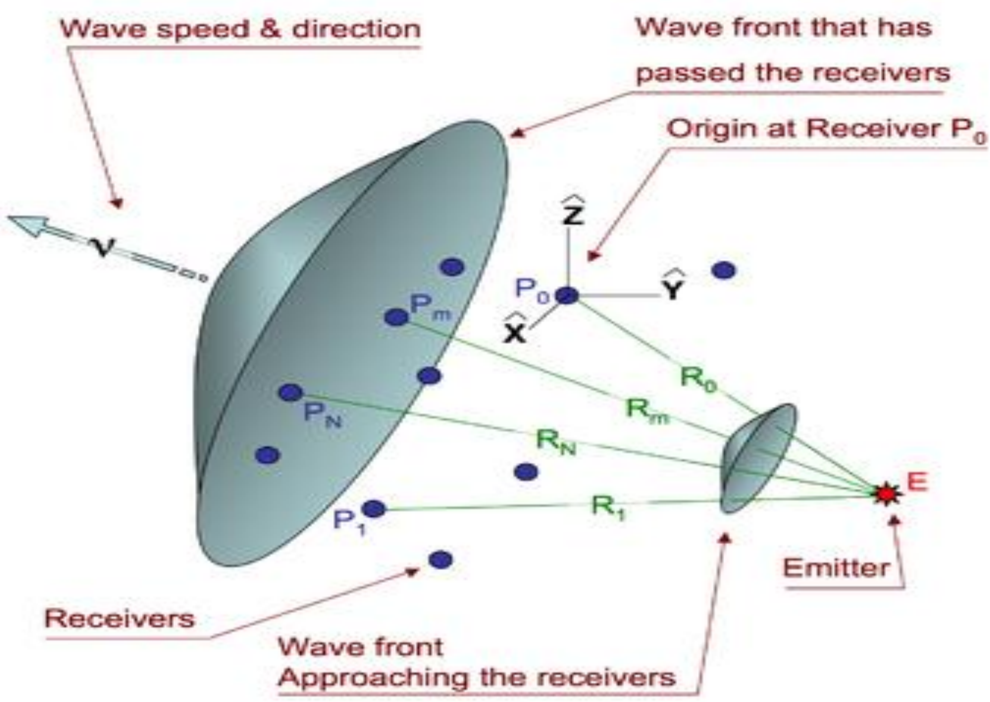


Figure 2.12 TDOA geometry [9]

** Measuring the Time Difference in a TDOA System*

The distance Rm in equation 1 is the wave speed (v) times transit time *(Tm)*. A TDOA multilateration system measures the time difference (*τm*) of a wavefront touching each receiver. The TDOA equation for receivers m and 0 is

$$\upsilon\tau_m = \upsilon T_m - \upsilon T_o$$

$$\upsilon\tau_m = R_m - R_o$$

2.3.1.2. Triangulation (AOA)

Triangulation is the process of determining the location of a point by measuring angles to it from known points at either end of a fixed baseline, rather than measuring distances to the point directly (multilateration). The point can then be fixed as the third point of a triangle with one known side and two known angles.

Triangulation can also refer to the accurate surveying of systems of very large triangles, called triangulation networks. This followed from the work of Willebrord Snell in 1615-17, who showed how a point could be located from the angles subtended from three known points, but measured at the new unknown point rather than the previously fixed points, a problem called resectioning. Surveying error is minimized if a mesh of triangles at the largest appropriate scale is established first, that points inside the triangles can all then be accurately located with reference to. Such triangulation methods of accurate large-scale land surveying until the rise of Global navigation satellite systems in the 1980s.

**** Distance to a point by measuring two fixed angles***

The coordinates and distance to a point can be found by calculating the length of one side of a triangle, given measurements of angles and sides of the triangle formed by that point and two other known reference points.

The following formulas apply in flat or Euclidean geometry. They become inaccurate if distances become appreciable compared to the curvature of the Earth, but can be replaced with more complicated results derived using spherical trigonometry.

**** Calculation***

Triangulation can be used to calculate the coordinates and distance from the shore to the ship. The observer at A measures the angle α between the shore and the ship, and the observer at B does likewise for β . With the length l or the coordinates of A and B known, then the law of sines can be applied to find the coordinates of the ship at C and the distance.

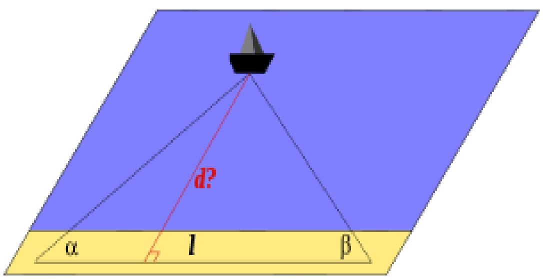


Figure 2.13 TDOA geometry [10]

$$l = \frac{d}{\tan\alpha} + \frac{d}{\tan\beta}$$

Therefore

$$d = l \,/\, (\frac{1}{\tan\alpha} + \frac{1}{\tan\beta})$$

Using the trigonometric identities tan α = sin α / cos α

and sin(α + β) = sin α cos β + cos α sin β, this is equivalent to:

$$d = \frac{l\,.\,\sin\alpha\,.\sin\beta}{\sin(\alpha+\beta)}$$

From this, it is easy to determine the distance of the unknown point from either observation point, its north/south and east/west offsets from the observation point, and finally its full coordinate[10].

2.3.1.3 GSM-based indoor localization:

GSM-based indoor localization possible is the use of wide signal-strength fingerprints. In addition to the 6-strongest cells traditionally used in the GSM standard, the wide fingerprint includes readings from additional cells that are strong enough to be detected, but too weak to be used for efficient communication., an indoor localization system based on wide area GSM fingerprints can achieve high accuracy, and is in fact comparable to an 802.11-based implementation.

**** GSM-based indoor localization has several benefits:***

1. the wide acceptance of cellular phones makes them ideal path for the computing of positions. A localization system based on cellular signals, such as GSM, leverages the phone’s existing hardware and removes the need for additional radio interfaces.

2. because cellular towers are dispersed across the covered area, a cellular-based localization system would still work in situations where a building’s electrical infrastructure has failed. Moreover, cellular systems are designed to tolerate power failures.

3. GSM, unlike 802.11 networks, operates in a licensed band, and therefore does not suffer from interference from nearby devices transmitting on the same frequency (e.g., microwaves, cordless phones).

Bahl et al observed that the strength of the signal from an 802.11 access point does not vary significantly in a given location , Due to the larger range of GSM cells, 802.11 fingerprinting will be more accurate than GSM fingerprinting given the same number of radio sources.

GSM is the most widespread cellular telephony standard in the world, and operates on the 850 MHz and 1900 MHz frequency bands.

Each band is subdivided into 200 KHz wide physical channels using Frequency Division Multiple Access (FDMA). Each physical channel is then subdivided into 8 logical channels based on Time Division Multiple Access (TDMA).

A GSM base station is typically equipped with a number of directional antennas that define sectors of coverage or cells. Each cell is allocated a number of physical channels based on the expected traffic load and the operator's requirements. Typically, the channels are allocated in a way that both increases coverage and reduces interference between cells. Thus, for example, two neighboring cells will never be assigned the same channel. Channels are, however, reused across cells that are far-enough away from each other so that inter-cell interference is minimized while channel reuse is maximized. The channel to cell allocation is a complex and costly process that requires careful planning and typically involves

field measurements and extensive computer-based simulations of radio accurate GSM Indoor Localization 145 signal propagation. Therefore, once the mapping between cells and frequencies has been established, it rarely changes. Every GSM cell has a special broadcast control channel (BCCH) used to transmit, among other things, the identities of neighboring cells to be monitored by mobile stations for handover purposes. While GSM employs transmission power control both at the base station and the mobile device, the data on the BCCH is transmitted at a full constant power. This allows mobile stations to compare signal strength of neighboring cells in a meaningful manner and choose
the best one for further communication. It is these BCCH channels that we use for localization.

* *Fingerprinting*

Two factors lead to the good performance of radio fingerprinting in the wireless band used by GSM and 802.11 networks. The first is that the signal strengths observed by mobile devices exhibit considerable spatial variability at the 1-10M level. That is to say, a given radio source may be heard stronger or not at all a few meters away. The second factor is that these same signal strengths are consistent in time; the signal strength from a given source at a given location is likely to be similar tomorrow and next week. In combination, this means that there is a radio profile that is feature-rich in space and reasonably consistent in time. Fingerprinting-based location techniques take advantage of this by capturing this radio profile for later reference.

To compare the stability of GSM and 802.11 signals, we recorded the signal strength of nearby 802.11 access points (AP) and 6-strongest GSM cells at several locations . GSM signals appear to be more stable than 802.11 signals. We believe that this is because 802.11 uses unlicensed overcrowded 2.4 GHz band, and therefore suffers from interference from nearby appliances such as microwaves and cordless phones.

Fingerprinting relies on a “training phase” in which a mobile device moves through the environment recording the strength of signals relates to the radio sources (e.g., 802.11 access points, GSM base stations, FM radio or TV stations). We refer to the physical position where the measurement is performed as a location, to the radio scan as a measurement and to the recording of the signal strength of a single source as a reading. That is, to build a radio map of the building, a mobile device takes a series of measurements in multiple locations of the building. Each measurement is composed of several readings; one for each radio source in range. The set of data recorded in a single location is also referred to as a training point. Since fingerprinting systems do not model radio propagation, a fairly dense collection of radio scans needs to be collected to achieve good accuracy.

Once the training phase is complete, a client can estimate its location by performing a radio scan (or equivalently collecting a testing point) and feeding it to a localization algorithm, which estimates the client’s location based on the similarity of the signal strength signatures between the testing and the training points. The similarity of signatures can be computed in a variety of ways, but it typically involves finding measurements in the training points that have the same radio sources with similar signal strengths. The easiest technique for estimating location is to choose the location of the training point with the closest Euclidean distance in a signal space. Better accuracy can be achieved by averaging the location of the K closest neighbors (or training points) in the radio map, where K is some small constant. It is also beneficial to use weighted averaging, so that neighbors closer in signal space are given higher weights [11].

2.3.2 Handset-based Mobile Positioning Technology:

This technology is referred to as "handset based" because the handset itself is the primary means of positioning the user, although the network can be used to provide assistance in taking the mobile device and/or making position estimate determinations based on measurement data and handset based position determination algorithms.

2.3.2.1 The Global Positioning System (GPS)

GPS is a space-based global navigation satellite system (GNSS) that provides reliable location and time information in all weather and at all times and anywhere on or near the Earth when and where there is an unobstructed line of sight to four or more GPS satellites.

GPS consists of three parts: the space segment, the control segment, and the user segment. GPS satellites broadcast signals from space, and each GPS receiver uses these signals to calculate its three-dimensional location (latitude, longitude, and altitude) and the current time [12].

The space segment is composed of 24 to 32 satellites in medium Earth orbit that transmit one-way signals that give the current GPS satellite position and time.

The control segment is consists of worldwide monitor and control stations that maintains the satellite in their in their proper orbits through occasional command maneuvers , and adjust the satellite clocks. It tracks the GPS satellites uploads updated navigational data, and maintains health and status of the satellite constellation.

The user segment consists of the GPS receiver equipment , which receives the signals from the GPS satellites and uses the transmitted information to calculate the user's three-dimensional position and time [4]

*** How does the GPS works?***

Three distinct parts make up the Global Positioning System. The first segment of the system consists of 24 satellites, orbiting 20,000 km above the Earth in 12-hour circular orbits. This means that it takes each satellite 12 hours to make a complete circle around the Earth. In order to make sure that they can be detected from anywhere on the Earth's surface, the satellites are divided into six groups of four. Each group is assigned a different path to follow. This creates six orbital planes which completely surround the Earth.

These satellites send radio signals to Earth that contain information about the satellite. Using GPS ground-based receivers, these signals can be detected and used to determine the receivers' positions (latitude, longitude, height.) The radio signals are sent at two different L-band frequencies. L-band refers to a range of frequencies between 390 and 1550 MHz. Within each signal, a coded sequence is sent. By comparing the received sequence with the original sequence, scientists can determine how long it takes for the signal to reach the Earth from the satellite. The signal delay is useful in learning about the Ionosphere and the Troposphere, two atmospheric layers that surround Earth's surface. A third signal is also sent to the receivers from the satellite. This signal contains data about the health and position of the satellite.

The second part of the GPS system is the ground station, comprised of a receiver and antenna, as well as communication tools to transmit data to the data center. The omni-directional antenna at each site, acting much like a car radio antenna, picks up the satellite signals and transmits them to the site receiver as electric currents. The receiver then separates the signals into different channels designated for a particular satellite and frequency at a particular time. Once the signals have been isolated, the receiver can decode them and split them into individual frequencies. With this information the receiver produces a general position (latitude, longitude, and height) for the antenna. Later, the data collected by the receiver can be processed again by scientists to determine different things, including another set of position coordinates for the same antenna, this time with millimeter accuracy.

The third part of the system is the data center. The role of the data center is doubled . It both monitors and controls the global GPS stations, and it uses automated computer systems to retrieve and analyze data from the receivers at those stations. Once processed, the data , along with the original raw data, is made available to scientists around the world for use in a variety of applications. Since global GPS sites are constructed and monitored by different institutions all over the world, there are many different data center locations [13].

2.3.2.2 Universal Transverse Mercator projection

The universal transverse Mercator (UTM) is a map projection that is based completely on the original transverse Mercator, with a secant cylinder (Figure 2.14). With UTM, however, the Earth (i.e., the ellipsoid) is divided into 60 zones of the same size; each zone has its own central meridian that is located at exactly the middle of the zone [14]. This means that each zone covers 6° of longitude, 3° on each side of the zone's central meridian. Each zone is projected separately (i.e., the imaginary cylinder will be rotated around the Earth), which leads to a much smaller distortion compared with the original transverse Mercator projection. Each zone is assigned a number ranging from 1 to 60, starting from λ= 180° W, and increases eastward (i.e., zone 1 starts at 180° W and ends at 174° W with its central meridian at 177° W) see Figure 2.15.

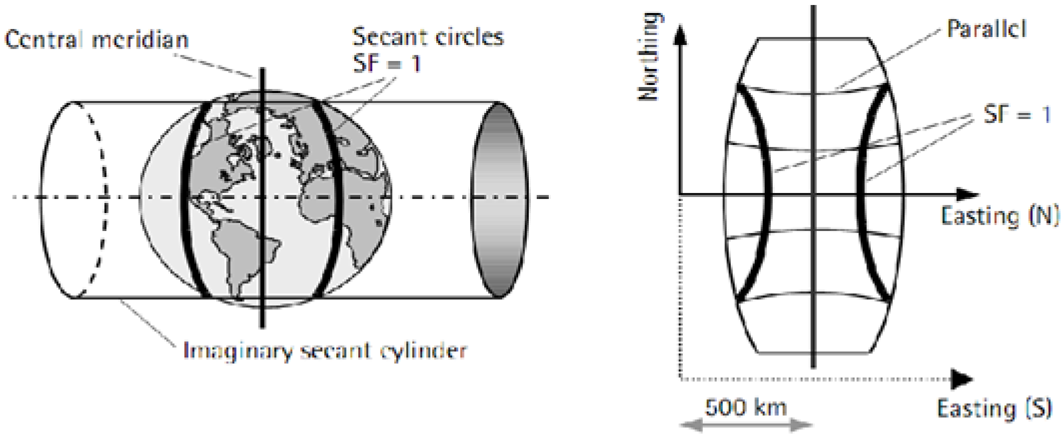


Figure 2.14 UTM Projection [14]

UTM utilizes a scale factor of 0.9996 along the zone's central meridian (Figure 2.14). The reason for selecting this scale factor is to have a more uniformly distributed scale, with a minimum deviation from one, over the entire zone. For example, at the equator, the scale factor changes from 0.9996 at the central meridian to 1.00097 at the edge of the zone, while atmidlatitude (ϕ =45° N), the scale changes from 0.9996 at the central meridian to 1.00029 at the edge of the zone. This shows how the distortion is kept at a minimal level with UTM.

Figure 2.15 UTM Zoning [14]

To avoid negative coordinates, the true origin of the grid coordinates (i.e., where the equator meets the central meridian of the zone) is shifted by introducing the so-called false northing and false easting (Figure 2.14). The false northing and false easting take different values, depending on whether we are in the northern or the southern hemisphere. For the northern hemisphere, the false northing and false easting are 0.0 km and 500 km, respectively, while for the southern hemisphere, they are 10,000 km, and 500 km, respectively.

A final point to be made here is that UTM is not suitable for projecting the polar regions. This is mainly due to the many zones to be involved when projecting a small polar area. Other projection types, such as the stereographic double projection, may be used .

2.3.2.3 Modified Transverse Mercator projection

The modified transverse Mercator (MTM) projection is another projection that, similar to the UTM, is based completely on the original transverse Mercator, with a secant cylinder [14]. MTM is used in some Canadian provinces such as the province of Ontario. With MTM, a region is divided into zones of 3° of longitude each (i.e., 1.5° on each side of the zone's central meridian). Similar to UTM, each zone is projected separately, which leads to a small distortion. In Canada, the first zone starts at some point just east of Newfoundland (λ =51° 30'W), and increases westward. Canada is covered by a total of 32 zones, while the province of Ontario is covered by 10 zones (zones 8 through 17). Figure 2.16 shows zone 10, where the city of Toronto is located.

MTM utilizes a scale factor of 0.9999 along the zone's central meridian (Figure 2.16). This leads to even less distortion throughout the zone, as compared with the UTM. For example, at a latitude of ϕ = 43.5° N, the scale factor changes from 0.9999 at the central meridian to 1.0000803 at the boundary of the zone. This shows how the scale variation and, consequently, the distortion are minimized with MTM [14]. This, however, has the disadvantage that the number of zones is doubled.

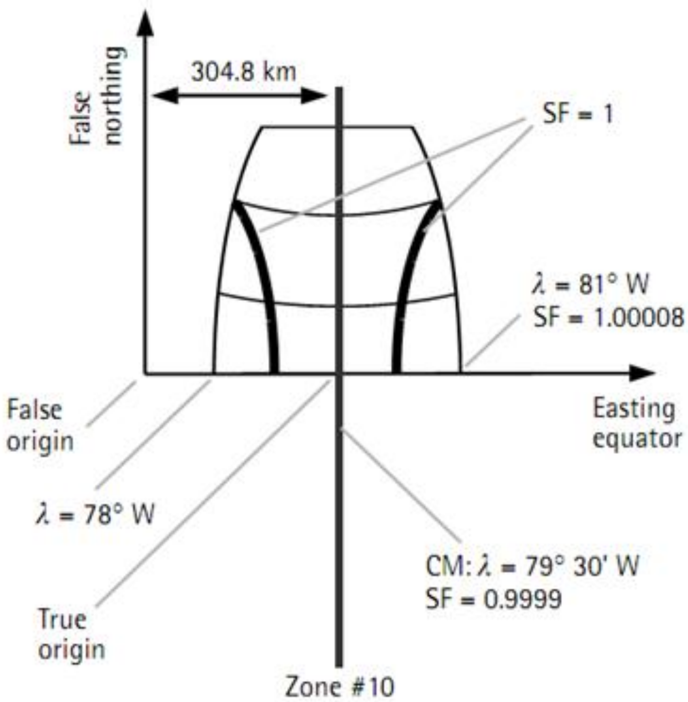


Figure 2.16 MTM Projection [14]

Similar to UTM, to avoid negative coordinates, the true origin of the grid coordinates is shifted by introducing the false northing and false easting. As Canada is completely located in the northern hemisphere, there is only one false northing and one false easting of 0.0 m and 304,800 m, respectively (see Figure 4.10).

- ***Converting Latitude and longitude to UTM***

These formulas are slightly modified from Army (1973). These are accurate to within less than a meter within grid zone.

P= point under consideration.

Lat = latitude point.

Long = longitude of point.

Long0 = central meridian of zone.

For example: Palestine located between 30 and 36; so $long0 = \frac{30+36}{2} = 33$

K0= scale along long0 = 0.9996.

$a = 6378137$

$b = 6356752.3142$

$e = \sqrt{(1 - b^2)/a^2} \approx 0.08$ .this is the eccentricity of the earth's elliptical cross section.

$e'^2 = (ea/b)^2 = e^2/(1 - e^2) \approx 0.007$. the quantity e' only occurs in even powers, so it need only be calculated as e'^2 .

$$n = \frac{a - b}{a + b}$$

$nu = a/\sqrt{1 - e^2 \sin^2(lat)}$. this is the radius of curvature of the earth perpendicular to the meridian plane. It is also the distance from the point in equation to the polar axis, measured perpendicular to the earth's surface.

P=(long-long0)

- ***Calculate the Meridional Arc:***

S is the meridional arc through the point in equation (the distance along the earth's surface from the equator). All angles are in radian.

- $S = A'lat - B'\sin(2lat) + C'\sin(4lat) - D'\sin(6lat) + E'\sin(8lat)$, where lat in radians
- $A' = a\left[1 - n + \left(\frac{5}{4}\right)(n^2 - n^3) + \left(\frac{81}{64}\right)(n^4 - n^5) \ldots..\right]$
- $B' = \left(\frac{3an}{2}\right)\left[1 - n + \left(\frac{7}{8}\right)(n^2 - n^3) + \left(\frac{55}{64}\right)(n^4 - n^5) \ldots..\right]$
- $C' = \left(\frac{15an^2}{16}\right)\left[1 - n + \left(\frac{3}{4}\right)(n^2 - n^3) \ldots..\right]$
- $D' = \left(\frac{35an^3}{48}\right)\left[1 - n + \left(\frac{11}{16}\right)(n^2 - n^3) \ldots..\right]$
- $E' = \left(\frac{315an^4}{51}\right)[1 - n \ldots..]$

$$k1 = Sk0$$

$$k2 = \frac{k0\, nu \sin(lat)\cos(lat)}{2}$$

$$k3 = \left[k0 \frac{nu \sin(lat)\, cos^3(lat)}{24}\right]\left[5 - tan^2(lat) + 9e'^2 cos^2(lat) + 4e'^4 cos^4(lat)\right]$$

$$k4 = ko\, nu \cos(lat)$$

$$k5 = \left(k0\, nu \frac{cos^3(lat)}{6}\right)\left[1 - tan^2(lat) + e'^2 cos^2(lat)\right]$$

Now;

$$Y = Northing = k1 + k2P^2 + k3P^4$$

$$X = Easting = k4P + K5P^3 \quad ,$$

NOTE: Easting X is relative to the central meridian. For conventional UTM easting ass 500000 meters to X

Finally; For calculating distance between two points we use the following formula:

$$Distance = \sqrt{(X1 - X2)^2 + (Y1 - Y2)^2} \quad \text{in meters.}$$

2.4 The Mobile Phone:

The cell phone that could be used in the project must have GPS utilization in order to determine the place where dose the mosque lies, it's operating system must allow our code to change the profile of the cell phone, also it must be able to catch the tower ids that support the cell phone in the place of mosque.

2.4.1 Mobile Operating System:

The operating systems is responsible for determining the functions and features available on the mobile phone, such as thumbwheel, keyboard, WAP, synchronization with applications, e-mail, GPS, text messaging and more.

In the world of mobile phones there is several operating systems such like, symbian OS , windows OS, palm OS , mobile Linux, and MXI, the most popular one is symbian .

2.4.1.1 Symbian OS:

Symbian is an operating system derives from the Epoc operating system. Epoc was developed by Psion for their handhelds in the 80's. Symbian is an evolution designed to be used in mobile phones, and comes to real devices indifferent flavors.

Symbian OS was created with three systems design principles in mind:

- the integrity and security of user data is paramount,
- user time must not be wasted, and
- all resources are scarce.

To best follow these principles, Symbian uses a microkernel, which has a request-and-callback approach to services, and maintains separation between user interface and engine. The OS is optimized for low-power battery-based devices and for ROM-based systems. The Applications, and the OS itself, follow an object-oriented design.

* *Developing on Symbian OS*

There are multiple platforms, based upon Symbian OS, that provides an SDK for application developers wishing to target a Symbian oS device , the main ones being UIQ, Series 60, etc. individual phone products, or families, often have SDKs or SDK extensions downloadable from the manufacturer's website too. The SDKs contain documentation, the header files and library files required to build Symbian OS software, and a Windows-based emulator ("WINS"). Up until Symbian OS version 8, the SDKs also include a version of the GCC compiler (a cross-compiler) required to build software to work on the device.

2.4.2 Mobile Programming Language:

As we said in the introduction of this chapter, the goal of this project is to build a mobile based application that block the cell phone for incoming calls, so this application need to interact with GSM network and GPS.

It is an important issue in the project to choose a suitable programming language that could be used to implement all the requirements of the project in the optimal way.

After reading and search we found that there is two standard mobile programming languages; J2ME and QT, in the following sections we will discuss both of them , each one with its specifications.

2.4.2.1 J2ME

Java 2 Platform, Micro Edition (J2ME), is the edition of the Java platform that is targeted at small, standalone or connectable consumer and embedded devices. J2ME technology consists of a virtual machine and a set of APIs suitable for tailored runtime environments for these devices. J2ME technology has two primary kinds of components – configurations and profiles.

The Java Me technology is based on three elements:

- A configuration provides the most basic set of libraries and virtual machine capabilities for a board range devices.
- A profile is a set of APIs that support a narrower range of devices.
- An optional package is a set of technology-specific APIs.

Overtime the Java Me platform has been divided into two base configuration, one to fit small mobile devices and one to be targeted towards more capable mobile devices like smart-phones and set top boxes.

The configuration for small devices is called the Connected Limited Device Profile (CLDC) and the more capable configuration is called the Connected Device Profile (CDC).

2.4.2.2 QT

Qt is a cross-platform application and UI framework used by hundreds of thousands of developers worldwide looking to create amazing user experiences on Windows, Mac, Linux/X11, embedded Linux, Windows CE , Windows Mobile, Symbian and Maemo devices.

Qt is used by thousands of companies in a multitude of leading industries enabling them to develop software and devices used by hundreds of millions of people every day.

* *Development of Qt on Symbian*

Qt applications are developed with C++ enhanced with additional extensions implemented by a pre-processor that generates standard C++ code before compilation. Qt also provides bindings for several other programming languages, like Python, Ruby and Perl.

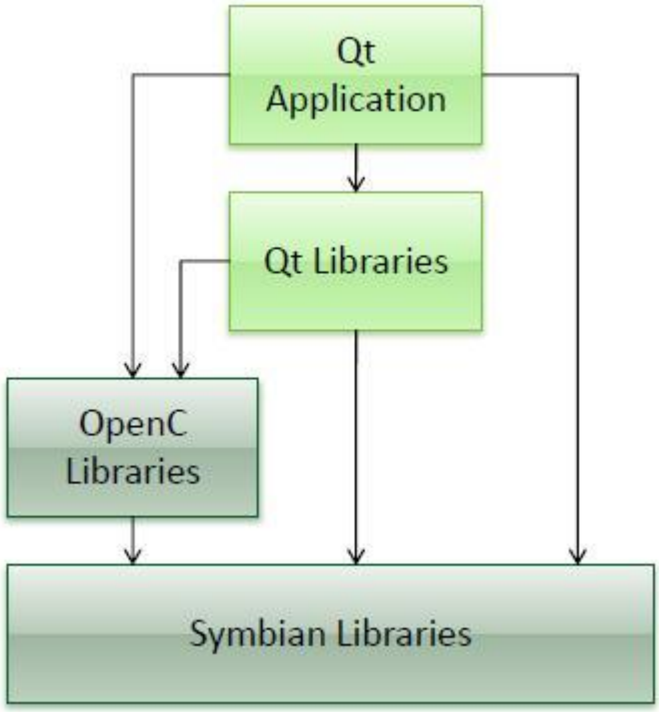


Figure 2.17 Qt Platform

Qt is notably used because of its GUI widgets, but also provides a set of non-GUI related features: SQL database access, XML parsing, thread management, network support and a unified cross-platform API for file handling. Qt has been successfully ported to the Nokia Symbian S60, Maemo, and MeeGo platforms.

Qt Mobility has been completely ported to Symbian, and commonly used mobile features are accessible through the Qt Mobility APIs such as camera, geolocation, and contacts APIs. There are rapid on-going progress of making all mobile features accessible, and some features which are not provided by Qt Mobility APIs can still be accessed through native Symbian APIs.

In order to develop Qt Symbian applications, you simply need to install the Nokia Qt SDK, which contains Qt SDK, Qt Mobility SDK, Qt Creator, Qt Simulator for Symbian and N900, and libraries, tools (including the emulator for S60 environment).

2.5 Summary

This chapter shows the theoretical background for the project that includes the detailed view of GSM and cellular network, and overview of the localization techniques that may be used in this project.

CHAPTER THREE 3

Project Design

3.1 Introduction

3.2 System entities

3.3 System Function

3.4 Block diagrams

3.5 System models

3.6 Data flow diagram

3.7 Summary

3.1 Introduction:

After explaining the theoretical background previously, chapter three comes to describe the general block diagram of the system as well as the specific system design with all its features that enable the system to work as required.

This chapter introduces two options for the system design to provide the network with information about the mobile location. Accordingly, this will allow the system to be able to change the mode of the mobile to silent during the prayer time:

1. The first option depends on GPS system: we will deal with GPS latitude, and longitude information that will be received from satellites orbiting around the earth to detect the approximate location.

2. In the second option, we will deal with GSM network to track the mobile location based on signal strength measurements.

Here, the usage of software only to achieve the goal of this project is a major feature. There is no hardware needed to build up from the original device. Instead, the usage of the GPS satellites, GSM tower signals, and the mobile phone itself as hardware for this project represent the important entities which will be described in detail later. Additionally, the description will include the used methodology in the work design.

3.2 System Entities:

A. Global Positioning System (GPS):

The GPS provides reliable location and time information in all weather, and at all times and anywhere on or near the Earth, when and where there is an unobstructed line of sight to four or more GPS satellites.

B. GPS Receiver :

A device that receives Global Positioning System (GPS) signals for the purpose of determining the device's current location on earth.

C. Mobile station:

It is a device used by mobile service subscribers for accessing services. It consist of two major elements: the *Mobile Equipment* and the *Subscriber Identity Module (*SIM).

D. Base Transceiver Station (BTS):

The BTS provides the physical connection of an MS to the network in form of the Air-interface.

E. Base Station Controller (BSC):

The BSC forms the center of the Base Station Subsystem (BSS), which takes care of all the central functions and the control of the (BSS).

F. Mobile Switching Center (MSC):

The MSC is mainly an exchanger with a switching capacity. It handles incoming and outgoing trunks. It also has functions to supervise calls and routines for charging and statistics purposes. It is the ability to handle mobile calls that turns it into an MSC. So far, the MSC can be compared with any ordinary switch in the fixed network.

G. Home Location Register (HLR):

The HLR is the main database that holds files for all the MSs in an operator's network.

H. Visitor Location Register (VLR):

The VLR is a database that holds a file for an MSs presents in an area controlled by the connected MSC. It is a file which will be erased in that specific VLR when the MS leaves that area.

3.3 System Function:

This project aims to achieve the following objectives:

1. Localize the mosque location using one or both of the following technologies:

   * GPS Technology.
   * GSM Network Technology.

2. Build a mobile software that detect the active location coordinates, then compare them to stored information, if there is a match then the software will test if it is a time of prayer, if yes moves the cell phone to SALAH profile.

3. Make this software working automatically without human or user intervention.

4. Design a website for marketing purposes.

3.4 Block diagrams:

3.4.1 Global Positioning System (GPS):

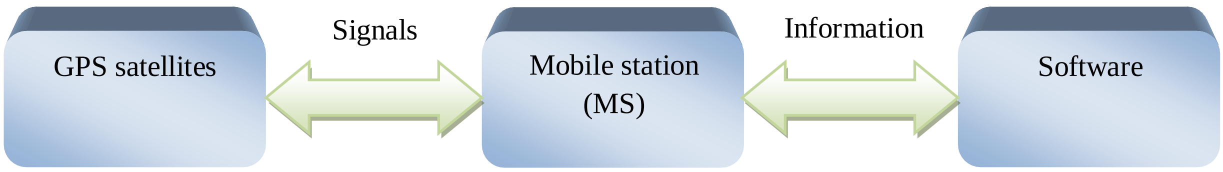


Figure 3.1: Block diagram for (GPS)

The GPS satellites broadcast signals, then the mobile receives these signals and analyze them by a software to give information about its current location. Then, according to this information, the mobile decides whether to change to silent mode or not.

3.4.2 Received Signal Strength Indicator (RSSI):

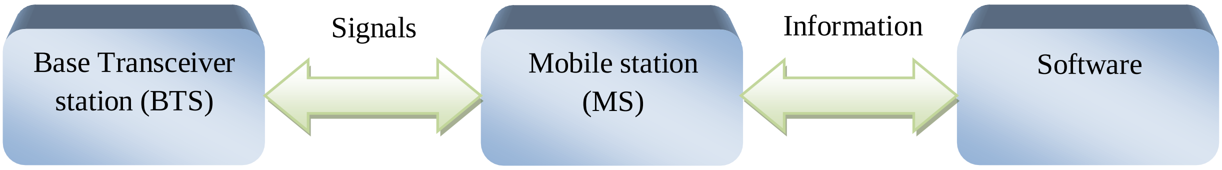


Figure 3.2: Block diagram for (RSSI) measurement

The mobile station (MS) takes the signals from the base transceiver stations (BTS), and measures the received signals strength from each BTS. Then it analyzes them using appropriate software to identify the mobile station's location. After that, the results of the analysis are reported to the system by the mobile. Consequently, the system decides, depending on the software, whether to change to silent mode or not.

3.5 System models:

3.5.1 Mobile based option (I):

Global Positioning System (GPS):

The Global Positioning System (GPS) is a space-based global navigation satellite system (GNSS) that provides location and time information, anywhere on or near the Earth, where there is an unobstructed line of sight to four or more GPS satellites, and is freely accessible by anyone with a GPS receiver.

GPS satellite signals:

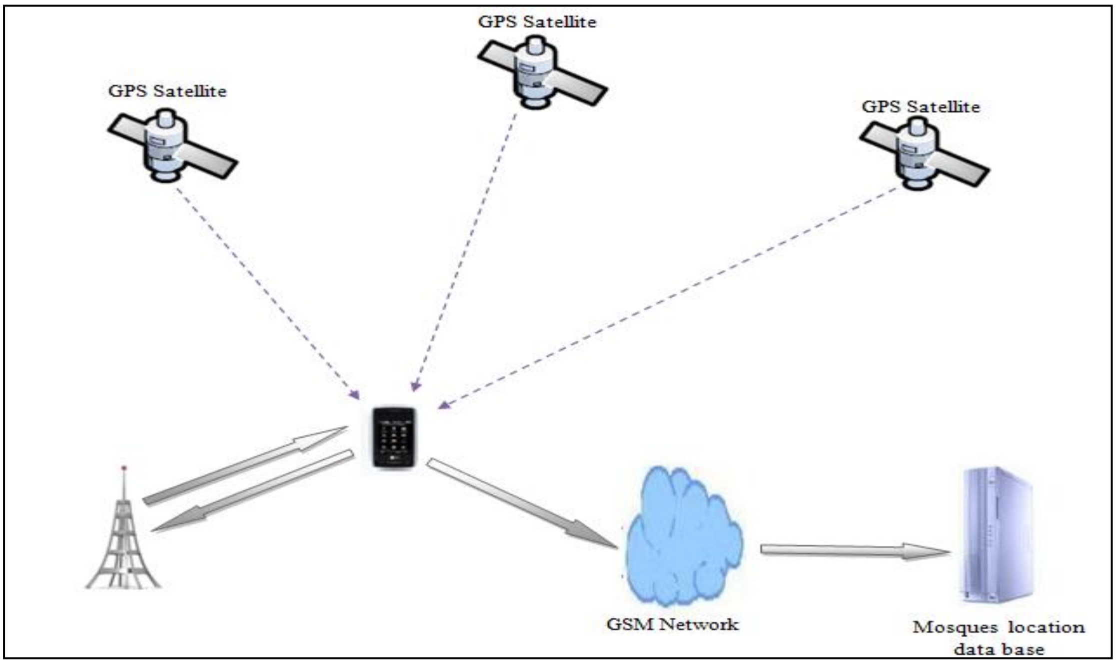


Figure 3.3: General block diagram

A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude). We will primarily be interested in the 2D positioning information (longitude and latitude).

*** GPS based location subsystem**

Latitude and Longitude Coordinates

We will be interested in the latitude and longitude that will be received from the signal.

There are three primary ways of describing locations using latitude and longitude coordinates:

1. ***Degrees Minutes Seconds (ddd° mm' ss.s")***

This is the most common format that is used on maps. This format will be converted to the degree decimal format to apply it on the equation of the distance. To convert from degrees minutes seconds to degrees decimal minutes divide the seconds by 60 to get the decimal minutes:

Decimal degree= degree ° M+(s/60)

To convert degree minute second to the format or decimal degree as follow:

Decimal degree = degree + (M/60) + (S/3600)

2. ***Degrees Decimal Minutes (ddd° mm.mmm')***

This format is used by aircraft guidance systems. If we have this format we are to convert it to the decimal degree format to determine the location. To convert degrees decimal minutes to degrees minutes seconds multiply the decimal by 60. To convert from degree decimal minute to decimal degree can be done using the following formula:

Decimal degree = (degree + (M/60) °

3. ***Decimal Degrees (ddd.dddd°)***

The United States National Weather Service and other agencies, as well as some computer based mapping systems, use this. In order to perform the equation of the distance between tow point the format must be in decimal degree. Therefore, at first we will transform the decimal into a radian measure. To do this we will multiply the latitudes and longitudes by $\pi/180$ or use in Excel =radiant(X) and = radiant(Y).

*** *The parameters that the equation of the distance will depend on it, and finally the equation of the distance:***

P= point under consideration.

Lat = latitude point.

Long = longitude of point.

Long0 = central meridian of zone.

For example: Palestine located between 30 and 36; so $long0 = \frac{30+36}{2} = 33$

K0= scale along long0 = 0.9996.

$a = 6378137$

$b = 6356752.3142$

$e = \sqrt{(1 - b^2)/a^2} \approx 0.08$ .this is the eccentricity of the earth's elliptical cross section.

$e'^2 = (ea/b)^2 = e^2/(1 - e^2) \approx 0.007$. the quantity e' only occurs in even powers, so it need only be calculated as e'^2 .

$$n = \frac{\mathrm{a} - \mathrm{b}}{\mathrm{a} + \mathrm{b}}$$

$nu = a/\sqrt{1 - e^2 sin^2(lat)}$. this is the radius of curvature of the earth perpendicular to the meridian plane. It is also the distance from the point in equation to the polar axis, measured perpendicular to the earth's surface.

P=(long-long0)

- ***Calculate the Meridional Arc:***

S is the meridional arc through the point in equation (the distance along the earth's surface from the equator). All angles are in radian.

- $\mathrm{S} = \mathrm{A'lat} - \mathrm{B'sin(2lat)} + \mathrm{C'sin(4lat)} - \mathrm{D'sin(6lat)} + \mathrm{E'sin(8lat)}$, where lat in radians
- $\mathrm{A'} = \mathrm{a}\left[1 - n + \left(\frac{5}{4}\right)(n^2 - n^3) + \left(\frac{81}{64}\right)(n^4 - n^5) \ldots..\right]$
- $\mathrm{B'} = \left(\frac{3an}{2}\right)\left[1 - n + \left(\frac{7}{8}\right)(n^2 - n^3) + \left(\frac{55}{64}\right)(n^4 - n^5) \ldots..\right]$
- $\mathrm{C'} = \left(\frac{15an^2}{16}\right)\left[1 - n + \left(\frac{3}{4}\right)(n^2 - n^3) \ldots..\right]$

- $D' = \left(\frac{35an^3}{48}\right)\left[1 - n + \left(\frac{11}{16}\right)(n^2 - n^3)\ \ldots..\right]$
- $E' = \left(\frac{315an^4}{51}\right)[1 - n\ \ldots..]$

$$k1 = Sk0$$

$$k2 = \frac{k0\ nu \sin(lat)\cos(lat)}{2}$$

$$k3 = \left[k0\frac{nu \sin(lat)\, cos^3(lat)}{24}\right]\left[5 - tan^2(lat) + 9e'^2 cos^2(lat) + 4e'^4 cos^4(lat)\right]$$

$$k4 = ko\ nu \cos(lat)$$

$$k5 = \left(k0\ nu\frac{cos^3(lat)}{6}\right)\left[1 - tan^2(lat) + e'^2 cos^2(lat)\right]$$

Now;

$$Y = Northing = k1 + k2P^2 + k3P^4$$

$$X = Easting = k4P + K5P^3 \quad ,$$

NOTE: Easting X is relative to the central meridian. For conventional UTM easting ass 500000 meters to X

Finally; For calculating distance between two points we use the following formula:

$$Distance = \sqrt{(X1 - X2)^2 + (Y1 - Y2)^2} \quad \text{in meters.}$$

Then we can calculate the distance between two points and then determine the location.

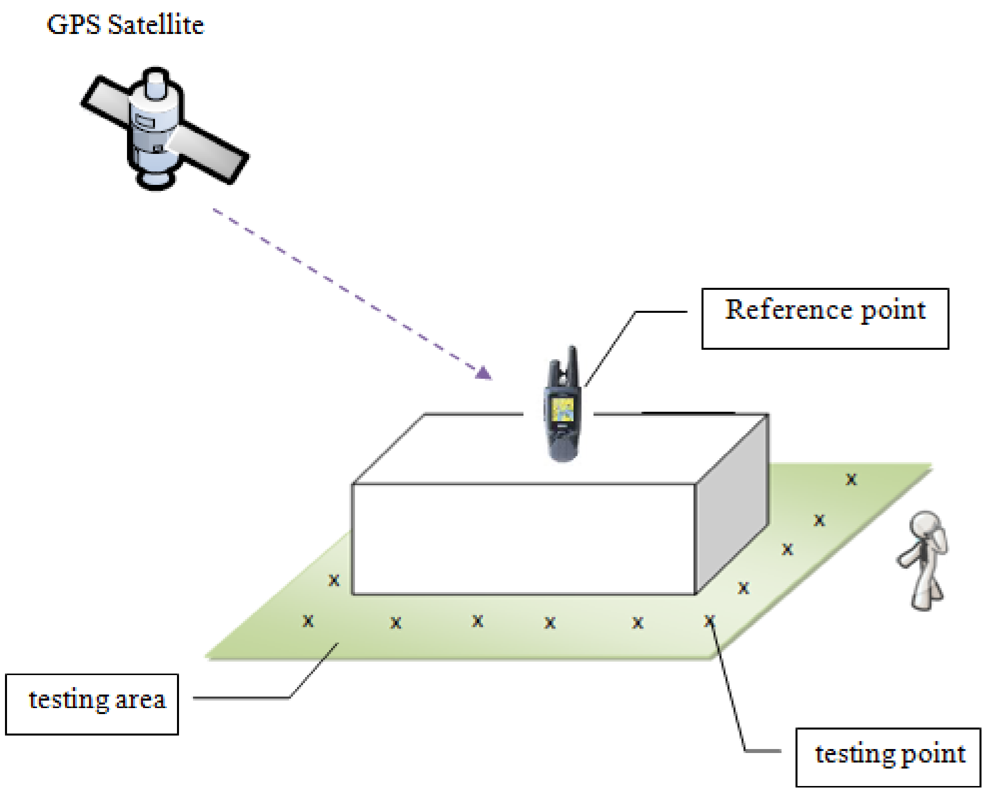


Figure 3.4: GPS model

As shown in figure 3.4 a reference point on the surface of the mosque is implemented, and the coordinates of this point is taken by a GPS receiver, in addition other points will be taken around the mosque, and to each point of these points the measurements of the position will be taken by the GPS device, according to the equation which is defined previously the distance between the reference point and each point of the surrounding points, and using a proper software these distances will be stored on Mobile station or on the network itself.

After that, using a smart phone with a software that measuring the GPS coordinates of its location, MS will estimate the distance between its GPS location and the reference points above the mosque.

Then while the MS moving it reads its position readings, and it takes these readings and compare these readings with the stored distances, if this reading is in the range of the testing area, or near of them the MS will be in silent mode depending on that.

As the surrounding points around the mosque increase, then more accuracy localization will be achieved, and the percentage of error will be decreased.

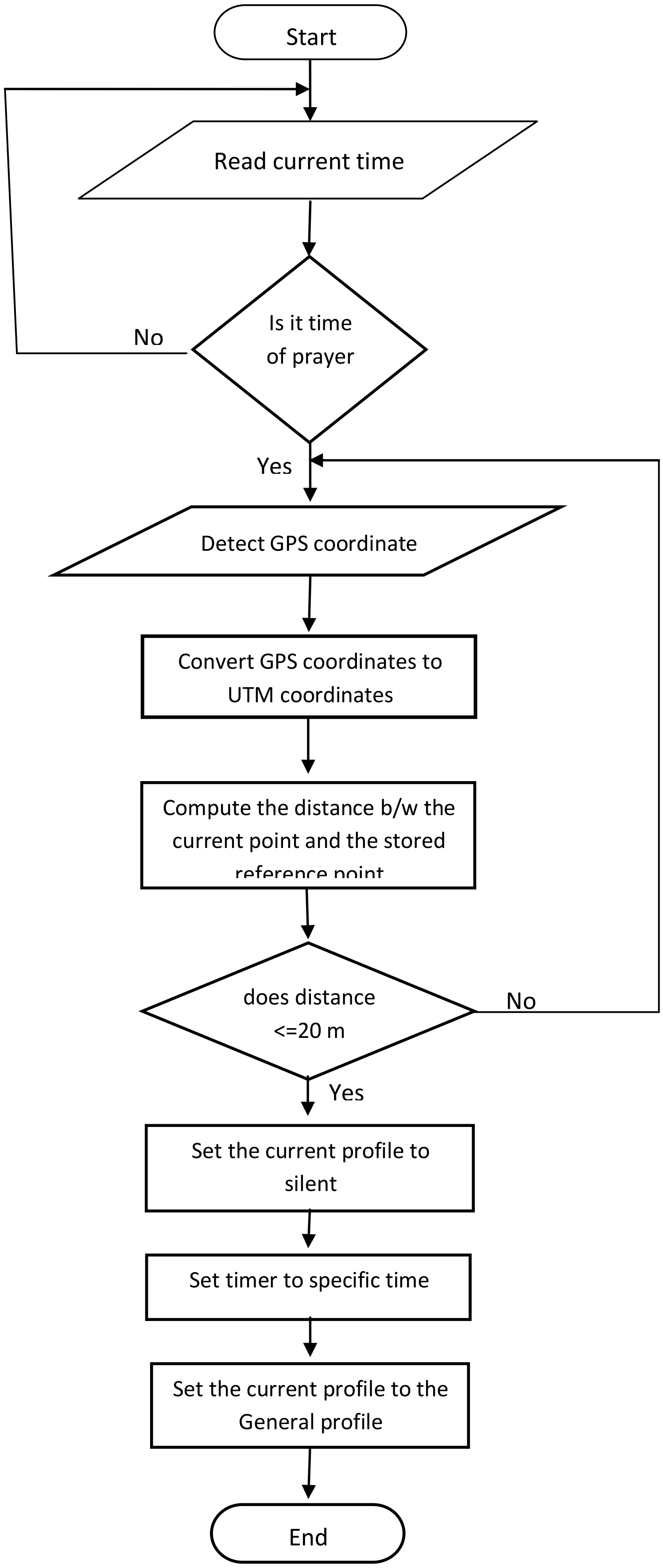


Figure 3.5: mobile based option (I) flow chart

Figure 3.5 describes how mobile based option work; it starts with searching for GPS, if it is found then it will be ready to receive a GPS coordinates, and then using a software installed on the mobile it calculate distance to the reference point, after that it compare calculated distances to those stored in the software, if they are the same it means the mobile in the target area then it switch to silent mode. Otherwise it stills in the previous mode and back to read new coordinates.

3.5.2 Mobile based option (II):

Signal strength measurement in a specific region is the best way to analyze the network performance in terms of coverage evaluation, network capacity, and call quality. It however provides a large indication about the behavior of the signal.

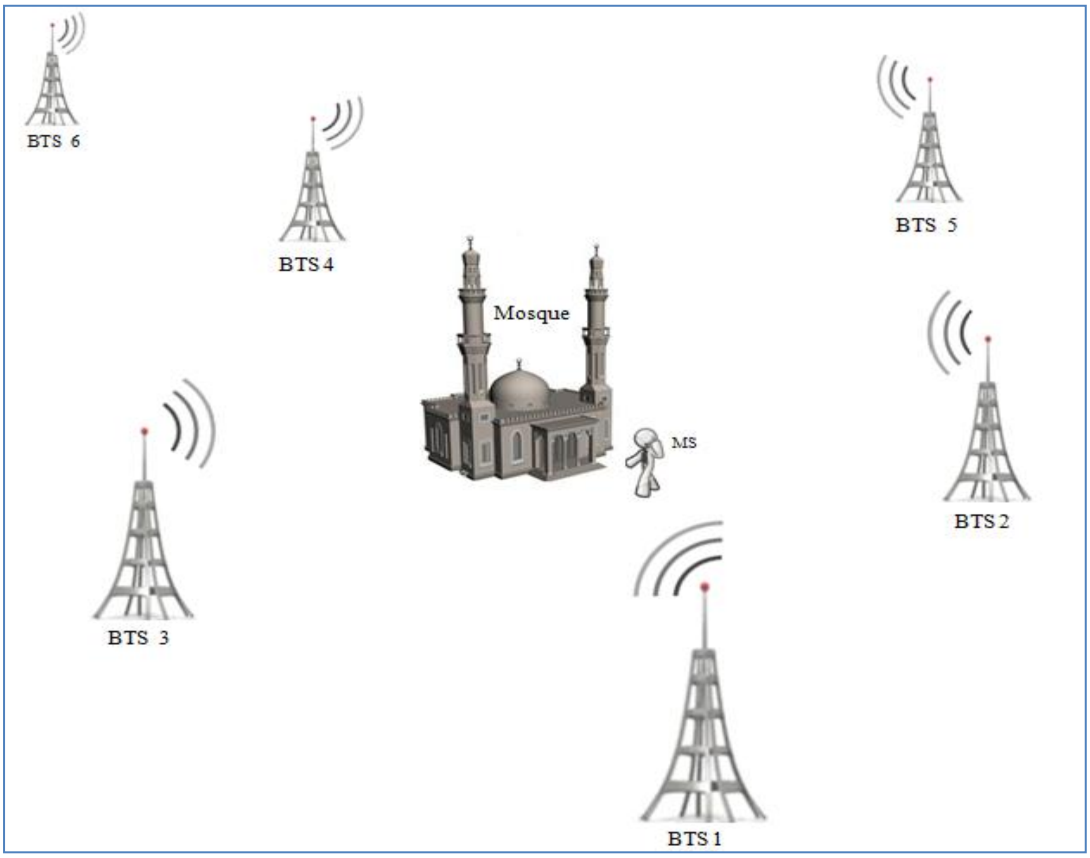


Figure 3.6: System model

Our project implemented on the Jawwal's network. In this system, MS reads signal strength from 6 base stations as maximum. It depends on the number of base stations that cover the target area. In other words, if that area is covered only by one tower, the MS reads the signal strength from that tower, otherwise it reads the strongest signals strength from cells that cover its area, but the maximum number of cells that MS can read signals strength from them at the same time is six cells.

The target area will be divided into sub-areas called “pixels”. As the number of pixels increases, consequently, more accuracy will be achievable about the determination of signal strength range inside the mosque. At these pixels, the signal strength measurements will be taken by such program, this program will appear these signals from the providing cells, and the cell identities on the mobile screen.

Figure 3.7 shows that the mosque is divided into n-pixels, indicating that each pixel has a specific area (to be determined). For each one of these pixels, a log profile will be taken for a specific time, as the time increases, then the readings will be more accurate, and the signal behavior appears more stable against obstacles, and this procedure will be replied for the n-pixels.

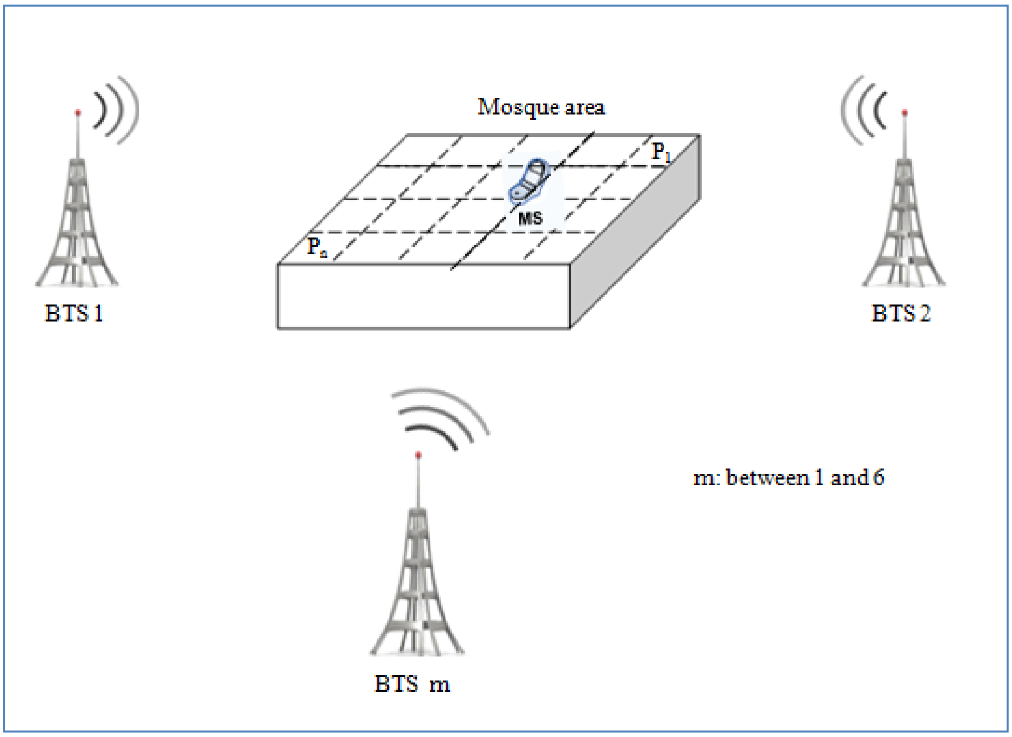


Figure 3.7: General block diagram

In each pixel, the measurements of the signal strength will be taken from the cells that cover the target area.

After that a table will be built including the cell IDs for cells that cover the mosque, and signal strength for each cell through all pixels. Here, each cell will have a range of signals strength inside the mosque.

Based on signal strength ranges included in the reference table; a software on the mobile will be introduced to compare the signal strength measurements received from the MS with the values in the reference table. Once the mobile's measurement from each cell is in the range of each cell specified in the reference table, and at the prayer time; the mobile will change itself to the silent mode, otherwise the MS is out of the mosque area.

Software can be installed on the MS, and it changes its mode to the silent mode depending on signal strength measurements.

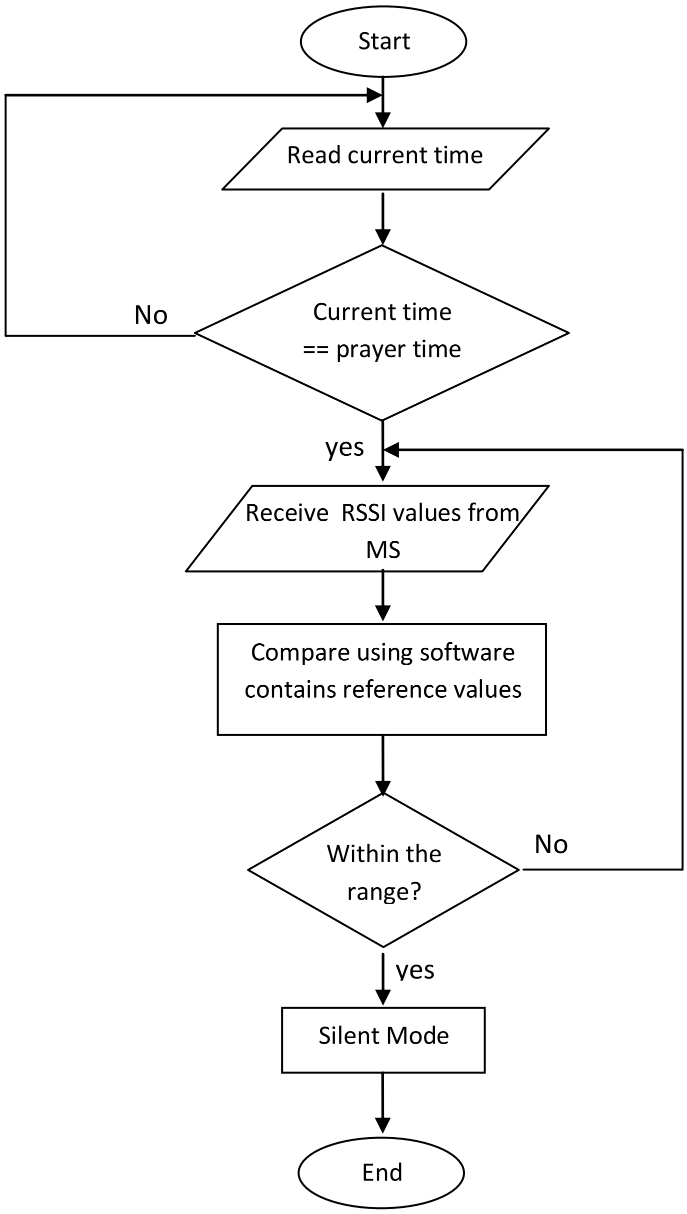


Figure 3.8: mobile based option(II) flow chart

The previous flow chart describes how the system implemented using second option will work, after a mobile measures RSSI from surrounding cells; it sends this measurement to the database of our application, which have a software contains reference values of RSSI, and then it compare the received values with the reference one, and if they are within the range specified in the software then the mobile will be in silent mode, otherwise it will be ready to receive a new measurement from the mobile.

3.6 Data flow diagram

A data flow diagram (DFD) is a significant modeling technique for analyzing and constructing information processes. DFD literally means an illustration that explains the course or movement of information in a process. DFD illustrates this flow of information in a process based on the inputs and outputs. A DFD can be referred to as a Process Model.

Figure 3.9 Shows our project's data flow diagram.

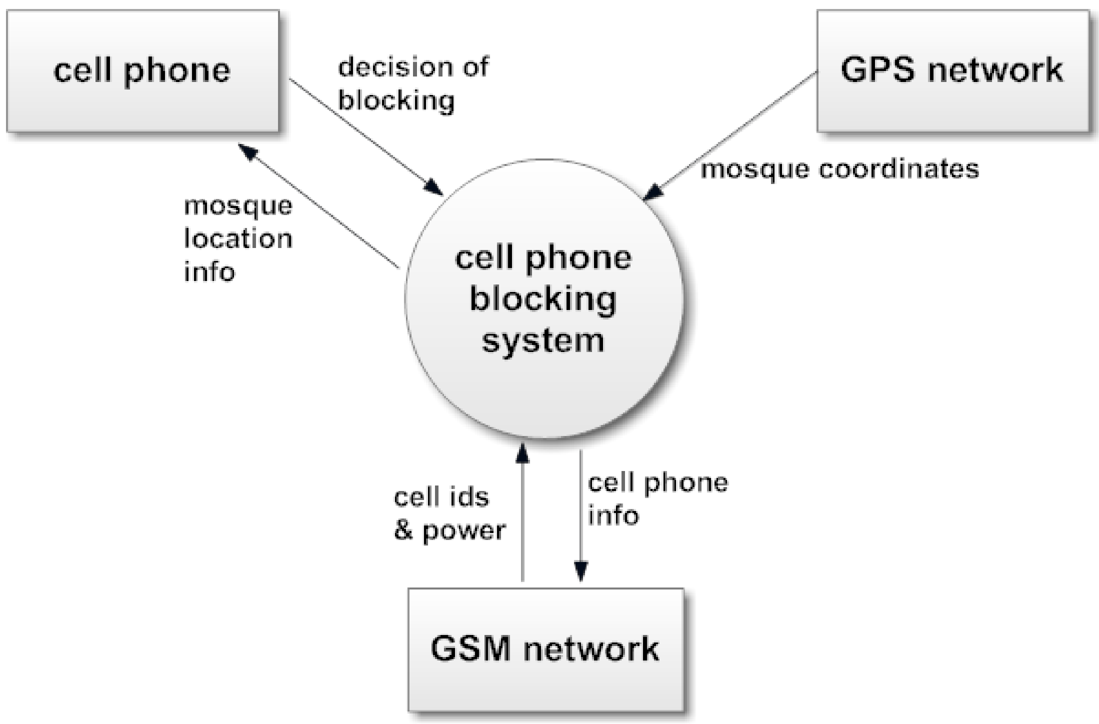


Figure3.9: Context level dataflow diagram for changing phone to silent mode

3.7 Summary

In this chapter the design options of this project was introduced, and the components that may be needed to implement these options are defined, and the software aspects showed how take the main role to do the general goal of this project.

CHAPTER Four 4

Software System Design

4.1 Introduction
4.2 General Design Options
4.3 Software Requirement Specification
4.4 Detailed Description Of System

4.1 Introduction

This chapter will present project software in more details, algorithms and flowcharts for each component of the hole system.

4.2 General Design Options

4.2.1 Software Application Options

There are many languages can be used to programming our system like java, Qt, C,C++. First J2ME language was used to develop the software but we find some problems i.e. it doesn't support operating system programming. Also we use Qt language but this language very difficult to use it, and some libraries are not open source for developers.

Finally, we use C++ and java language to develop the program, where we choose C++ language to program Symbian OS mobile phones, and Java language to program Android OS mobile phones.

- ***Programmers Reasons***

The programmers of the system have a good background knowledge and good experience that can help them to install, configure and deal with Java and C++ applications in a good way rather than other applications.

- ***Application Library and good user guide***

Java applications have a huge build-in libraries in it, and it is open source language, so it can help the programmer for develop system in easily way, and so java can configure to install other library if needed easily without confusion.

C++ applications have some open source libraries, and its needed for symbian signed certificate and some permissions, but we use this language for this reason, a lot of companies use Symbian operating system devices such as Nokia and Sony Ericson.

the Java and C++ also support user guide file that help the programmers to use application and gives them the necessary assistant while programming process.

4.2.2 Environment Option

The most powerful system is the system which build with less possible requirements, so in our project users of software can use the mobile application easily .

This system uses a SIS or SISX file for Symbian OS mobile, or APK file for Android OS mobile to be able the mobile to run the application. Or debugging the program on phone to install the application.

4.3 Software Requirement Specification

This section describe the software programs that run on PC to provide a development environment.

4.3.1 Carbide.c++

Carbide.c++ IDE is a software program that runs on PC to provide a development environment for Symbian OS mobile applications.

To programming on Carbide.c++ environment, it needs some requirements to work properly:

- S60_3rd_Edition_SDK_Feature_Pack_2_v1_1.
- Carbide_cpp_v2_7 IDE.
- ActivePerl-5.6.1 .

4.3.1.1 Symbian Project Files

This sub section describes the files used in a Symbian project. And shows the different types of files (build configuration files, source files, etc.)

☒ ***Build Configuration Files***

The following files are used in the Symbian application build process.

- ✓ ***bld.inf file:*** a component definition file used by bldmake to define the abld.bat and make files.
- ✓ ***mmp file:*** which specifies the project.
- ✓ ***mk extension makefiles:*** which are used most commonly to build your SVG (tiny) graphics files into mif files, but may also be used for other builds that are not taken by auto-generated make files, such as building context sensitive helps or for automatic sis file building.

☒ ***Source Files***

Source files are divided into following groups:

- ✓ Source code files
- ✓ Resource files
- ✓ Graphics files
- ✓ Registration files

Source files are compiled during the build operation, as follows:

- Source code file .cpp is compiled into an executable file (.exe).
- Resource file .rss is compiled into .rsc.
- Graphics file .svg is compiled into .mif.
- Registration file _reg.rss is compiled into _reg.rsc.

1) Source code files:

Source code files contain the code used in your application. Source code files include:

- ***h:*** header files contain the class declarations for the classes used in the source files.
- ***cpp :*** cpp source code files containing the classes used in the application implementation.

2) Resource files

In the Symbian platform, resource files are used to define GUI components such as status panes, menu bars, views, and dialogs, among other structures.

The following resource files are typically used in Symbian applications:

- **.rls** : localisation files contain the strings used in the application UI. The Symbian platform naming convention is loc and lNN, where NN is a language code from the Symbian locale IDs.
- **.rss :** resource files used for GUI components in the application.
- **.hrh :** resource header file used to define flag values.

3) Graphics files

Graphic files contain the graphics used in your application. Usually, you need at least files for the icons used in the grid and list menus. Graphic files might include:

- **bmp :** bitmap (pixel) files for graphics used in the application and for the grid map and navigation pane.
- **svg :** SVG-tiny (vector) files for graphics used in the application and for the grid map and navigation pane.

4) Registration files

Registration files contain information on registering applications to make them visible in the application menu and to provide other information to the underlying operating system.

- **.xml :** backup registration file.
- **reg.rss :** resource file used for creating registration resource files.

Package Files

Pkg files are used to generate sis installation files to install your application on a mobile device. See the Installation File topic.

For more information on

- pkg file syntax.
- Creating a pkg file.

Output Files

The output files of a Symbian application project. These files are generated as a result of the build process.

Executable files

Examples of executable files include

- **.exe files**: used among other purposes for GUI-based applications.
- **.dll** *(dynamic link library)* **files**: used for shared libraries.

Compiled resource files

- **.rsc or rnn**: where NN is a two number Symbian locale ID - compiled, machine-readable resource files used by the application.

- The resource compiler converts resource source files (.rss) into a .rsc containing the resources used by the application. The compiler also produces a resource header file (.rsg).

- **.rsg :** resource header file containing the symbolic IDs of the resources.

Note: The .rsg file is included in the source files so that the C++ compiler has access to the symbolic IDs of the used resources.

Installation File

Symbian applications are packaged as Symbian Installation System (SIS) files for installation on mobile devices.

Figure 4.1 show symbian project files diagram . and figure 5.2 show carbide.c++ environment for our project.

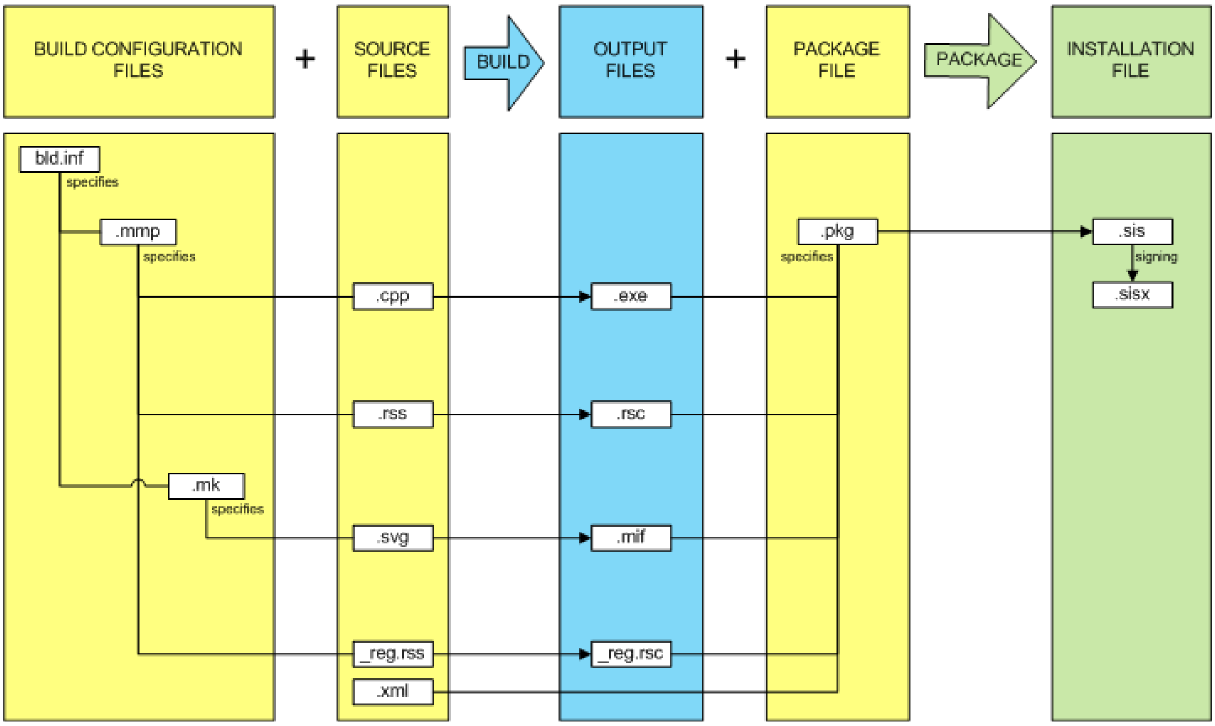


Figure 4.1: Development and deployment steps.

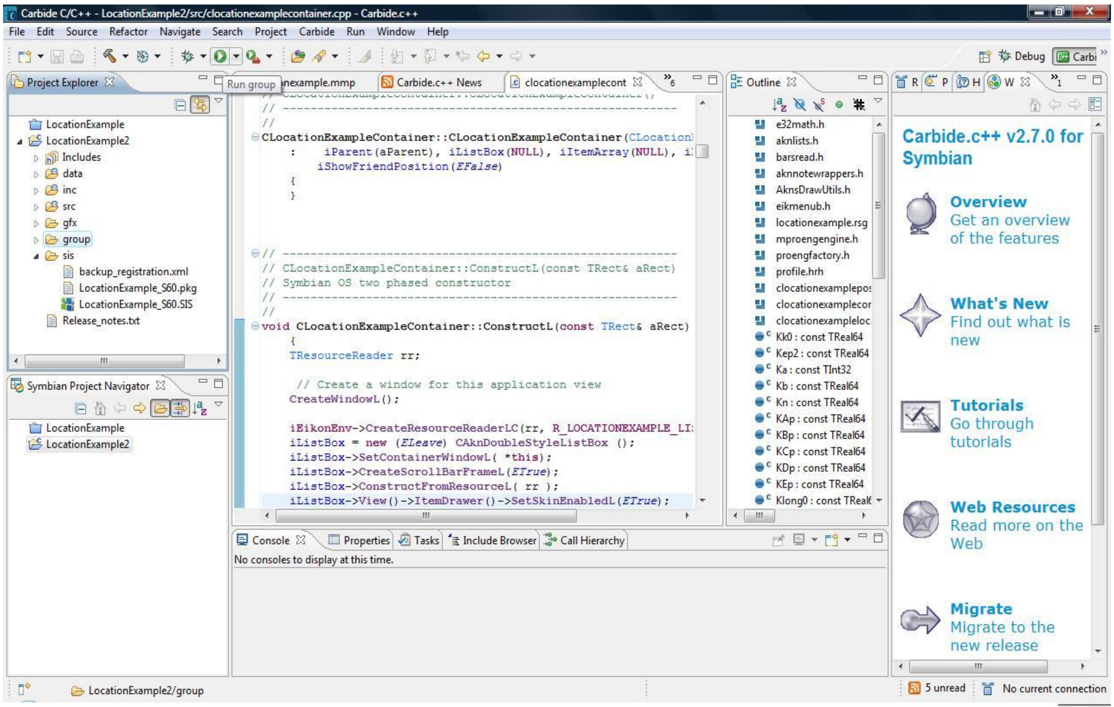


Figure 4.2: carbide.c++ enviroment

4.3.2 Signing sis file

After build the sis file for project, you can't use it without symbian signing. You need to sign it using symbian signed website as following:

1. go to https://www.symbiansigned.com/app/page/public/openSignedOnline.do web site.
2. Press *#06# on your phone to get IMEI for your phone.
3. Follow website procedures.
4. Then you will receive signed sis file on your mail.
5. Now the file ready to work on your phone, send it to your phone using Bluetooth or pc suite.
6. Finally fix it on your phone to be ready to use.

4.3.3 Symbian project code

In this section we will explain main function for Symbian operating system code. We will talk about the main steps for our project develop :

1. **Detect GPS coordinates from satellites.**

To read GPS coordinates first we use this method for activate GPS.

```
void CLocationExampleEngine::ActivateGpsL()
```

Then we detect GPS coordinates in degree minute second form as follow:

```
position.Latitude()
position.Longitude()
```

2. **Convert GPS coordinates to UTM coordinates.**

First we convert GPS coordinates to decimal degree x,y to use it in UTM conversion.

```
void CLocationExampleContainer::GetDegreesString(const TReal64&
aDegrees,TBuf<KDegreeLength>& aDegreesString) const
```

then We develop this method to make conversion using UTM conversion equations to obtain reading in meters.

```
void CLocationExampleContainer::ProcessPositionInfoL(const
TPositionInfo& aPositionInfo )
```

3. **Compute the distance b/w the current point and the stored reference point.**

```
avrx = x - x1;
avry = y - y1;
Math::Pow(avrx2, avrx, 2);
Math::Pow(avry2, avry, 2);
TReal64 sum = avrx2 + avry2;
Math::Sqrt(dist, sum);
```

4. **Check the location based on distance.**

```
if(dist <= 20){
      iEikonEnv->AlertWin(_L("you are inside the mosque"),iDispVal);
                }
else iEikonEnv->AlertWin(_L("you are outside the mosque"),iDispVal);}
```

5. **Check the time does it time of prayer.**

```
void CLocationExampleContainer::prayrtimes(const TInt& hou, const
TInt& min, const TInt& sec ) const
```

6. **Take decision based on time.**

If the condition true then the mobile will be set to silent mode.

```
if(time = tref){
MProEngEngine* engine  = ProEngFactory::NewEngineL();
CleanupReleasePushL(*engine);
engine->SetActiveProfileL(EProfileSilentId);
CleanupStack::PopAndDestroy(1);}
```

7. **Set timer to specific time.**

```
timer.After(timerStatus,1000000);
User::WaitForRequest(timerStatus);
```

✓ Set the current profile to general.

```
engine->SetActiveProfileL(EProfileGeneralId);
```

The following figures show test for if two conditions true.

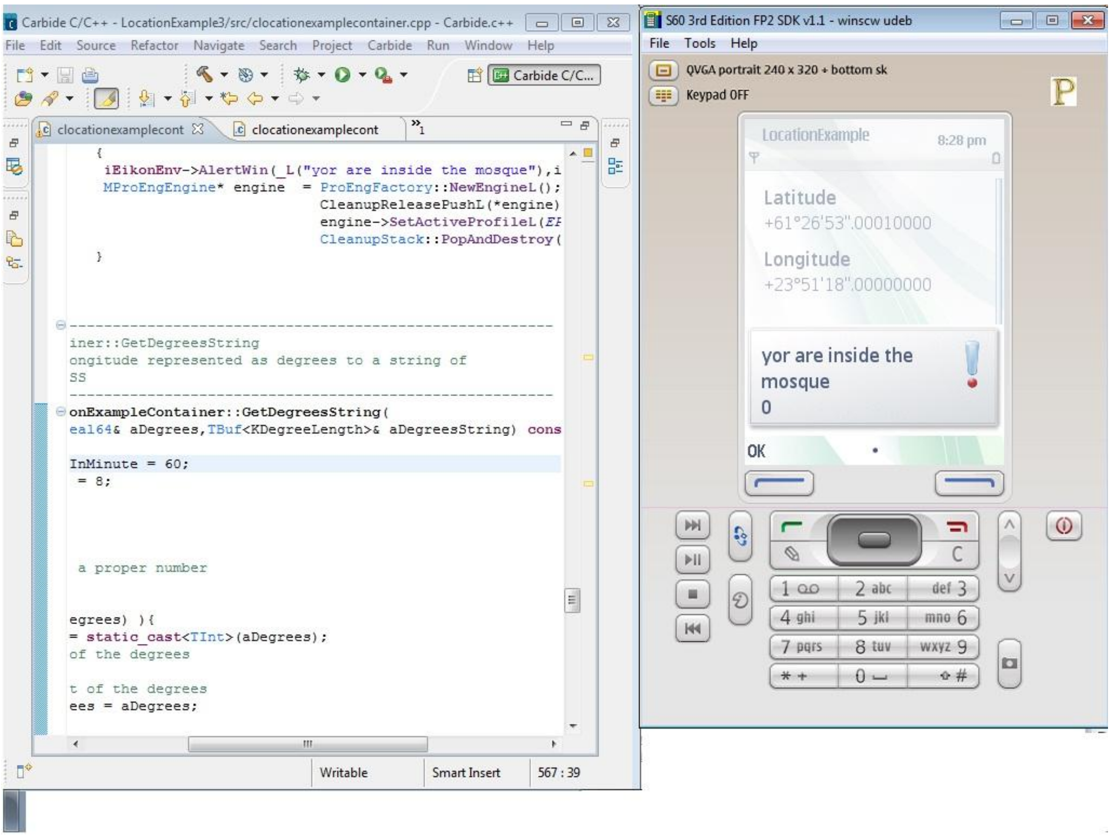


Figure 4.3 : First condition test.

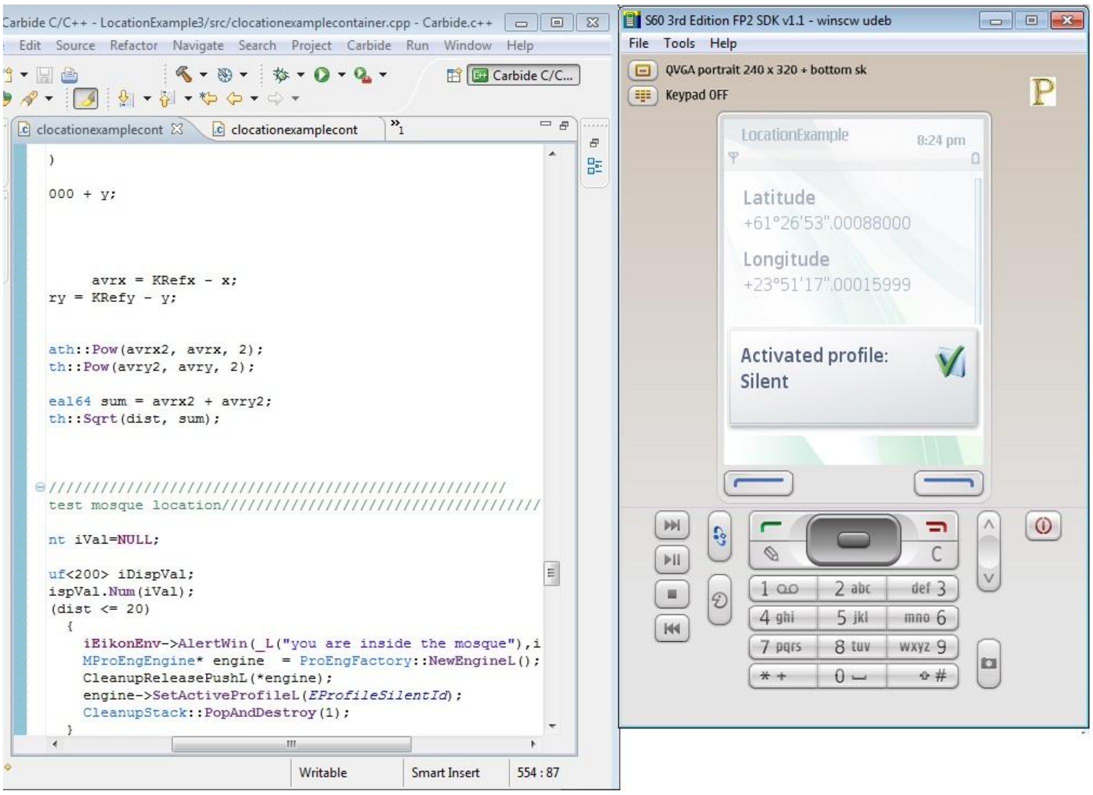


Figure 4.4 : second condition test

And the following figure show if the condition false.

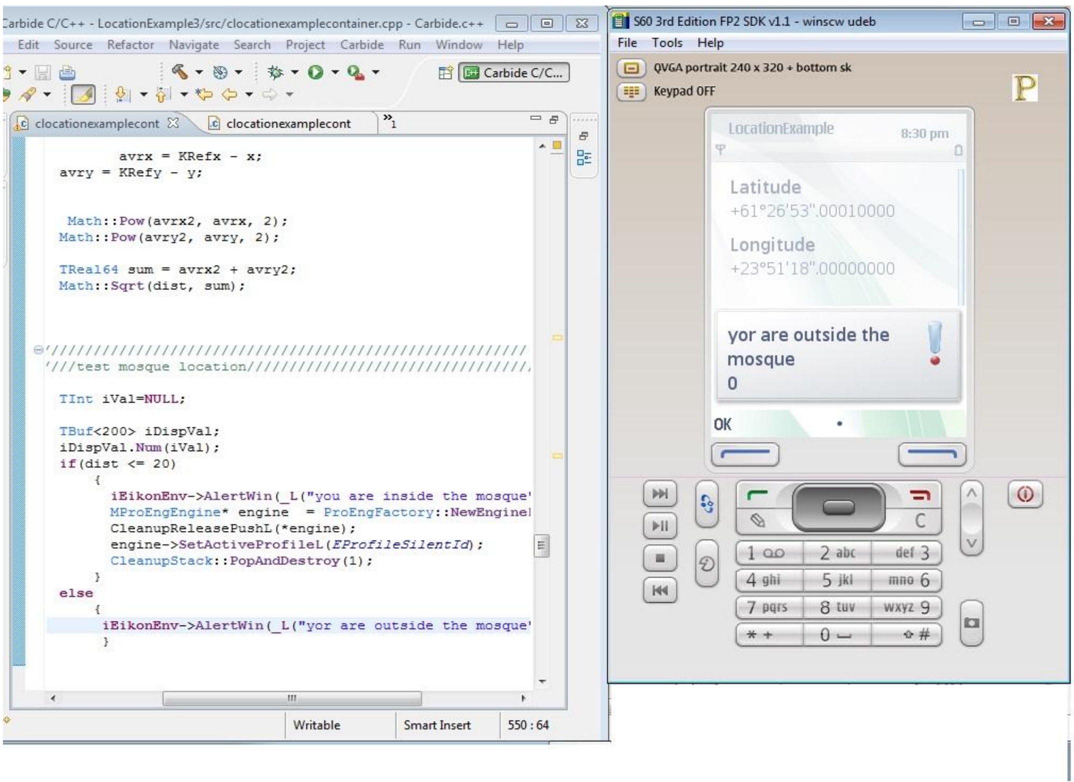


Figure 4.5: False condition test

4.3.4 Eclips ID:

Eclips in a development environment that is first build for java development purposes, in our project we used this ID for developing on android operating system.

Also this ID allow you to test your application on a simulator before installing the application on real device.

The following figure show the layout of the eclips ID.

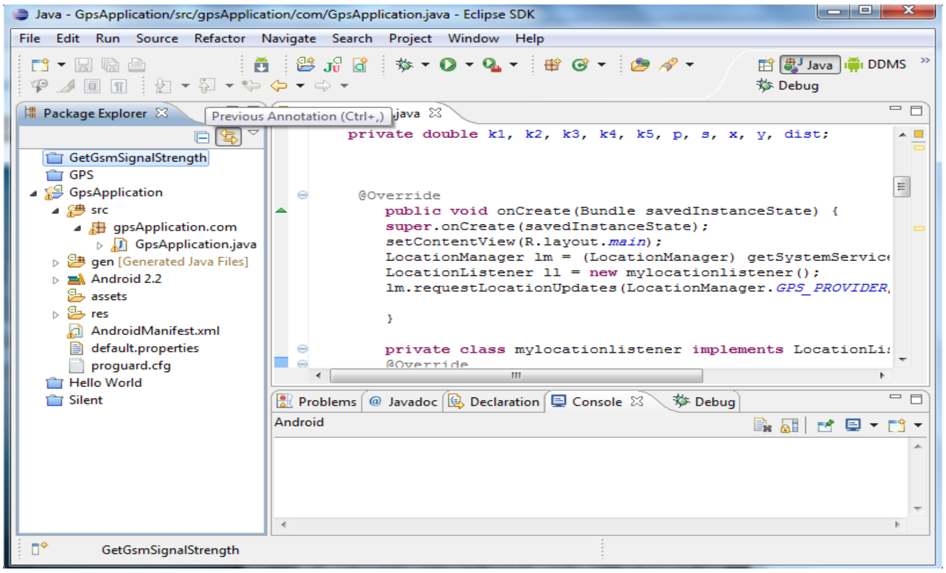


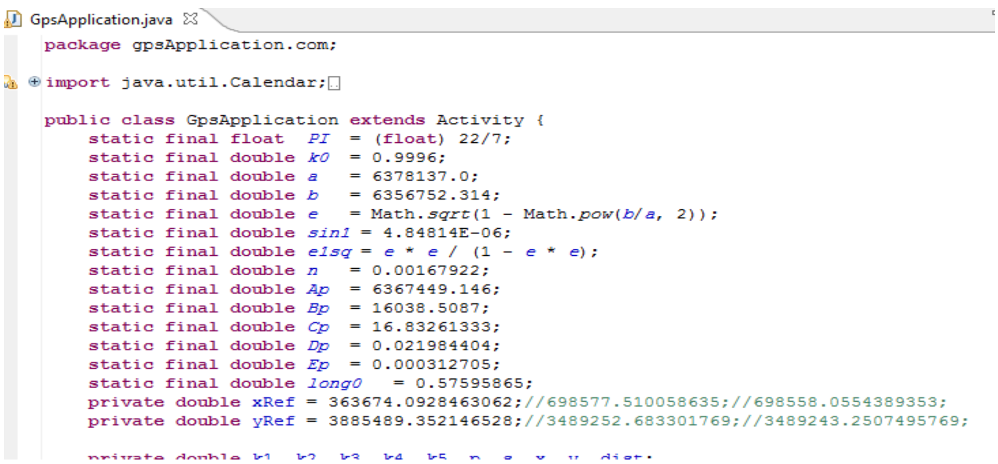
Figure 4.6: Eclips ID

The emulator that is used for testing applications in figure 5.7

Figure 4.7: Android Emulator

As you build a new project a number of folders and files could be created, the most important files are YourApplication.java, and AndroidManifest.xml, main.xml, YourApplication.apk.

YourApplication.java: it is the file that contain the code of your algorithm as java code.



```
GpsApplication.java
package gpsApplication.com;

import java.util.Calendar;

public class GpsApplication extends Activity {
    static final float  PI  = (float) 22/7;
    static final double k0  = 0.9996;
    static final double a   = 6378137.0;
    static final double b   = 6356752.314;
    static final double e   = Math.sqrt(1 - Math.pow(b/a, 2));
    static final double sin1 = 4.84814E-06;
    static final double e1sq = e * e / (1 - e * e);
    static final double n   = 0.00167922;
    static final double Ap  = 6367449.146;
    static final double Bp  = 16038.5087;
    static final double Cp  = 16.83261333;
    static final double Dp  = 0.021984404;
    static final double Ep  = 0.000312705;
    static final double long0   = 0.57595865;
    private double xRef = 363674.0928463062;//698577.510058635;//698558.0554389353;
    private double yRef = 3885489.352146528;//3489252.683301769;//3489243.2507495769;
```

Figure 4.8: YourApplication.java

AndroidManifest.xml: this file contain a list of permissions and specification of the android application, as determining the version of android mobile phone that could run this application.

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
      package="gpsApplication.com"
      android:versionCode="1"
      android:versionName="1.0">

    <uses-sdk android:minSdkVersion="4" />
    <uses-permission android:name="android.permission.ACCESS_COARSE_LOCATION"></uses-pe
    <uses-permission android:name="android.permission.ACCESS_FINE_LOCATION"></uses-perm
    <uses-permission android:name="android.permission.ACCESS_LOCATION_EXTRA_COMMANDS"><
    <uses-permission android:name="android.permission.ACCESS_MOCK_LOCATION"></uses-perm
    <uses-permission android:name="android.permission.INTERNET"></uses-permission>
    <uses-permission android:name="CONTROL_LOCATION_UPDATES"></uses-permission>

    <application android:icon="@drawable/icon" android:label="@string/app_name" android
        <activity android:name=".GpsApplication"
                  android:label="@string/app_name">
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />
                <category android:name="android.intent.category.LAUNCHER" />
            </intent-filter>
        </activity>
```

Figure 4.9: AndroidManifest.xml

Main.xml: this file used to show the outer layout of your application which, this file could be viewed whether as xml file or graphical layout.

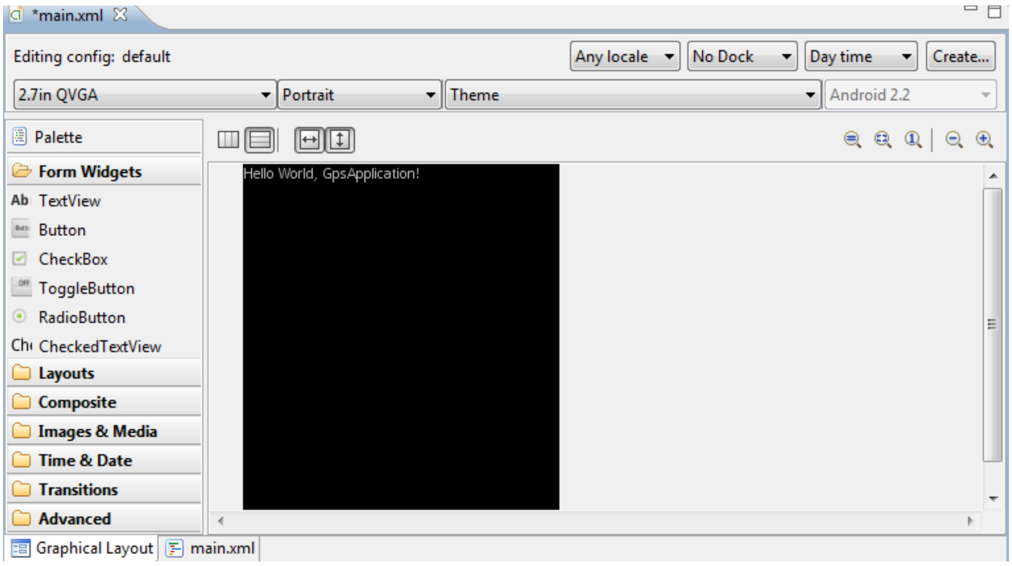


Figure 4.10: main.xml

YourApplication.apk: this file is most important one, since it is the file that moved and installed on real devices, all other files contents are gathered within this file.

4.4 Detailed Description of System Components and Related Flowcharts

This section describe the system design, including the application.

- ***Android programming:***

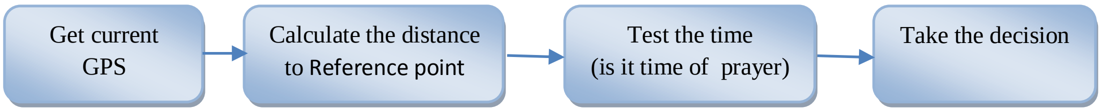


Figure 4.11: System Diagram

- ***Get current GPS coordinates : mylocationlistener()***

As the application starts, it will start searching for the current gps coordinates using **mylocationlistener()**, which search continuously for new updates in location coordinates, the coordinates will be saved as Longitude and Latitude.

```
double longitude  = location.getLongitude();
double latitude   = location.getLatitude();
```

after this these coordinates are converted to utm system which aims to get the gps coordinates as x, y points.

gpsToutmConversion(): this method convert to utm system using standard formula.

- ***Calculate the distance to Reference point : calculateDistance(longitude, latitude)***

A reference point of a mosque is stored in the application, as mylocationlistener(), got new coordinates and convert it to x, y points a new method for calculating the distance between current coordinates and the stored reference point using a standard formula for distance between two GPS points.

► *calculateDistance(x, y):*

Test the time, **is it time of prayer?**

If the distance within the range that we determine depending on the mosque dimensions, then we test if the current time is a prayer time.

► *Take the decision:*

If the two conditions met, the application will convert the mobile profile to silent mode, then after that if the condition of location changed profile to normal again and show you a message that you still outside the mosque. Figure(4.12,4.13) show the testing on emulator.

The profile will be changed using the following lines of codes:

```
AudioManager am =
(AudioManager)getSystemService(Context.AUDIO_SERVICE);

am.setRingerMode(AudioManager.RINGER_MODE_SILENT);
```

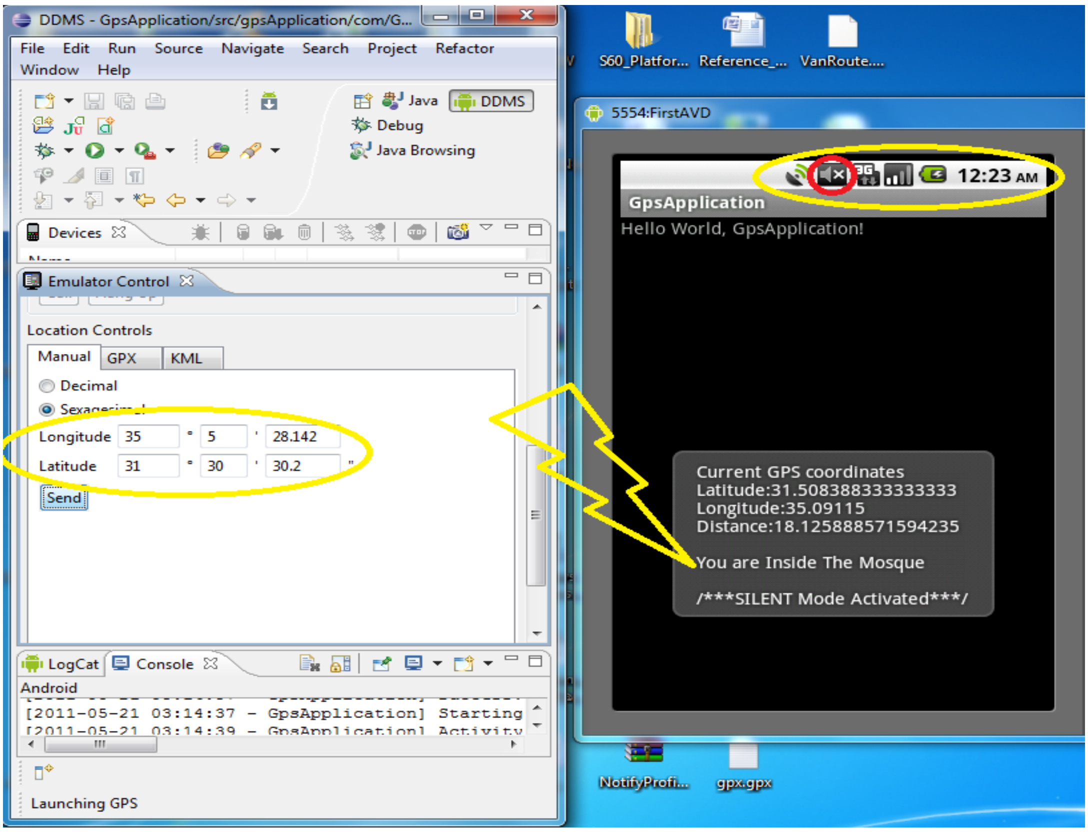


Figure 4.12: Testing for a coordinates within the mosque range

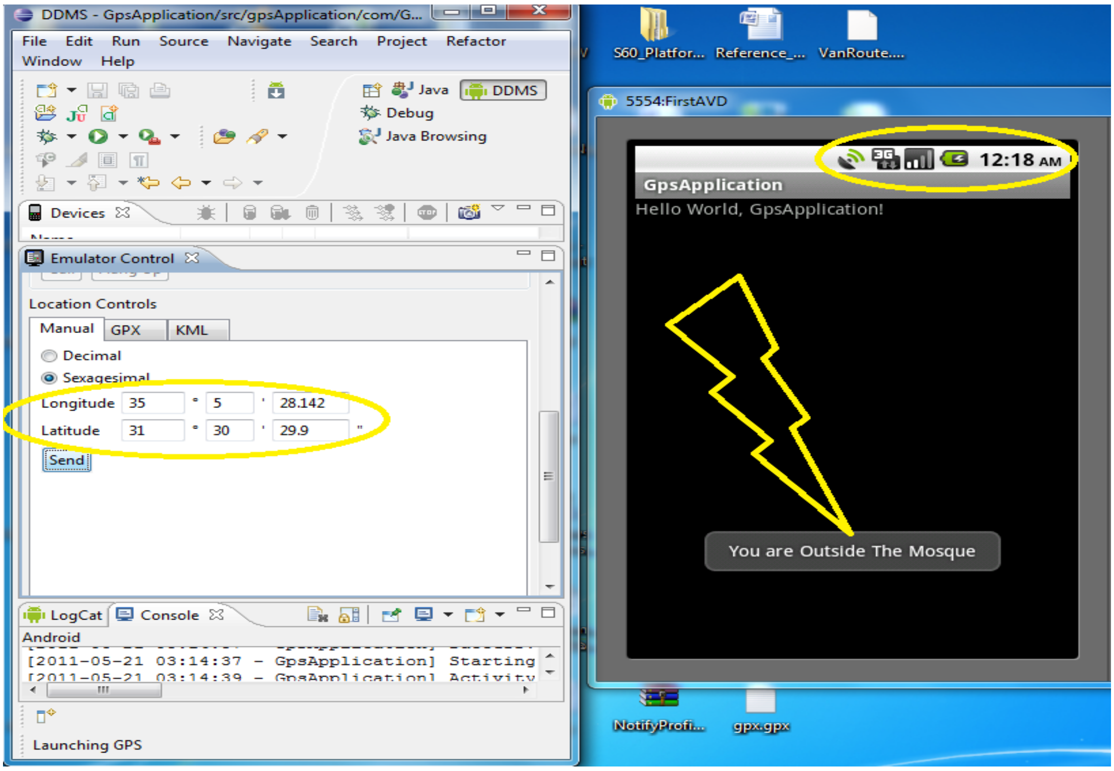


Figure 4.13: Outside the mosque

CHAPTER FIVE 5

System Measurement

5.1 Overview:

Testing is one of the most important phases of making an project. This phase is done at the end of the project to ensure that the system achieves its requirements and its specifications.

5.2 Project Implementation:

The project will be implemented using software. The software consists of the Symbian C++ program for the smart phone determine the location, and then to calculate the distance between the entrance of the mosque and the reference point which located on the center of the mosque, as we decide it.

5.3 Experimental Measurements:

The testing of the project starts by taking many coordinate points using the application on the smart phone *(express music 5800),* and take the same coordinates for the same points using GARMIN GPS device from the department of civil engineering and architecture.
The first test starts by calculating the distance between measured coordinates (*Entrance of the mosque*), and a reference point result from both devices, and comparing the results by calculating the error percentage using the following formula:

$$\text{Percent error} = \frac{(observed\ value - true\ value)}{true\ value} \times 100\%$$

The calculated distance is obtained by the following formulas:

- ***Converting Latitude and longitude to UTM***

These formulas are slightly modified from Army (1973). These are accurate to within less than a meter within grid zone.

P= point under consideration.

Lat = latitude point.

Long = longitude of point.

Long0 = central meridian of zone.

For example: Palestine located between 30 and 36; so $long0 = \frac{30+36}{2} = 33$

K0= scale along long0 = 0.9996.

$a = 6378137$

$b = 6356752.3142$

$e = \sqrt{(1 - b^2)/a^2} \approx 0.08$ .this is the eccentricity of the earth's elliptical cross section.

$e'^2 = (ea/b)^2 = e^2/(1 - e^2) \approx 0.007$. the quantity e' only occurs in even powers, so it need only be calculated as e'^2 .

$$n = \frac{\mathrm{a - b}}{\mathrm{a + b}}$$

$nu = a/\sqrt{1 - e^2 sin^2(lat)}$. this is the radius of curvature of the earth perpendicular to the meridian plane. It is also the distance from the point in equation to the polar axis, measured perpendicular to the earth's surface.

P=(long-long0)

- ***Calculate the Meridional Arc:***

S is the meridional arc through the point in equation (the distance along the earth's surface from the equator). All angles are in radian.

- $\mathrm{S} = \mathrm{A'lat} - \mathrm{B'sin(2lat)} + \mathrm{C'sin(4lat)} - \mathrm{D'sin(6lat)} + \mathrm{E'sin(8lat)}$, where lat in radians
- $\mathrm{A'} = \mathrm{a}\left[1 - n + \left(\frac{5}{4}\right)(n^2 - n^3) + \left(\frac{81}{64}\right)(n^4 - n^5) \ldots..\right]$
- $\mathrm{B'} = (\frac{3an}{2})\left[1 - n + \left(\frac{7}{8}\right)(n^2 - n^3) + \left(\frac{55}{64}\right)(n^4 - n^5) \ldots..\right]$
- $\mathrm{C'} = (\frac{15an^2}{16})\left[1 - n + \left(\frac{3}{4}\right)(n^2 - n^3) \ldots..\right]$
- $\mathrm{D'} = \left(\frac{35an^3}{48}\right)\left[1 - n + \left(\frac{11}{16}\right)(n^2 - n^3) \ldots..\right]$
- $\mathrm{E'} = \left(\frac{315an^4}{51}\right)[1 - n \ldots..]$

$$k1 = Sk0$$

$$k2 = \frac{k0\ nu \sin(lat)\cos(lat)}{2}$$

$$k3 = \left[k0 \frac{nu \sin(lat)\, cos^3(lat)}{24}\right] \left[5 - tan^2(lat) + 9e^{'2} cos^2\,(lat) + 4e^{'4} cos^4(lat)\right]$$

$$k4 = ko\ nu \cos(lat)$$

$$k5 = \left(k0\ nu \frac{cos^3(lat)}{6}\right)\left[1 - tan^2(lat) + e^{'2} cos^2(lat)\right]$$

Now;

$$Y = Northing = k1 + k2P^2 + k3P^4$$

$$X = Easting = k4P + K5P^3 \quad ,$$

NOTE: Easting X is relative to the central meridian. For conventional UTM easting ass 500000 meters to X

Finally; For calculating distance between two points we use the following formula:

$$Distance = \sqrt{(X1 - X2)^2 + (Y1 - Y2)^2} \quad \text{in meters.}$$

5.3.1 Experimental Results:

The following tables show the results which we obtain after making some GPS measurements at our sample location which is *ALNOOR Mosque*, near to building B.

The following experiment was done to examine the accuracy of system software in calculating distance between the reference point and the entrance of the mosque, compared with the GPS device. to determine whether you are inside or outside the mosque.

- ***Experiment:***

We did the following scenario; at our sample location we take to points separated by 25m, and we read there GPS coordinates by using GARMIN GPS device and our software which installed on Express music 5800 Nokia phone. After that the distance between these points calculated by the previous equation.

1) Measurement using GARMIN GPS device:

The following table shows the longitude and latitude of first point and its X and Y coordinates, there are ten minutes between each measurement

Table 5.1: Longitude and Latitude of first point using GPS device

Longitude of first point	Longitude (Y) (in meter)	Latitude of first point	Latitude (X) (in meter)
E035°05' 2".5	3492139.545	N 31°32' 50".2	197812.6988
E035°05' 2".1	3492160.902	N 31°32' 50".9	197817.5632
E035°05' 1".5	3492148.282	N 31°32' 50".5	197801.9735
E035°05' 2".3	3492148.684	N 31°32' 50".5	197801.9735
E035°05' 3".2	3492152.215	N 31°32' 50".6	197846.75
E035°05' 3".4	3492155.396	N 31°32' 50".7	197851.9661
E035°05' 2".2	3492142.474	N 31°32' 50".3	197825.827
E035°05' 2".1	3492160.902	N 31°32' 50".2	197812.6988
E035°05' 2".2	3492142.474	N 31°32' 50".3	197825.827
E035°05' 2".3	3492148.684	N 31°32' 50".3	197825.827
E035°05' 2".3	3492148.684	N 31°32' 50".4	197823.131
E035°05' 2".4	3492139.495	N 31°32' 50".3	197825.827
E035°05' 2".5	3492139.545	N 31°32' 50".7	197851.9661
E035°05' 2".3	3492148.684	N 31°32' 49".8	197823.4828
E035°05' 2".7	3492139.646	N 31°32' 50".2	197812.6988
E035°05' 2".3	3492148.684	N 31°32' 50".3	197825.827
E035°05' 2".7	3492139.646	N 31°32' 50".9	197817.5632
E035°05' 2".4	3492139.495	N 31°32' 50".4	197823.131
E035°05' 2".0	3492133.135	N 31°32' 50".0	197815.4535
E035°05' 2".0	3492139.294	N 31°32' 50".2	197815.3362
E035°05' 2".4	3492139.495	N 31°32' 50".2	197825.8857
E035°05' 2".4	3492142.575	N 31°32' 50".3	197825.827
E035°05' 1".9	3492139.244	N 31°32' 50".2	197812.6988
E035°05' 2".4	3492142.575	N 31°32' 50".3	197825.827

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Table 5.2 shows the longitude and latitude of second point which is 25m away from first one and its X and Y coordinates, there are ten minutes between each measurement.

Table 5.2: Longitude and Latitude of Second point using GPS device

Longitude of second point	Longitude (in meter)	Latitude of second point	Latitude (in meter)
E035°05' 1".3	3492129.704	N 31°32' 50".3	197796.816
E035°05' 1".4	3492132.834	N 31°32' 50".0	197794.3545
E035°05' 1".2	3492132.733	N 31°32' 50".0	197794.3545
E035°05' 1".3	3492129.704	N 31°32' 50".0	197794.3545
E035°05' 1".5	3492139.043	N 31°32' 50".1	197799.6293
E035°05' 1".5	3492139.043	N 31°32' 50".1	197799.6293
E035°05' 1".3	3492129.704	N 31°32' 50".0	197794.3545
E035°05' 1".2	3492132.733	N 31°32' 50".0	197794.3545
E035°05' 1".3	3492129.704	N 31°32' 50".0	197794.3545
E035°05' 1".3	3492129.704	N 31°32' 50".1	197799.6293
E035°05' 1".3	3492129.704	N 31°32' 50".0	197794.3545
E035°05' 1".2	3492132.733	N 31°32' 50".1	197799.6293
E035°05' 1".2	3492132.733	N 31°32' 50".2	197794.2373
E035°05' 1".2	3492132.733	N 31°32' 50".1	197799.6293
E035°05' 1".6	3492126.775	N 31°32' 49".8	197805.0213
E035°05' 1".5	3492139.043	N 31°32' 50".2	197794.2373
E035°05' 1".6	3492126.775	N 31°32' 49".6	197805.1385
E035°05' 1".3	3492135.863	N 31°32' 50".1	197796.9333
E035°05' 1".3	3492129.704	N 31°32' 49".9	197797.0505
E035°05' 1".2	3492132.733	N 31°32' 50".0	197794.3545
E035°05' 1".1	3492132.683	N 31°32' 50".0	197791.7172
E035°05' 1".2	3492132.733	N 31°32' 50".0	197794.3545
E035°05' 1".2	3492129.654	N 31°32' 49".9	197794.4132
E035°05' 1".4	3492132.834	N 31°32' 50".1	197799.6293

Now; we calculate the distance between our points, and percentage error, the results which we obtained shown on the following table.

The real distance was 25m and the following results show the error in GPS system. And the same experiment done for different time of day along different few days.

Table 5.3: Distance and percentage error for GPS device

No	Distance (m)	Percentage Error%
1	31.80362149	27.21449 %
2	33.30859309	33.23437 %
3	17.31526606	30.73894 %
4	30.54530678	22.18123 %
5	47.41431182	89.65725 %

6	53.4179086	113.6716 %
7	25.47558717	1.902349 %
8	24.52685837	1.892567 %
9	25.47558717	1.902349 %
10	27.08823616	8.352945 %
11	29.11401602	16.45606 %
12	32.24800704	28.99203 %
13	27.08823616	8.352945 %
14	30.45217861	21.80871 %
15	31.52379276	26.09517 %
16	21.32635373	14.69459 %
17	49.45077487	97.8031 %
18	30.45215443	21.80862 %
19	18.72006315	25.11975 %
20	21.98356364	12.06575 %
21	34.84092409	39.3637 %
22	32.97534181	31.90137 %
23	20.64807031	17.40772 %
24	27.95016417	11.80066 %
Average	30.50946	

Percent error = $\frac{(observed\ value - true\ value)}{true\ value}$ = $\frac{30.50946 - 25}{25}$ x 100%

=22%

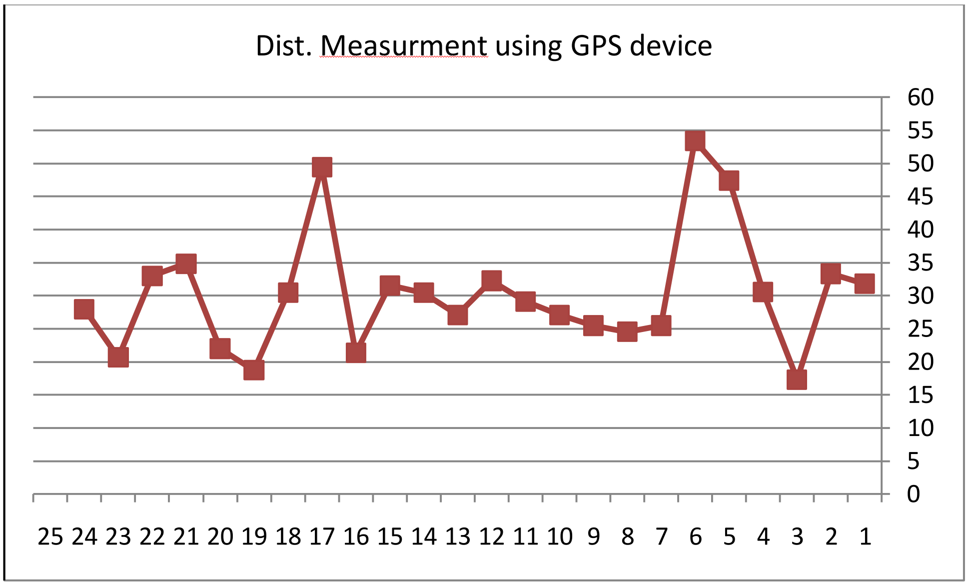

figure 5.1: Measured distances distribution by GPS device

Figure 5.1 shows the distribution of measured distances around the actual value (25m).

2) Measurement using phone program:

Here; the same scenario was done on the same points but here by using system program.
The following reading taken by Express music 5800 phone where the program was installed.
Table 5.4 shows the longitude and latitude of first point and its X and Y coordinates, there are ten minutes between each measurement.

Table 5.4: Longitude and Latitude of first point using system program

Longitude of first point	Longitude (in meter)	Latitude of first point	Latitude (in meter)
E035°05' 2".146	3492142.416	N 31°32' 50".299	197819.1287
E035°05' 2".124	3492144.807	N 31°32' 50".377	197818.5028
E035°05' 2".387	3492127.262	N 31°32' 49".803	197825.7756
E035°05' 2".225	3492131.492	N 31°32' 49".943	197821.421
E035°05' 2".690	3492140.565	N 31°32' 50".230	197833.5164
E035°05' 2".036	3492136.818	N 31°32' 50".119	197816.3331
E035°05' 2".097	3492139.743	N 31°32' 50".213	197817.8868
E035°05' 1".981	3492137.252	N 31°32' 50".134	197814.8738
E035°05' 2".277	3492139.033	N 31°32' 50".187	197822.6493
E035°05' 2".381	3492141.764	N 31°32' 50".274	197825.3412
E035°05' 2".058	3492139.385	N 31°32' 50".202	197816.8647
E035°05' 1".879	3492147.241	N 31°32' 50".460	197811.9926
E035°05' 1".714	3492135.732	N 31°32' 50".089	197807.8584
E035°05' 2".017	3492143.799	N 31°32' 50".346	197815.699
E035°05' 2".163	3492126.688	N 31°32' 49".788	197819.8767
E035°05' 2".300	3492119.273	N 31°32' 49".545	197823.6323
E035°05' 2".090	3492136.106	N 31°32' 50".095	197817.7714
E035°05' 1".024	3492130.705	N 31°32' 49".937	197789.7497
E035°05' 1".800	3492137.592	N 31°32' 50".148	197810.092
E035°05' 2".207	3492139.121	N 31°32' 50".191	197820.8008
E035°05' 2".193	3492136.804	N 31°32' 50".116	197820.4756
E035°05' 2".086	3492135.241	N 31°32' 50".067	197817.6823
E035°05' 2".217	3492138.233	N 31°32' 50".162	197821.0816
E035°05' 1".849	3492143.314	N 31°32' 50".333	197811.2758
E035°05' 2".121	3492137.199	N 31°32' 50".130	197818.5685

Table 5.5 shows the longitude and latitude of second point which is 25m away from first one and its X and Y coordinates, there are ten minutes between each measurement.

Table 5.5: Longitude and Latitude of second point using system program

Longitude of second point	Longitude (in meter)	Latitude of second point	Latitude (in meter)
E035°05' 1".257	3492135.657	N 31°32' 50".094	197795.8027
E035°05' 1".239	3492135.678	N 31°32' 50".095	197795.3274
E035°05' 1".275	3492128.275	N 31°32' 49".854	197796.4181
E035°05' 1".560	3492124.907	N 31°32' 49".740	197804.0015
E035°05' 1".425	3492129.027	N 31°32' 49".875	197801.9443
E035°05' 1".270	3492131.536	N 31°32' 49".960	197796.2241
E035°05' 1".150	3492131.877	N 31°32' 49".973	197793.0517
E035°05' 1".282	3492132.374	N 31°32' 49".987	197796.5248
E035°05' 1".258	3492126.357	N 31°32' 49".792	197796.0061
E035°05' 1".343	3492123.936	N 31°32' 49".712	197798.2948
E035°05' 1".357	3492127.607	N 31°32' 49".831	197798.5943
E035°05' 1".347	3492131.36	N 31°32' 49".953	197798.259
E035°05' 1".290	3492130.715	N 31°32' 49".933	197796.7674
E035°05' 1".401	3492126.305	N 31°32' 49".788	197799.7799
E035°05' 1".166	3492129.667	N 31°32' 49".901	197793.5159
E035°05' 1".079	3492129.962	N 31°32' 49".912	197791.2149
E035°05' 1".348	3492134.625	N 31°32' 50".059	197798.2232
E035°05' 1".320	3492126.788	N 31°32' 49".805	197797.6337
E035°05' 1".573	3492125.93	N 31°32' 49".773	197804.325
E035°05' 1".141	3492124.45	N 31°32' 49".732	197792.9556
E035°05' 1".049	3492132.134	N 31°32' 49".983	197790.3821
E035°05' 1".077	3492128.329	N 31°32' 49".859	197791.1932
E035°05' 1".072	3492125.647	N 31°32' 49".772	197791.1124
E035°05' 1".378	3492133.254	N 31°32' 50".014	197799.0408
E035°05' 1".273	3492132.154	N 31°32' 49".980	197796.2915

Now; we calculate the distance between our points, and percentage error, the results which we obtained shown on the following table.

The real distance was 25m and the following results show the error in system program in calculating distance . And the same experiment done for different time of day along different few days.

Table 5.6: Distance and percentage error for system program

No	Distance (m)	Percentage Error%
1	24.285689	2.8572454 %
2	24.908537	0.3658509 %
3	29.374878	17.499512 %
4	18.622795	25.508821 %
5	33.614295	34.45718 %
6	20.790955	16.836179 %
7	26.051274	4.2050972 %
8	18.986349	24.054604 %
9	29.505048	18.02019 %
10	32.394065	29.57626 %
11	21.73749	13.050039 %
12	20.995634	16.017465 %
13	12.172986	51.308056 %
14	23.652678	5.3892866 %
15	26.528647	6.114589 %
16	34.134322	36.537288 %
17	19.604186	21.583256 %
18	8.8032214	64.787114 %
19	13.010648	47.957407 %
20	31.473663	25.894652 %
21	30.453739	21.814957 %
22	27.376111	9.5044437 %
23	32.50461	30.018439 %
24	15.84015	36.6394 %
25	22.841101	8.6355969 %
Average	23.98652	

$$\text{Percent error} = \frac{(observed\ value - true\ value)}{true\ value} \text{ x } 100\% = \frac{23.98652 - 25}{25} \text{ x } 100\%$$

= 4.05%

Here, we note that the average distance about 24m, and percentage error is 4.05 %, these results are peter from those taken by the GPS device which was average value about 30,5m with average percentage error of 22%.

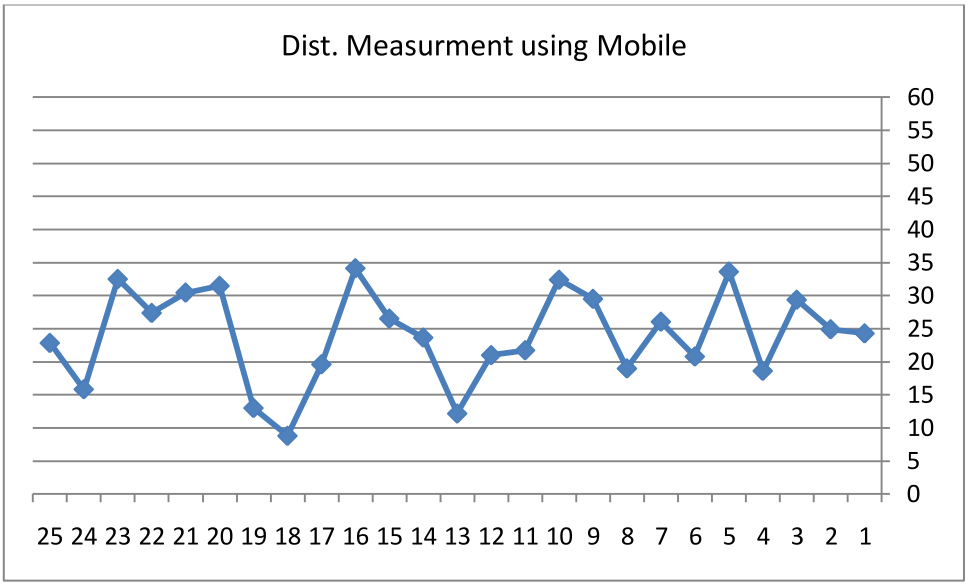

figure 5.2: Measured distances distribution

Figure 5.2 shows the distribution of measured distances around the actual value (25m).

5.3.2 Received power measurement and analysis:

Also to determine whether you are outside or inside the mosque we try to study the received power behavior in and outside the mosque.

Experiment was done by splitting the mosque into number of areas called pixels, and TEMS device was used to measure the received power level in each pixel inside and outside the mosque, along period of time about one minute in each pixel, then the average power from each cell in each pixel was calculated, and the results are contained in the following map.

Pixel4

Cell ID	average Power (dBm)
11111	-57.58
11112	-73.04
10121	-79.46

Pixel 3

Cell ID	average Power (dBm)
11111	-57.03
11112	-72.09
10121	-79.54

Pixel 2

Cell ID	average Power (dBm)
11111	-55.37
11112	-70.19
10121	-77.64

Pixel 1

Cell ID	average Power (dBm)
11111	-51.83
11112	-67.31
10121	-75.69

Pixel 8

Cell ID	average Power (dBm)
11111	-56.10
11112	-76.15
10251	-78.88

Pixel 7

Cell ID	average Power (dBm)
11111	-57.18
11112	-72.41
10251	-79.28

Pixel 6

Cell ID	average Power (dBm)
11111	-56.50
11112	-70.29
10121	-80.18

Pixel 5

Cell ID	average Power (dBm)
11111	-53.70
11112	-70.60
10121	-77.40

Pixel 10

Cell ID	average Power (dBm)
11111	-61.82
11112	-77.23
10251	-81.88

Pixel 9

Cell ID	average Power (dBm)
11111	-55.35
11112	-75.00
10251	-76.02

Figure 5.3: Map #1

11-5-2011

Pixel 12

Cell ID	average Power (dBm)
11111	-60.75
11112	-76.86
10251	-82.69

Pixel 11

Cell ID	average Power (dBm)
11111	-58.82
11112	-75.35
10251	-78.42

Outside the Mosque

Pixel 13

Cell ID	average Power (dBm)
11111	-66.41
10251	-67.88
10121	-74.80
10842	-76.59

Pixel 14

Cell ID	average Power (dBm)
11111	-63.90
10251	-70.72
10842	-75.61
11112	-76.91

Pixel4

Cell ID	average Power (dBm)
11111	-53.8
11112	-69.8
10121	-77.7

Pixel 3

Cell ID	average Power (dBm)
11111	-55.88
11112	-77.7
10121	-77.72

Pixel 2

Cell ID	average Power (dBm)
11111	-57.53
11112	-70.4
10121	-77.3

Pixel 1

Cell ID	average Power (dBm)
11111	-56.125
11112	-72.9
10121	-78.87

Pixel 8

Cell ID	average Power (dBm)
11111	-54.5
11112	-69.9
10251	-74.64

Pixel 7

Cell ID	average Power (dBm)
11111	-55.5
11112	-70.5
10251	-77.76

Pixel 6

Cell ID	average Power (dBm)
11111	-57.79
11112	-73.46
10121	-∞

Pixel 5

Cell ID	average Power (dBm)
11111	-53.4
11112	-70.9
10121	-74.7

Pixel 10

Cell ID	average Power (dBm)
11111	-61.83
11112	-78.98
10251	-81.95

Pixel 9

Cell ID	average Power (dBm)
11111	-58.5
11112	-74.7
10251	-77.33

Figure 5.4: Map #2

10-5-2011

Pixel 12

Cell ID	average Power (dBm)
11111	-61.54
11112	-76.24
10251	-81.2

Pixel 11

Cell ID	average Power (dBm)
11111	-57.13
11112	-76.3
10251	-80.85

Outside the Mosque

Pixel 13

Cell ID	average Power (dBm)
11111	-66.4
10251	-69.8
10121	-77.25
10842	-75.38

Pixel 14

Cell ID	average Power (dBm)
11111	-66.9
10251	-71.51
10842	-76.57
11112	-75.05

Pixel4

Cell ID	average Power (dBm)
11111	-59.51
11112	-71.50
10121	-79.46

Pixel 3

Cell ID	average Power (dBm)
11111	-56..99
11112	-73.84
10121	-∞

Pixel 2

Cell ID	average Power (dBm)
11111	-56.24
11112	-69.65
10121	-∞

Pixel 1

Cell ID	average Power (dBm)
11111	-57.04
11112	-70.03
10121	-∞

Pixel 8

Cell ID	average Power (dBm)
11111	-55.907
11112	-71.62
10251	-

Pixel 7

Cell ID	average Power (dBm)
11111	-57.18
11112	-72.41
10251	-∞

Pixel 6

Cell ID	average Power (dBm)
11111	-55.943
11112	-72.09
10121	-∞

Pixel 5

Cell ID	average Power (dBm)
11111	-58.06
11112	-72.011
10121	-∞

Pixel 10

Cell ID	average Power (dBm)
11111	-62.91
11112	-71.62
10251	-79.29

Pixel 9

Cell ID	average Power (dBm)
11111	-59.41
11112	-76.45
10251	-74.985

Figure 5.5: Map #3

9-5-2011

Pixel 12

Cell ID	average Power (dBm)
11111	-59.79
11112	-76.37
10251	-77.5

Pixel 11

Cell ID	average Power (dBm)
11111	-60.76
11112	-79.654
10251	-80.33

Outside the Mosque

Pixel 13

Cell ID	average Power (dBm)
11111	-66.224
10251	-70.81
10121	-80.14
10842	-76.041

Pixel 14

Cell ID	average Power (dBm)
11111	-66.75
10251	-67
10842	-75.61
11112	-76.91

Pixel4

Cell ID	average Power (dBm)
11111	-53.81
11112	-67.09
10121	-80.99

Pixel 3

Cell ID	average Power (dBm)
11111	-55.53
11112	-71.50
10121	-80.52

Pixel 2

Cell ID	average Power (dBm)
11111	-49.97
11112	-67.47
10121	-78.74

Pixel 1

Cell ID	average Power (dBm)
11111	-57.437
11112	-69.25
10121	-76.52

Pixel 8

Cell ID	average Power (dBm)
11111	-54.58
11112	-67.29
10251	-74.64

Pixel 7

Cell ID	average Power (dBm)
11111	-50.80
11112	-67.88
10251	-74.86

Pixel 6

Cell ID	average Power (dBm)
11111	-47.79
11112	-65.86
10121	-77.61

Pixel 5

Cell ID	average Power (dBm)
11111	-53.70
11112	- ∞
10121	-76.41

Pixel 10

Cell ID	average Power (dBm)
11111	-57.20
11112	-69.71
10251	-∞

Pixel 9

Cell ID	average Power (dBm)
11111	-56.64
11112	-∞
10251	-∞

Pixel 12

Cell ID	average Power (dBm)
11111	-60.34
11112	-72.66
10251	-∞

Pixel 11

Cell ID	average Power (dBm)
11111	-56.69
11112	-70.74
10251	-76.38

Figure 5.6: Map #4

23-4-2011

Outside the Mosque

Pixel 13

Cell ID	average Power (dBm)
11111	-62.47
10251	-64.88
10121	-75.44
10842	-71.39

Pixel 14

Cell ID	average Power (dBm)
11111	-58.90
10251	-69.44
10842	-71.74
11112	-∞

The previous four maps are taken in different days, with the same experiment procedure, as we note there is a dominant cell in this area that the mobile always connect with it which is cell ID (11111), and as appear from the analysis there is a different in its average power level inside and outside the mosque.

5.3.3 System Testing:

Figure 5.7: outside the mosque

This figure shows the message that appear on the mobile when it is outside the mosque .

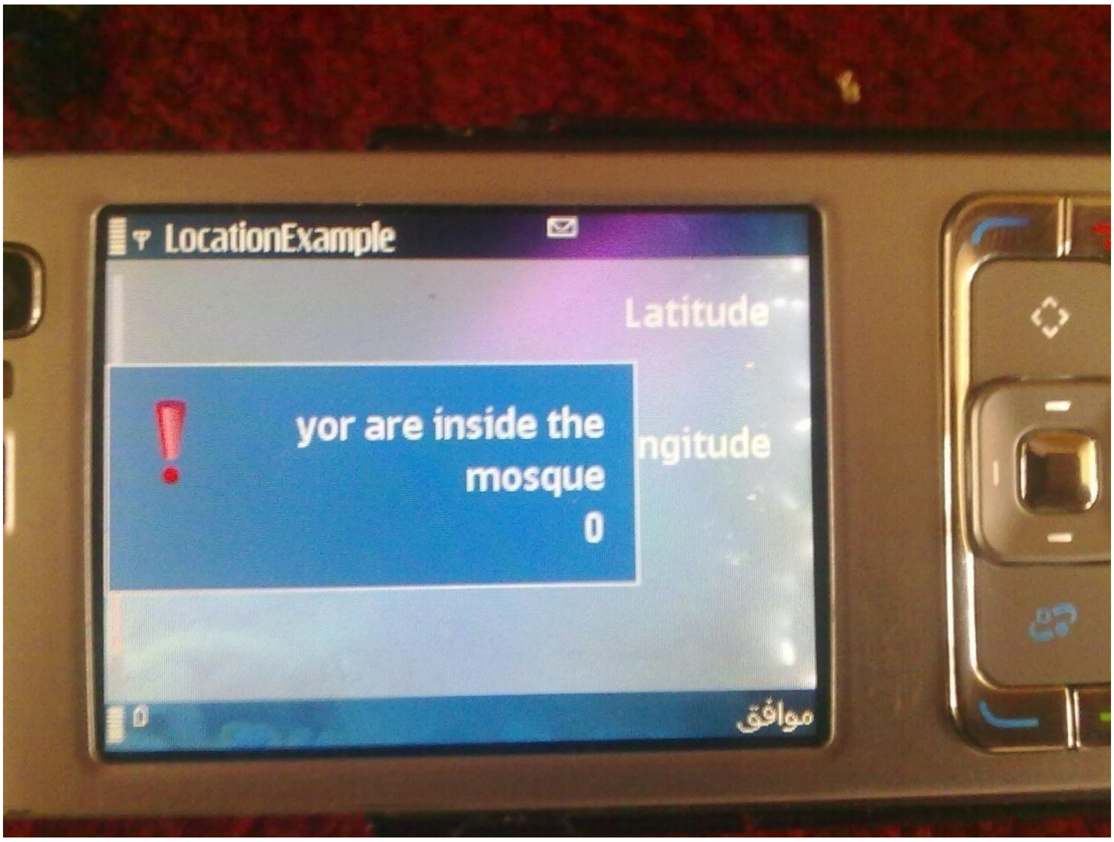

Figure 5.8: inside the mosque

When the mobile is inside the mosque the message that appear on the mobile is shown in figure 5.8.

Table 5.7: Results of switching to silent and to normal mode

Exp No.	Inside (silent mode)	Outside (normal mode)
1	Before 2.35 m	After 4.00 m
2	Before 3.50 m	After 2.50 m
3	Before 2.90 m	After 1.80 m
4	Before 4.20 m	After 3.40 m
5	Before 1.58 m	After 2.20 m
6	Before 3.70 m	After 4.00 m
7	Before 2.50 m	After 4.50 m
8	Before 2.55 m	After 3.75 m
9	Before 3.15 m	After 2.45 m
10	Before 0.95 m	After 3.00 m
11	Before 2.20 m	After 2.85 m
12	Before 2.95 m	After 2.40 m
13	Not change	After 1.20 m
14	Before 1.35 m	After 2.90 m
15	Before 2.55 m	After 2.65 m
Average	**Before 2.60 m**	**After 2.90 m**

5.4 Summary:

This chapter presents the actual project implementation along with the various testing stages.

CHAPTER SIX 6

Conclusion and Future Work

6.1 Conclusion

- In this project, we have done quite a number of things. We have studied the characteristics and behavior of Symbian OS and Android OS and also learned how to program applications used in Symbian OS and Android OS . Furthermore, we studied several GSM topics and technologies that are integral to our project.

- The most significant issues on this project were the communication, training, and documentation of our larger efforts. Communication with each other among the group member was extremely vital. Documentation needing to be available and complete at the end project took a great deal of time to plan for and complete it.

- This project was a challenge for us, yet we were able to use a lot of things that we have learned to solve the problems and come up with solution to make this system work.

- There are big differences between the theoretical and real world implementations.

6.2 Problems

For any project, it is the nature of things to face problems. Nevertheless, we were able to cover some of the difficulties we faced.

The first problem was the accuracy of GPS reading which leads to error in calculated distance.

Another problem encountered during the testing of the system was that whenever taking any coordinate points, the sky must be relatively free of clouds, because the presence of clouds and the lack of clarity of the air affect on the results, and the accuracy of values. That problem was solved by taking coordinate points on cloud-free days.

The second problem was the lack of programming method that reads and displays the RSSI level.

Also there is some hardware limitations such as the GPS receiver sensitivity which leads to some error in GPS reading.

Another problem was the incomparability of some programming language with the mobile operating system, this problem was solved by using C++ and java programming language to develop the program.

6.3 Future work

We tried our best to choose the rational design to achieve the objectives of our project. We also believe that any work cannot reach perfection. Still, a lot of thought and ideas can further be utilized to enhance the current results achieved. Some of these ideas are:

Adding additional features to the current application. Many users in any place can enter their reference point and use this application.

Appendix

The following tables show the results of experiments done to check the accuracy in distance calculated by our chosen equation, GPS coordinates are taken by our mobile and GPS device.

Abu-ktailah by mobile

No	Distance (m)	Percentage Error%
1	24.285689	2.8572454 %
2	24.908537	0.3658509 %
3	29.374878	17.499512 %
4	18.622795	25.508821 %
5	33.614295	34.45718 %
6	20.790955	16.836179 %
7	26.051274	4.2050972 %
8	18.986349	24.054604 %
9	29.505048	18.02019 %
10	32.394065	29.57626 %
11	21.73749	13.050039 %
12	20.995634	16.017465 %
13	12.172986	51.308056 %
14	23.652678	5.3892866 %
15	26.528647	6.114589 %
16	34.134322	36.537288 %
17	19.604186	21.583256 %
18	8.8032214	64.787114 %
19	13.010648	47.957407 %
20	31.473663	25.894652 %
21	30.453739	21.814957 %
22	27.376111	9.5044437 %
23	32.50461	30.018439 %
24	15.84015	36.6394 %
25	22.841101	8.6355969 %
Average	23.98652	

Percent error = $\frac{(observed\ value - true\ value)}{true\ value}$ x 100% = $\frac{23.98652-25}{25}$ x 100%

=4.05%

Abo ktailah by GPS device

No	Distance (m)	Percentage Error%
1	31.80362149	27.21449 %
2	33.30859309	33.23437 %
3	17.31526606	30.73894 %
4	30.54530678	22.18123 %
5	47.41431182	89.65725 %
6	53.4179086	113.6716 %
7	25.47558717	1.902349 %
8	24.52685837	1.892567 %
9	25.47558717	1.902349 %
10	27.08823616	8.352945 %
11	29.11401602	16.45606 %
12	32.24800704	28.99203 %
13	27.08823616	8.352945 %
14	30.45217861	21.80871 %
15	31.52379276	26.09517 %
16	21.32635373	14.69459 %
17	49.45077487	97.8031 %
18	30.45215443	21.80862 %
19	18.72006315	25.11975 %
20	21.98356364	12.06575 %
21	34.84092409	39.3637 %
22	32.97534181	31.90137 %
23	20.64807031	17.40772 %
24	27.95016417	11.80066 %
Average	30.50946	

Percent error $= \frac{(observed\ value - true\ value)}{true\ value}$ x 100% $= \frac{30.50946-25}{25}$ x 100%

=22%

PPU mosque by mobile

No	Distance (m)	Percentage Error%
1	17.577	29.69091 %
2	22.786	8.855667 %
3	20.679	17.28194 %
4	10.009	59.96001 %
5	16.236	35.05582 %
6	15.118	39.52782 %
7	24.757	0.969078 %
8	37.6	50.59347 %
9	27.88	11.53553 %
10	22.09	11.60870 %
11	26.643	6.572707 %
12	21.783	12.86551 %
13	14.587	41.65161 %
14	27.6	10.40545 %
15	20.165	19.33914 %
16	27.349	9.396711 %
17	23.938	4.245825 %
18	1.996	92.01468 %
19	19.207	23.16965 %
20	21.11	15.55639 %
Average	20.95	

Percent error = $\frac{(observed\ value - true\ value)}{true\ value}$ x 100% = $\frac{20.95-25}{25}$ x 100%

=16.16444%

Al- jaladah by mobile

No	Distance (m)	Percentage Error%
1	26.50086	6.003435%
2	24.66837	1.326522%
3	16.8034	32.78642%
4	24.27629	2.894829%
5	20.55042	17.79833%
6	27.1747	8.698794%
7	26.03998	4.159908%
8	24.69035	1.238592%
9	30.09613	20.38451%
10	34.05754	36.23015%
11	29.85876	19.43503%
12	43.369	73.476%
13	25.32217	1.28875%
14	30.15382	20.61527%
15	37.52104	50.08415%
16	33.93488	35.73953%
17	18.04043	27.83829%
18	27.88778	11.55113%
19	25.65021	2.600827%
20	25.66957	2.678264%
21	23.65349	5.386058%
22	29.82459	19.29835%
23	25.48407	1.936272%
24	16.74778	33.0089%
25	20.13029	19.47883%
Average	26.72424	

Percent error = $\frac{(observed\ value - true\ value)}{true\ value}$ x 100% = $\frac{26.72424-25}{25}$ x 100%

=6.896942%

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