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Design and Implementation of Heartbeat Monitoring Application by using Android Mobile Phone

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DEDICATION

This thesis is dedicated to my family. To my caring parents who supported me all the way since the beginning of my thesis and have been a great source of motivation and inspiration, and who took great challenges to see me prosper in life. To my brothers and sisters, who offered me unconditional love and support through this long hard journey.

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List of Abbreviations

ECG	Electrocardiogram
ICU	Intensive Care Unit
SDK	Software Development Kit
WHO	World Health Organization
FTP	File Transfer Protocol
EHR	Electronic Health Record
SRS	Software Requirements Specification
SDLC	Software Development Life Cycle
GPS	Global Positioning System
OS	Operating System
API	Application Programming Interface
Android	Android Operating System
IEEE	The Institute of Electrical and Electronics Engineers
HTTPS	Hyper Text Transfer Protocol Secure
XML	Extensible Markup Language
UML	Unified Modeling Language
IDE	Integrated Development Environment
GUI	Graphical User Interface
SMS	Short Messaging Service
APK	Android Application Package Kit

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Abstract

In this era of technology and precision, our lives depend largely on the technological devices which are being developed in various aspects of life, especially those of healthcare. The Types of these devices are increasing every day, but only a few of them   support Healthcare System. Although there are other equipments that can be used to monitor human health, still there are difficulties in using these devices in hospitals, for instance the function of electrocardiogram (ECG) is to continuously monitor the patient when he is in the intensive care unit (ICU) at the hospital. This requires the patient to go to hospital for tests to make sure that his heart functions normally. ECG device is medically important and must be available in almost every hospital and it helps doctors to follow patient's heart condition in ICU.

This thesis illustrates a system to monitor a patient's heartbeat whether the patient is inside or outside his/her home. This system reads, records and stores the signals by Polar H7 Smart Heart Rate Monitor via Bluetooth communication and in the case of abnormal indications, it sends a warning SMS to doctors for help.The proposed project will use the Android SDK (Software Development Kit) technology to prominently display the signal as a graphic that would be easy for the user to see and a convenient language which were carefully selected to implement the project.

Time is a very important element for   patients who suffer from a heart condition, So we propose the design of a program to monitor and follow up on cases of cardiac patients remotely using a mobile, It registries notes, send SMS and send medical advice to patients before the risk increased.

Keywords: ECG, Patient, Sensor, Smart Phone, Android, Bluetooth.

Chapter 1

Introduction

1.1   Introduction

The development of medical science contributes towards lengthening the human lifespan expectancy. Therefore, the proportion of the elder people in the society is increasing and taking proper care of these people should most certainly be one of the prime responsibilities of the society. ECG is one of the means to follow up the heart condition, and if ECG can be used frequently, it is easier for the physician to identify a problem from the ECG's history of a sick person (it has long been preferred by physicians) [4].

The importance of ECG as a medical tool has led to the development of various types of ECG recording system. The developed systems vary from a simple ECG recorder that can only monitor the ECG signal to a sophisticated system with computer analysis and database. By using the computer, patients can record and save their reliable ECG data by themselves at home. Moreover, the Internet services like e-mail and File Transfer Protocol (FTP) can also be used as a communication tool to send the recorded ECG data to the medical center. What they need is an ECG data acquisition system at home, which is easy for recording, viewing and sending the ECG data to the medical center with reliable accuracy via mobile or internet [4].

Today, the heart diseases are one of the major causes of death in the world. For example, the risk of having a stroke doubles every decade and after the age of 55 the risk grows advancing in age (WHO). Several studies showed that many people are unaware of their health condition and are not diagnosed until they pass away. This indicates that statistically heart problems will be aggravated and become worse [1].

The heart is one of the most vital organs within the human body. It acts as a pump that circulates oxygen and nutrient carrying blood around the body in order to keep it functioning. The circulated blood also removes waste products generated from the

body to the kidneys, when the body is exerted the rate at which the heart beats will vary proportional to the amount of effort being exerted.

By detecting the voltage created by the beating of the heart, its rate can be easily observed and used for a number of health purposes.

An ECG is a graphical trace of the voltage produced by the heart. In other words, it represents the electrical activity of the human heart, and this signal can be measured by the electrodes of the human body in a typical clash and brought the signals from these electrodes to a simple electric circuit with speakers and analogue-digital converters [2], as shown in (Figure 1.1).
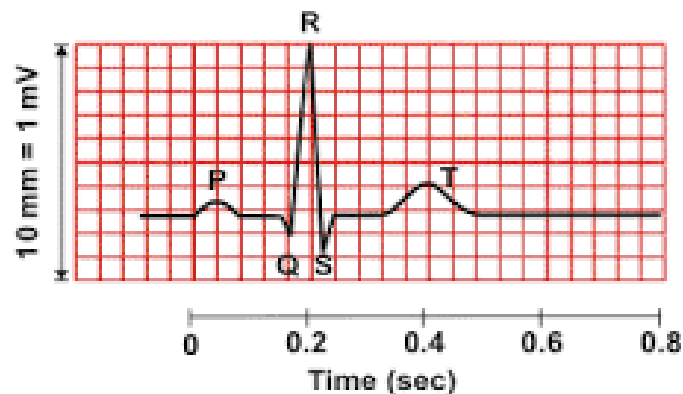
Figure 1.1: The ECG waves [2].

1.2   ECG waves, their meaning.

The ECG is used to assess cardiac rhythm and conduction. It provides information about chamber size and is the main test used to assess for myocardial ischaemia and infarction and heart to work normally, the resting heart rate is normal for adults range from 60-100 beats per minute. A normal ECG contains three distinct sections:

- **P wave**: is the result of action potential that cause depolarization of the atrial myocardium.
- **QRS complex**: is composed of three individual waves, is result from ventricular depolarization and signals the onset of ventricular contraction.
- **T wave**: represent ventricular repolarization.

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Thus, the ECG is very useful for doctors to diagnose the disorder in patients who suffer from heart disease that doctors should notice all the time.

1.3   Types of ECG Devices

There are different types of electrocardiography (ECG) devices, and each has its own special features. ECG devices can vary in size and function, but all work essentially in the same way in checking for cardiac abnormalities. They just fundamentally differ in the extent of the data they capture, the data they show and record, their mobility, and their featured applications.

ECG devices are predominantly used in medical diagnostic testing to monitor the patient's heart rate, particularly the electrical signals produced. They are usually referred to by the number of leads created; in other words, the number of electrical signals they can monitor at a time. [5]

- **12-Lead ECG.**

  The 12-lead ECG is the standard ECG device used for medical diagnostic testing. It uses 10 electrodes with color-coded wires. Six of the electrodes are placed on the chest, and the other 4 are placed on each of the limbs. This type of ECG device can provide a printed record of the ECG, unlike other types. A 12-lead ECG records 12 different electrical signals at around the same time. They are used to diagnose heart attacks and heart murmurs. Symptoms that frequently call for the use of a 12-lead ECG include chest pain, fainting, or seizures.[5]

- **5-Lead ECG**

A 5-lead ECG device uses 5 electrodes, 4 of which are placed on each of the limbs and 1 on the chest. It is usually used for continuous monitoring, like during a major surgical procedure or while a patient is being transported in an ambulance. This does not provide ECG printouts, and may or may not store a permanent record of the ECG readings.[5]

- **3-Lead ECG**

A 3-lead ECG device uses 4 electrodes placed on each of the limbs, which is enough to produce adequate data on heart rhythm monitoring. Like the 5-lead ECG, it does

not give out a printed copy of the ECG recording because it is mainly used for continuous monitoring of heart rhythm. A 3-lead ECG can also be used jointly with other cardiac diagnostic tests, such as an echocardiogram [5].

- **Portable Handheld ECG monitor**

Portable handheld ECG monitors are the smallest ECG devices in the markets today. In spite of their portable and handheld size, they can display and record heart rate like their larger counterparts. They can catch critical data that is helpful in improving heart disease management, and they can give an automatic evaluation in as fast as 30 seconds. Users need not place corded electrodes on their body with this type of ECG. They have a built-in electrode/s, so all you need is to press a button or two on the device and it will start recording. They can identify at least 9 kinds of arrhythmias[5].

- **Wireless ECG**

Wireless ECGs are similar to a standard ECG device, but without the wires. The electrodes used have wireless units that transmit data to the computer or telemetry station. A wireless ECG provides more functionality and comfortable for patients, who wouldn't have to worry about wires attached to their bodies. It can be beneficial in acquiring basic information on a patient with a heart condition, monitor a patient in a hospital, or heart rhythm during surgery [5].

1.4 Problem Statement

This research is to look for the problems and difficulties facing the current system of the health care, Specially for heart patients, and to discuss the appropriate solutions to develop this system.

In fact, the main problem of the current system is that there are no enough devices that provide health care to heart patients around the clock whether the patients be inside or outside their home. Today there are many devices that are used to monitor human health and they are used in specific periods of time. This renders the current system unattended and very weak. For example, the people who are suffering from the heart disease always go to hospitals in specific periods of time in order to know the condition of the heart and find out if there is something wrong. So, the current system is not safe for these patients because in some cases the heart may be at risk without the knowledge of the patient.

The other problem is that   there is no connection between the patient and the doctor or between the patient and the hospital by using smart phones, which makes the health care system very weak, because the current system can monitor the patient's condition from nearby and not from a remote site [13].

For example,   there are people who have heart disease and live in their homes where the process of monitoring heart schemes always happen at specific times given by the doctor to monitor the heart condition and there are no devices for monitoring the condition of the heart automatically and sending the chart to the doctor   at the hospital. Furthermore, if the patient's heart is suffering from any weakness, the device will not send any warning or alert message to the hospital or doctor that there is a dangerous situation facing the patient and this makes the health care system very weak.

This research will provide a mechanism to monitor and follow-up patients who complain of heart diseases, whether they were inside or outside   their homes, but whose condition is not critical,   but If so be their condition is critical; it is natural to be in hospitals, especially in the intensive care unit.

1.5 Aims of The Research

The main aim of this research is to design an application that runs on Smart mobile phone to display the ECG signal for heart patients who are in or out of their homes and who cannot go to hospitals to make sure that their hearts work properly. Also, it aims to send the result of the patient's ECG to the doctor via the mobile or through the recommendation of the stored Database SQLite (Knowledge Base) helper to be given to the patient. More importantly, it provides a good opportunity to see how we can store all patient data in the database and refer to it at any time.

1.6 Objectives

In order to realize the above mentioned aims, several objectives have to be achieved first. These objectives are:

- Review of the literature on the healthcare systems, Specially for heart patients, by using mobile technology.
- The study of design features, principles and design patterns that a mobile application should follow.
- Study of the platform " Android Studio " which the mobile application will run on.
- Investigation of tools that will be used to design and develop a mobile application in the Android operating system.
- Provide tactics for solving common problems in Android application development to help new developers.
- Design and development of an Android application that helps heart patients to establish a direct communication with doctors, regardless of their geographical location, and without the need to go to the hospitals.
- Evaluation of the usefulness of the application. The evaluation will be based on heart patients and doctors that will use the mobile application in real time.

1.7 Solution Approach

1. Firstly, a clear definition of the specific problems concerning the measurement of the patient's heartbeat.

2. Describe the system requirements and the design method. In this research work we chose Waterfall Methodology.

3. Clarify the models and techniques used to describe the proposed project in all the phases of our methodology.

4. Clarify the mechanism to design user interfaces, which can display information on mobile devices.

5. Finally, Present a case study (Part Applied) to illustrate the proposed approach. In this research, The Java programming language, Android studio and the android Software development Kit (SDK) are used as the development tools and environment.

1.8 Thesis structure :

The remaining chapters of this thesis are organized as follows:

- **Chapter 2:** This chapter presents the background, overview of healthcare systems by using mobile technologies, overview of Systems development life cycle and overview of Sensors. It also introduces Introduction of mobile technology and the literature review of previous research related to android application development.

Chapter 3: This chapter presents in detail the methodology used in this thesis. It describes the requirements analysis of the system under development, presented the software requirements specifications (Using IEEE STD 830-1993) which is delivered to the requirements phase, followed by the Phases of the Methodology.

- **Chapter 4:** This chapter presents a case study to show how the proposed project could be used through patients.

- **Chapter 5:** This chapter presents the concluding remarks and the future work.

Chapter 2

Background & Related Works

2.1 Introduction

This chapter presents a background on some of the important topics that might help us in preparing the present work, it consists of six sections. Section 2.2 demonstrates an overview of healthcare systems by using mobile technologies, section 2.3 demonstrates an Overview of Systems development life cycle, section 2.4 demonstrates an overview of Sensors, section 2.5 demonstrates general description of mobile technology, and section 2.6 demonstrates the main related work to project topic from journals and papers related to this thesis.

2.2 Overview of Healthcare Systems by Using Mobile Technologies

Human health is a priority in every country, unfortunately in undeveloped countries where Obesity and Hypertension disorders are increasing every year, the number of the unattended heart patients is increasing as well. Due to the lack of sufficient health services, low standards of living and ignorance, which are the main reasons behind this situation, great efforts have been exerted to take care of patients with a heart condition, and there is still a lot of work to make [30].

At present, heart disease is one of the most serious diseases that may threaten human life. The electrocardiogram (ECG) plays an important role in the prevention of heart disease, it diagnosis the abnormality of the patient's heart and provides quick help for patients. [31]

Whereas healthcare industry is technically facing a big problem, especially in the field of information technology (IT), it is very important to develop the medical systems used in this Industry, of these systems are the electronic health record (EHR) technology and network IT systems which will be of great importance to all the people and the things involved in the healthcare sector.

By allowing information to be shared more easily among doctors' offices and hospitals, and across health systems, EHRs are revolutionizing the Industry.

Benefits include improved efficiency across the board, including better care coordination, easier access to patient information, and to use the smart phone technology to provide better health services to patients[32].

There is a range of challenges facing the health care system. These challenges and difficulties prevent patients from being financially able to pay for the high costs of healthcare and the inaccessibility to hospitals [33]. Mobile technology offers ways to help meet these challenges, Using Mobile Phone Health applications, sensors, medical devices, and monitor patients remotely Products, there are ways by which to improve the delivery of health care. And the technology can help to reduce costs by facilitating the provision of care, People and linking providers to their own health care. Applications allow both Patients and providers access to reference materials, laboratory tests, and Medical records using mobile devices [33].

 Mobile health (m-health) is a developing field that can play a significant role to improve healthcare quality and efficiency. Mobile health applications (apps) running on smart phones and tablet computers are growing rapidly. These applications provide healthcare professionals and the general public, including patients with specialized tools, processes, and communication means [27–29] to support electronic healthcare practice and to improve the quality of health among the general public.

Mobile phones have become an integral part of modern life. Due to the ever increasing processing power, mobile phones are rapidly expanding its area from a sole device of telecommunication to organizer, calculator, gaming device, web browser, music player, audio/video recording device, navigator etc. The processing power of modern mobile phones has been utilized by many innovative purposes [34].

2.3 Overview of Systems development life cycle

A Software development life cycle process is a type of structure or framework used in the development of any software product. There are many different lifecycle models defined. Waterfall model, spiral model, prototyping model are a few such models. Each model is described by a sequence of activities. The development steps or the activities may vary in each and every model, but all the models will include planning, requirement, analysis, design etc [23].

The waterfall model emphasizes more on the step by step process. The spiral model emphasizes on risk assessment while the prototyping model   takes an incremental approach in each and every phase of the development process. [22, 55]

In software engineering, a project in order to be successfully developed needs to be structured, planned and implemented under particular specifications . For this thesis the Waterfall development methodology is adopted.

2.4 Overview of Sensors

A sensor is a hardware device that is designed to acquire information from an object and convert it into an electrical signal [53].

This hardware is composed of three parts:

- The sensing element

- Signal processing.

- A sensor interface.

Sensors are commonly used to obtain context information in robotics and machine vision applications. They are becoming more affordable, can be easily placed everywhere, unobtrusive to wear, with different sizes, less power consumption and less cost [54]. Although the traditional definition of sensor as given in the beginning of this subsection, the term " sensor " does not only mean a sensing hardware, it also refers to every data source which can provide contextual information.

Matthias et al [56] classify sensors into different groups; **Physical sensors**, **virtual sensors**, and **logical sensors**.

In the following subsections there will be a brief description of each group.

2.4.1 Physical Sensors

A physical sensor is the most frequently used types. It senses different types of contexts such as light (e.g. Color sensor), visual context (e.g. Camera), audio (e.g. Microphones), motion (e.g. Motion detectors), acceleration (e.g. Accelerometer), location (e.g. GPS), touch (e.g. Touch sensors implemented on mobile devices), temperature (e.g. Thermometers), physical attributes (e.g. Blood pressure), etc.[56]

The main advantages of sensors are that they are easy to place on the body because they are lightweight, small and inexpensive. They can be put on the different parts of the body to get the needed information regarding the scope of

this study, which is about to create an application to measure a patient's heartbeat using a smart phone.

There are lots of products out in the market. Most of these products share similar characteristics as some have distinctive features. Polar, Zephyr, Runtastic, Garmin, Wahoo and Scosche Rhythm are some of the Heart Rate monitoring products that have been picked to review in this context. The common features are that they all provide accurate HR measurement for mobile applications. Table 2.1 shows Comparison of heart rate monitoring products in terms of their compatibility with operating systems, the communication technology they support, and their battery life.

Table 2.1: Comparison of heart rate monitoring products [[37], [38], [39], [44], [45], [46], [51]]

No	Product Name	OS	Communication Technology	Battery Power
1	Zephyr BioHarness 3	Android	Bluetooth Classic	26 Hours per charge
2	Polar H7	Apple iPhone 4S and more	Bluetooth 4.0	User replaceable battery(CR2025), and battery life up to 350 hours
3	Runtastic Combo HR	Android 4.3 , Samsung Galaxy S4 iPhone **5s,5c,5** iPhone 4s	Bluetooth 4.0	The battery life is around 2.5 years given that it is used 1 hour per day.
4	RHYTHM Chest Strap	Compatible with iPhone, iPad, &iPod	Bluetooth Classic	Rechargeable battery, avg. life 6 hours
5	WAHOO Blue HR Strap	Bluetooth 4.0-enabled iOS device	Bluetooth 4.0	Replaceable 3 volt CR2032 coin cell battery is used and estimated to last about a year.
6	Garmin	iPhone 3GS, 4, 4S iPad	iPod touch	ANT+ Adapter	Utilizes CR2032 battery, and user indicated that it can last about a year or more

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2.4.2 Virtual Sensors

A virtual sensor refers to data sources and collects context data from software applications or services. For instance, an application that checks employees' electronic calendars in order to estimate their day off and reorganize their working hours, or a service to determine a person's location by browsing a travel-booking system instead of using a tracking system (e.g GPS) could be considered as virtual sensors [56].

2.4.3 Logical sensors

A logical sensor is used to solve higher or complicated tasks by using a combination of information sources, physical and virtual sensors, which include additional information from databases[56].

2.5 Introduction to Mobile Technology

2.5.1 Smartphone

A smart phone is a mobile phone with an advanced mobile operating system which combines the features of a personal computer operating system with other features useful for mobile or handheld use. They typically combine the features of a cell phone together with other popular mobile devices, such as personal digital assistant (PDA), media player and GPS navigation unit [35]. Most smart phones can access the Internet, have a touch screen user interface, with either an LCD, OLED, AMOLED.

There are Features of Mobile Application which are as follows [36]:

- Media support .

- Support for Web Services.

- SQLite for structured and offline data storage.

- Support for Location and Maps.

- Integrated browser .

- Graphics - 2D, 3D graphics based on the OpenGL.

- Bluetooth, EDGE, 3G, and WiFi.

- Camera, GPS, Compass, and Accelerometer.

2.5.2 Bluetooth

Bluetooth is a wireless technology standard for exchanging data over short distances (using short-wavelength Ultra High Frequency (UHF) radio waves in the industrial, scientific and medical band (ISM band) from 2.4 to 2.485 GHz) from fixed and mobile devices, and building personal area networks (PANs). Invented by telecom vendor Ericsson in 1994, it was originally conceived as a wireless alternative to RS-232 data cables. It can connect several devices, overcoming problems of synchronization. Bluetooth technology can be used at home, in the office, in the car, etc. This technology allows to the users instantaneous connections of voice and information between several devices in real time. The way of transmission used assures protection against interferences and safety in the sending of information.[42-43]. Bluetooth technology is used in several useful applications in our daily lives, including:

1. Possible off connect the cellular phone devices with each other or with devices (microphones) or with the car kit.
2. A small computer network between computers in a small geographical area (personal) network.
3. Means the introduction of a computer, such as the mouse or the keyboard where it is dispensed wire.
4. Directed by means of a computer, such as printers where they are dispensing wire.
5. Transfer files and information between devices through the transfer of system elements.

There are different versions of Bluetooth technologies we have since 1999.
1. Bluetooth v1.0 and v1.0B(with mandatory Bluetooth hardware device address)
2. Bluetooth v1.1 (ratified as IEEE standard 802)
3. Bluetooth v1.2 (faster connection and discovery)
4. Bluetooth v2.0 + EDR (enhanced data rate).
5. Bluetooth v2.1 (secure simple pairing-SSP).
6. Bluetooth v3.0 (high speed data transfer)
7. Bluetooth v4.0 (low energy consumption –recently used in apple i-phone 4S).

2.5.3 Android mobile phone

An Android phone is a smart phone running on Google's open source Android operating system. Many different manufacturers make Android phones, including HTC, Motorola, and Samsung. Still, all Android phones do share some common features. For example, All of them have touch screens. Dozens of different Android phones are now available, and all of the major cellular carriers in the U.S. offer Android phones [9].

A smart phone in is a wireless computer that can make calls and fit in your pocket. As opposed to a basic phone that can simply send and receive messages or make and receive calls and might come with a few basic games installed a Smartphone can do these things and a whole lot more. Smart phones can access and search the internet, give directions, take pictures, videos, social network, email, etc. [10].A Set of smart phone devices shown in Figure 2.1

Figure (2.1):A Set of smart phone devices[10].

2.5.4 The Android Platform

The Android platform is a relatively new operating system that is based on Java Programming interface. It provides tools such as the emulator, the debugger and specific libraries that enable the developers to create Android applications easily. On the other hand, because of its emerging nature, some features are not applicable since its APIs are renewed daily and that makes it more difficult to develop more complex applications. Every Android application is assigned a unique key which is generated by the development environment [49][52]. An Android application consists of the following parts [49]:

- **Activities**: which are what the user interacts with (e.g., the activity that a button performs when a user presses a button).
- **Views**: which are the interface layouts (e.g., the home screen).
- **Services** : which are background activities that the user cannot see or interact with (e.g., the notification activity).
- **Content Provider** : which supports data provision and data transfer to applications(e.g., the SQLite database can act as a content provider).
- **Intents**: which send asynchronous messages between activities in the app or between other apps and enable the data transmission (e.g., the e-mail intent communicates with the e-mail app).
- **Broadcast Receivers**: which receive messages from the systems (e.g., when the battery runs low) [50].
- **Manifest File**: in which all the application's parts are declared and without it the project cannot run.

There are definitely many other features, for instance a database, which can be implemented in an Android project. Android includes a set of core libraries that provides most of the functions available in the core libraries of the Java programming language [23]. Libraries are a set of C, C++ libraries used by various components in Android development. Here is a list of libraries:

1. **System C library** - a BSD-derived implementation of the standard C system library (libc), tuned for embedded Linux-based devices.
2. **Media Libraries** - based on Packet Video's Open CORE; the libraries support playback and recording of many popular audio and 12 video formats, as well as static image files, including MPEG4, H.264, MP3, AAC, AMR, JPG, and PNG.
3. **Surface Manager** - manages access to the display subsystem and seamlessly composites 2D and 3D graphic layers from multiple applications.
4. **Lib Web Core** - a modern web browser engine which powers both the Android browser and an Embeddable web view.
5. **SGL** - the underlying 2D graphics engine.
6. **3D libraries** - an implementation based on OpenGL ES 1.0 APIs; the libraries use either hardware 3D acceleration (where available) or the included, highly optimized 3D software rasterizer.
7. **FreeType** - bitmap and vector font rendering.

8. **SQLite** - a powerful and lightweight relational database engine available to all applications.

2.5.5 SQLite Data Base

SQLite is an Open Source Database which is embedded into Android. SQLite supports standard relational database features like SQL syntax, transactions and prepared statements. In addition, it requires only little memory at runtime (approx. 250 KByte). SQLite is a software library that implements a self-contained, serverless, zero-configuration, transactional SQL database engine. SQLite is the most widely deployed SQL database engine in the world [7, 24].

SQLite supports the data types TEXT (similar to String in Java), INTEGER (similar to long in Java) and REAL (similar to double in Java). All other types must be converted into one of these fields before saving them in the database. SQLite itself does not validate if the types written to the columns are actually of the defined type, e.g. writing an integer into a string column and vice versa.

SQLite is available on every Android device. Using an SQLite database in Android does not require any database setup or administration. The SQL statements for creating and updating the database must only be defined and the database is automatically managed for users by the Android platform[7].

Android provides full support for SQLite databases. Any databases that is created will be accessible by name to any class in the application, but not outside the application [7, 14].

The recommended method to create a new SQLite database is to create a subclass of SQLiteOpenHelper and override the onCreate() method, in which and SQLite command is executed to create tables in the database. An example is shown in Figure 2.2.

```java
public class DictionaryOpenHelper extends SQLiteOpenHelper {

    private static final int DATABASE_VERSION = 2;
    private static final String DICTIONARY_TABLE_NAME = "dictionary";
    private static final String DICTIONARY_TABLE_CREATE =
                "CREATE TABLE " + DICTIONARY_TABLE_NAME + " (" +
                KEY_WORD + " TEXT, " +
                KEY_DEFINITION + " TEXT);";

    DictionaryOpenHelper(Context context) {
        super(context, DATABASE_NAME, null, DATABASE_VERSION);
    }

    @Override
    public void onCreate(SQLiteDatabase db) {
        db.execSQL(DICTIONARY_TABLE_CREATE);
    }
}
```

Figure (2.2): Sample Android Applications [7]

SQLite has many Advantages [8], we mention some of these :

1. Small size.
2. Ease of installation.
3. Easy to transfer data from one provider to another.
4. No coding problems, especially with the Arabic language.
5. The database is only one file.
6. Support the size of the database of 2 terabytes (2048 GB).
7. Contact code and query them easy (similar to MySQL more simply).
8. Can be used on sites that do not support MySQL.

2.6 Related Works

This Section addresses the main related work to project topic from journals and papers that are related to this project, which are mobile health care on Android devices for patients with heart. There   are many papers and   journals used to healthcare systems by using mobile technologies, some of these papers are listed below :

2.6.1 Mobile Health Monitoring Through Biotelemetry (MBS System)[16].

A group of students at the University of Virginia in the United States of America (Jurik et al., 2009), Presented research on how to improve health through monitoring biotelemetry using mobile computing. This group has done the project, which they created a new device that allows the sensors to collect the heart rates and send the heart rate data to the mobile via wireless technique.MBS System has three tier-architectures are:
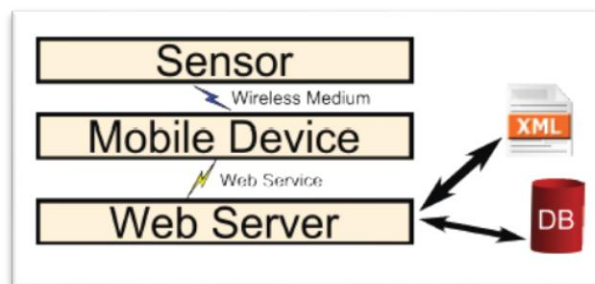
Figure(2.3) :Block diagram[16]

- **Tier One:** includes physiological sensor (ECG), microcontroller (Bluetooth) and radio with swathe. This tier which is Sensors prototype checks the heart

rates and collects the heart rate data (ECG data) and transmits the data via a wireless technique to the second tire which is mobile device.

- **Tier Two:** contains mobile device, which receive a data from the sensors via wireless technique and transfer sensors data to show the result/events of the heart rates (ECG event) through the graphs.

- **Tire Three:** is a web server (web portal) includes the web service and database. This tier allows the authorized users to view the sensors information and ECG graphs data.

Figure (2.4):The sensor sends a wireless signal to the mobile device.[16]
Figure (2.5) : web portal: The user interface permits an overview of heart rates and a view of the full ECG signal on demand.[16]

Advantages:

- The device is easy to be used .
- The system contains sensors to collect the heart rate data.
- The system contains wireless techniques that can send the heart rate data to the mobile device.
- The System used database that store all ECG data.
- The system used server that allows authorized users to view the ECG Data.

Disadvantages:

- Requires placing sensors on the chest of the patient properly and this may take time and therefore it is a complex process.
- There is no warning in case of deterioration of the patient's condition.

2.6.2 Android Based ECG Monitoring System [17]

A group of students Studying at Department of Electrical Engineering at the University of Engineering and Technology Lahore ,Pakistan. (AyazAkram et al,

2013), Presented a research on the development of low power and portable ECG monitoring device based on MSP430 microcontroller and an Android Phone. This work was done in order to provide a reliable solution for cardiovascular patients who can help them to analyze their ECG easily.

This paper discussed the implementation of the project, which aimed to develop an ECG monitoring system based on a smart phone platform. It was a low cost heart rate monitoring solution based on a low power MSP430 microcontroller, which was fully integrated with sensing electrodes on the transmitter side. The controller converts the analog signal to a digital signal via an inbuilt analog-to-digital converter, conditioned and filtered it for transmission via a Bluetooth transceiver IC compatible with the MSP430. Figure 2.6 shows block diagram of implementation
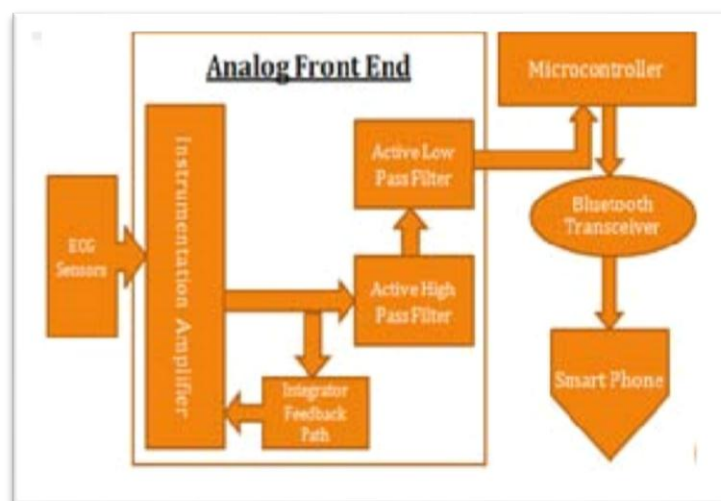
Figure (2.6): Block diagram of the implementation.[17]

The **Bluetooth** was chosen for its near-ubiquity in mobile phones apart from its lowest consumption as compared to Wi-Fi and GPRS.

Microcontroller receives run signal from Android app and starts converting analog signals to digital samples. When it takes a fixed amount of samples, it scales them so that they can be displayed on Mobile Phone screen. An application which is run in microcontroller scales data samples so that the signal can be displayed on a mobile screen accurately.

The **android** platform based smart phone would be used for diagnosis and would also be able to transmit captured images or videos to a healthcare center or a medical professional for specialist advice.
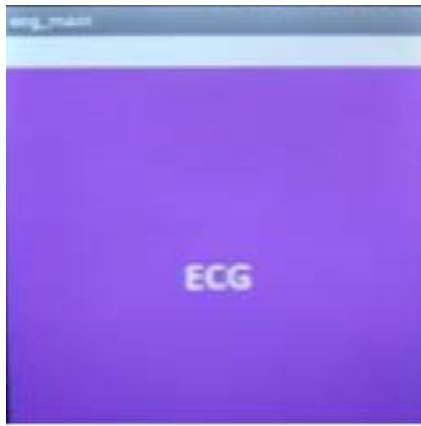
Figure (2.7): Splash Activity.[17]   Figure (2.8): ECG Signal.[17]

The aim of this project was to develop a prototype android ECG application that worked with the ECG analog end . The application would be used for the realization of ECG data signals that were sent from the heart rate monitoring device via Bluetooth communication.

Advantages:

- The device is usable.
- The system contains Bluetooth technique that can send the heart rates data to the mobile device.
- The system allows authorized users to view the ECG Data.

Disadvantages:

- There are no databases that store all ECG data.
- There is no warning in case of deterioration of the patient's condition.

2.6.3 Design and Implementation of Wireless Handheld Device   For Android Cell Phone. [18]

A group of students in Nagpur University in Department of Electronics Engineering , India, who are Poonam T. Bedarkar and Shanti Swamy have researched about how to use a portable system for remote monitoring of cardiac activity by a handheld device with wireless transmission for real time ECG acquisition so that we could archive and visualize both in a mobile phone and a PC.

They created a small size wireless ECG system capable of transmitting ECG signal via Bluetooth technology to laptop and mobile phone. Figure 2.9 shows a block diagram of implementation . The System has three important modules are:
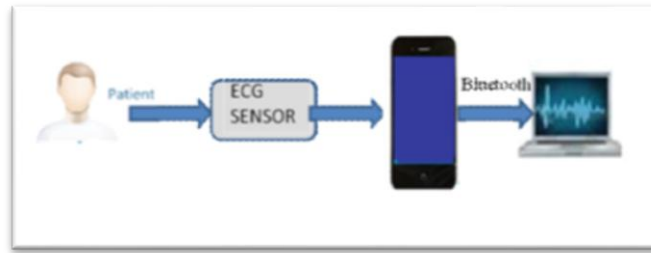
Figure (2.9): Block diagram.[18]

- ECG sensor.
- Android mobile phone.
- Bluetooth.

This group have implemented the project by using ECG sensor to measure ECG from a patient's body on mobile phone and they got ECG and by using Bluetooth technology Then transmit ECG Signal to PC.

The application uses mobile terminal which runs on any mobile phone equipped with Bluetooth. Its user interface allows communications with other devices, and they could receive cardiac signals and could visualize real-time data signal.

In this paper, This group gained a result by capturing ECG using ECG sensor in mobile phone .

Figure (2.10): ECG Wave form in mobile phone.[18]

Advantages:

- The device is easy to use and has a low cost.
- The system contains Bluetooth technique that can send wave form on mobile phone, then transmit ECG Signal to PC.

- The system allows authorized users to archive and visualize both in a mobile phone and a PC.

Disadvantages:

- There are no databases that store all ECG data.
- There is no warning in case of deterioration of the patient's condition.

2.6.4 Health Monitoring System Using Smart Phones and Wearable Sensors[19]

A group of the students in the University of Technology, Sydney in the Australia(Valerie GAY and Peter LEIJDEKKERS) have carried out a research about how to improve the Health Monitoring by using mobile technology. The project, which they designed was a new device that allows to sensors to collect a data from the patient's body and then send a data to the mobile device via Bluetooth. The mobile device can send all data to the server via the internet and also if there are any emergency situations the device will call an ambulance automatically and send SMS to family members via GPS.

The architectures of the system are:

- **Sensors**: many sensors that used to collect or monitor healthcare of the human. These sensors attached to the human's body. For example, ECG, accelerometer and other sensors.
- **External Device**: many external devices used to check healthcare of the human which are: ECG Monitor, Oximeter, Blood Pressure, GPS, Weight Scale and these external devices sharing with the mobile device via Bluetooth.
- **Bluetooth**: send a data from external devices to the mobile device via Bluetooth.
- **GPS**: If there are any emergency situations the device will automatically calls an ambulance and specify the location and place of the emergency situation by using GPS. Also, the GPS can warn and send a message automatically via SMS to the family members.
- **Server and internet**: send or transmitted data to the server via the internet for the doctors, call center, Caregivers and Ambulance.
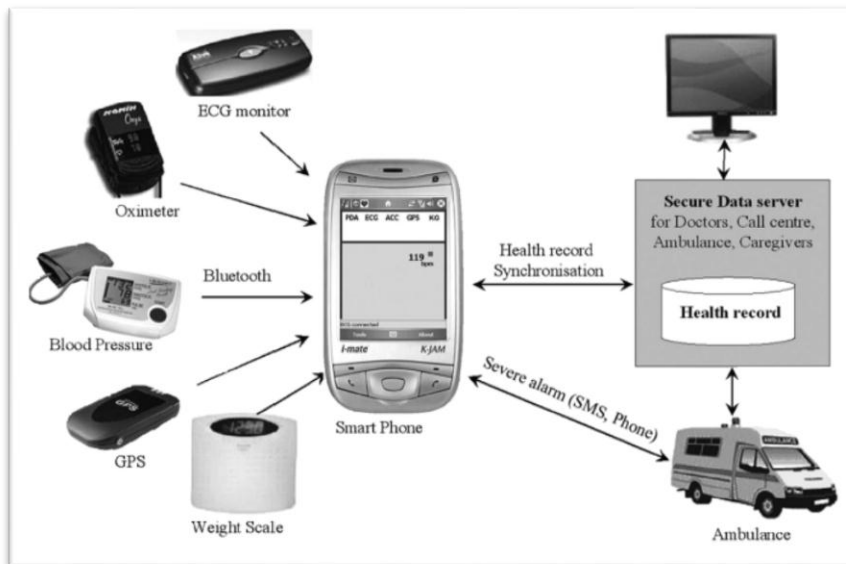
Figure (2.11) :The architectures of the system[19]

Advantages:

- It is Usability .

- The device can do many process at the same time, which means that it can collect many cases such as:

  - ❖ ECG.

  - ❖ Blood Pressure.

  - ❖ Weight Scale.

  - ❖ Oximeter.

- Support Bluetooth technique to send data from external devices to the mobile.

- Includes server to make communication between patient and hospital.

- Calls an ambulance if there are any an emergency situation.

- Sends SMS to the family members if there is any an emergency situation.

Disadvantages:

- Using many devices (external devices) to check human's body consuming time .

- To check or collect any healthy data for any patient that should to the attach the sensors in the body consuming time.

2.6.5 Android ECG Application Development[11]

In [11], a design and implementation of android ECG application have been proposed to work together with VS100, a wearable sensor vitalsens Bluetooth ECG monitoring device . The objective of this journal is to produce an application that can operate with Vitalsens ECG monitoring devices from Intelesens. The ECG data signals from the sensor are sent to smart phone via Bluetooth communication. The authors have successfully developed a prototype of android application and from the experiments, the results were obtained. Figure 2.14 shows an overview of Vitalsens Vs100 wireless network area proposed by this journal [11].

Figure (2.12): System overview of Vitalsens Vs100.[11]

There are two limitations of the proposed system in [11] which Bluetooth connects between sensor and smart phone or laptop, and that requires a lot of power consumptions to send the data and hence, smart phone will quickly run out of battery. It is not efficient for users of outdoors activities. On the other hand , there is no verification of the correctness of the results that were obtained from the experiments. The authors just assumed that the results obtained are correct.

2.6.6 Mobile Healthcare on Android Devices [12]

In [12], a mobile healthcare system for monitoring of ECG data of a patient has been discussed. The work in this paper used the shimmer sensor to sense ECG heart rate from the patient and the data are sent via wireless connection to the smart phone. The data are stored in the server before they are sent to the doctors in order to check the condition of the patient. Figure 2.13 shows the overview of the system proposed in this paper [12].
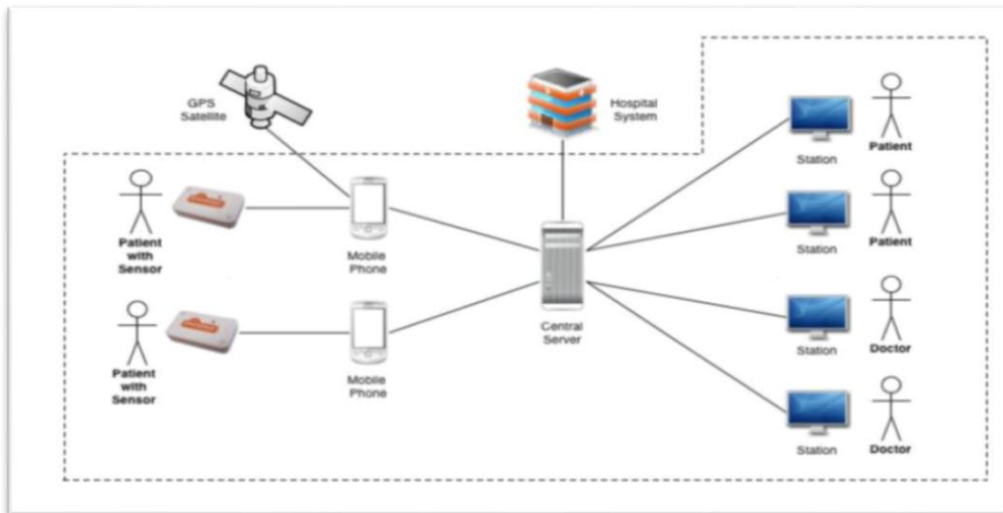
Figure(2.13) : Overview of Mobile Healthcare System.[12]

The proposed system in this paper used Ruby on Rails web application running on an Apache server to store on MySQL database.

Hypertext Transfer Protocol Secure (HTTPS) is used to ensure an encrypted communication and secure identification of the web server. However, the type of sensors that used in this system are quite big and hence it is not efficient for the user to carry the sensors while he/she is doing activities.
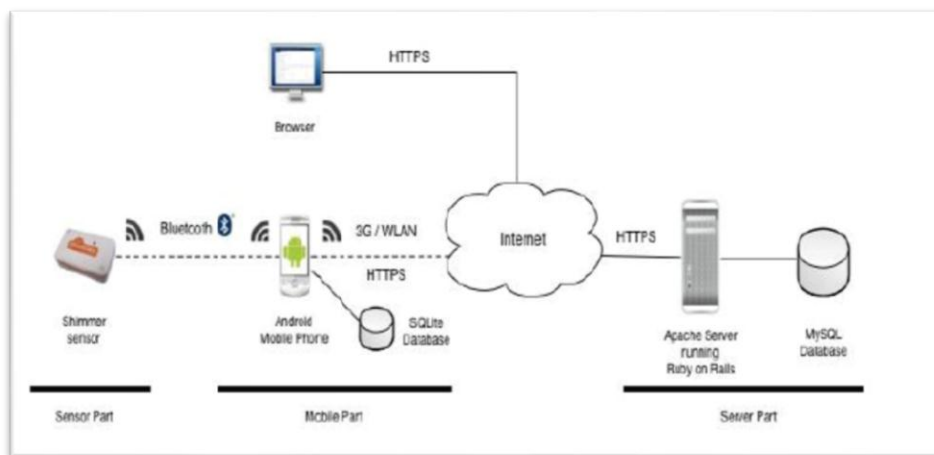

Figure (2.14): Overview of Mobile Healthcare on Android Device.[12]

2.6.7 An ECG Monitoring and Alarming System Based On Android Smart Phone[20].

A group of students at the University of Peking in the Beijing of China (Xiaoqiang Guoet al, 2013) designed and developed an ECG monitoring and alarming system based on Android smart phone.

This system used an ECG device which collects the ECG signal and transmits it to an Android phone; and high resolution ECG pictures are transmitted to doctors' phone in a user-friendly way, which can help doctors keep track of their patient's condition easily. The Android phone detects alarms, which come from the ECG devices. When alarms occur, Android phone will capture the ECG images and the details about the alarms, and sends them to the cloud Alarm Server (AS).

The system is composed of four parts:

A **portable device** with an **ECG senor** for collecting and analyzing ECG signal, an **android phone** to be a processing center for detecting and sending alarms, an **alarm server** for handling the alarm messages and report to doctors, and android phones which are held by doctors and family to receive alarm message. The system architecture is shown in Figure 2.15.
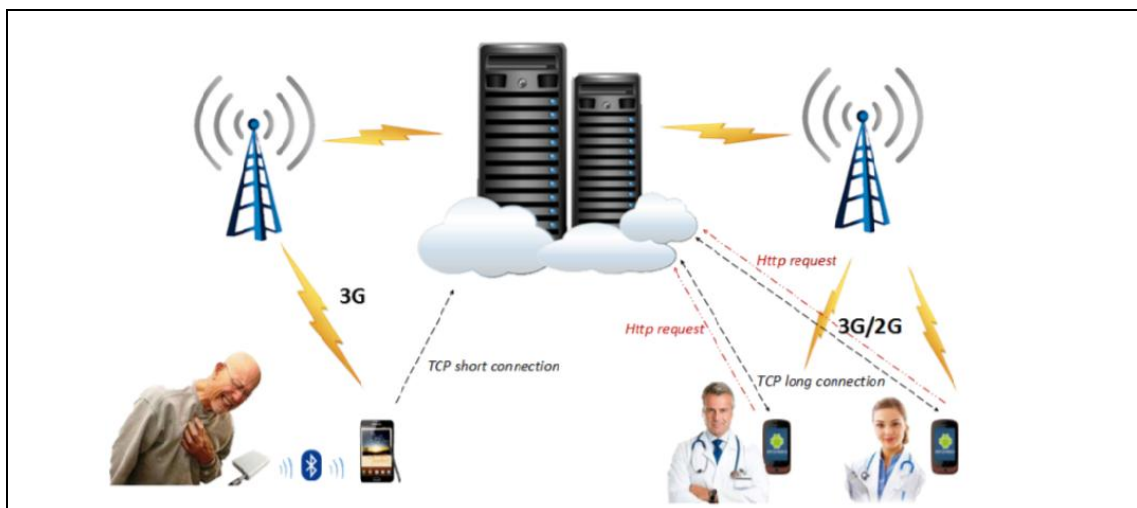
Figure (2.15): System Architecture.[20]

Process of an alarm in the system:

The Android phone requests a TCP connection to Alarm Server to send this message. After validating its identity, Alarm Server establishes the connection. Then the alarm message is sent through the channel. After that, the ECG image is uploaded to a specified directory under the Web Server. They are used TCP protocol to transport the alarm messages and ECG images to alarm server, because TCP is a reliable protocol

that could make sure alarm messages and ECG pictures arrived safe and orderly. Between Alarm Server and doctor's phone, a long IP connection is maintained so that the Push Server could push the message and the ECG image URL to doctors' phone on time. When the doctor reads the message on his phone, an Android Web View could be used to show the ECG image by the URL. Thus an HTTP connection is built to transport high resolution ECG image .The whole processing is shown in Figure 2.16.

Figure (2.16): Process of an alarm in the system.[20]

Figure (2.17): ECG Device and Android smart phone.

2.6.8 Intelligent Mobile Health Monitoring System (IMHMS)[21]
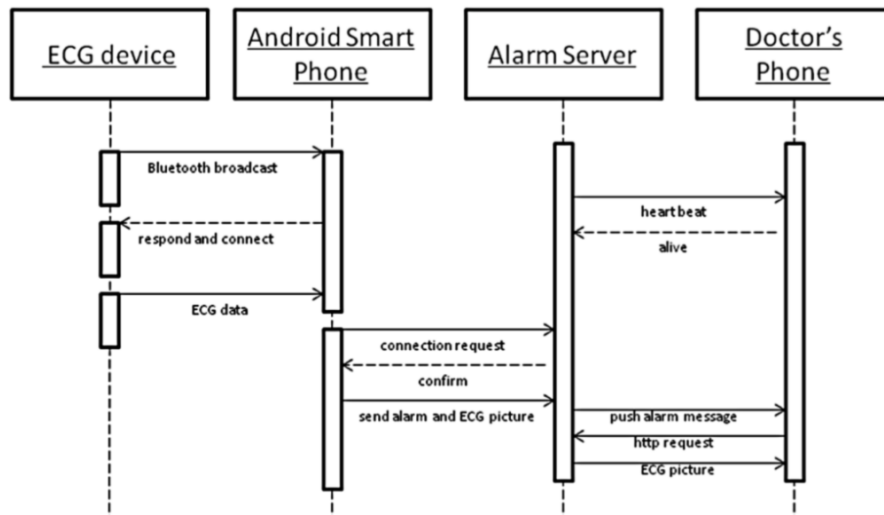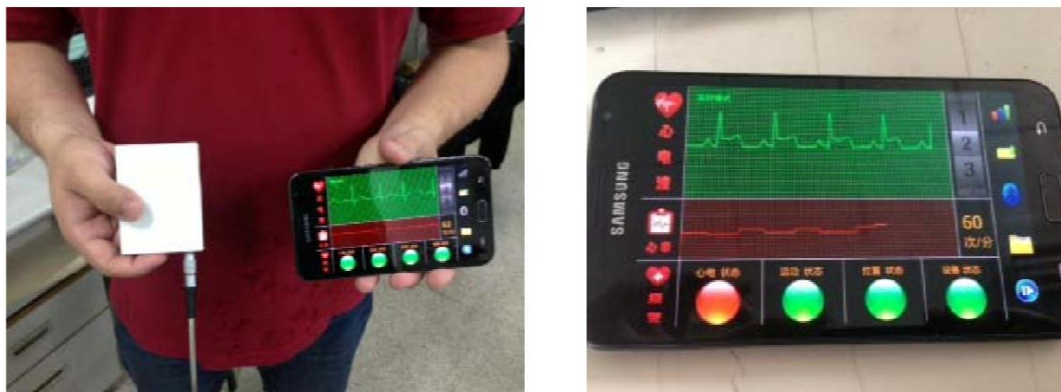
A group of students in Bangladesh University of Engineering & Technology, Marquette University and University of Illinois at Urbana-Champaign,(Shahriyar et al, 2009) Conducted a Research about how to improve Health Monitoring System by using Mobile computing. They designed a new device that allows the sensors to collect, aggregate and summary the patient's physiological data and then the sensors network will transmit a summary data that was collected through the sensor to the patient's personal computer, cell phone or PDA. After that these devices will send summarize data that collected by sensors network to the medical server for analysis. Finally the medical server will furnish notes to the devices, and through these notes the patients can adopt measures or steps necessary actions according on the notes. The system architecture is shown in Figure 2.18
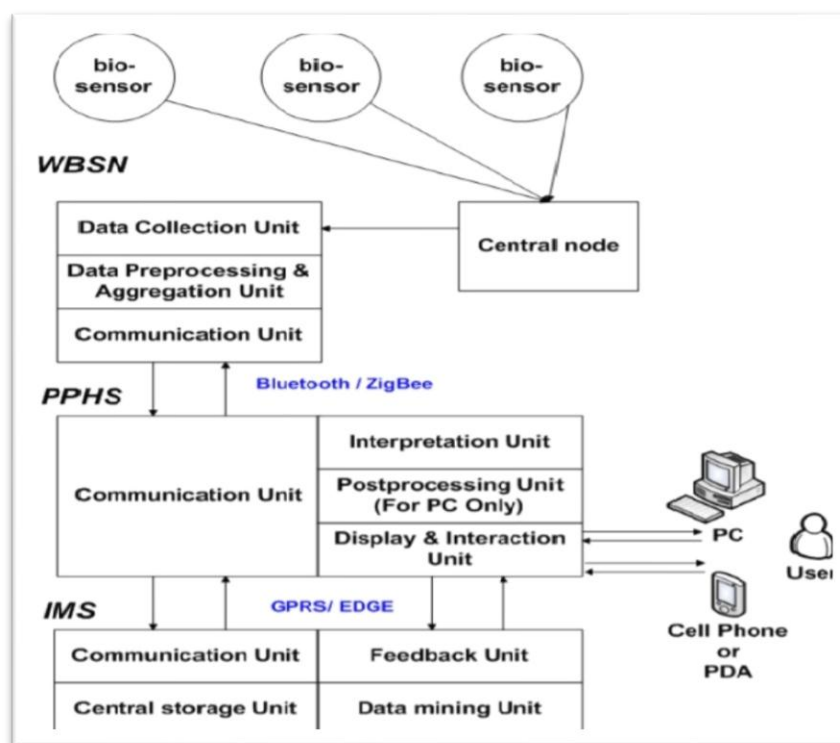
Figure (2.18): IMHMS System Architecture.[21]

IMHMS has three components which are :

- **Wearable Body Sensor Network [WBSN]**

it contains bio-sensors that can put on the patient's body and can collect data from patient's body. Actually, there are many sensors on the patient's body and each sensor will send its data to the group leader. After the sensors collected a data from the patient's body and send it to the group leader after that the group leader send the

collected information to the central controller and the central controller is answerable for transferring patient's data to the personal computer, cell phone or PDA and after that the WBSN will communicate with the second component which is PPHS through wireless technique. WBSN is shown in Figure 2.19
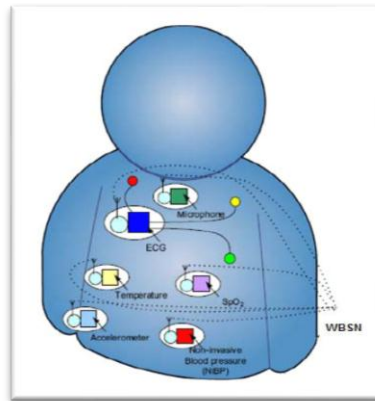
Figure (2.19): WBSN.[21]

- **Patients Personal Home Server[PPHS]**

    After the PPHS receive the data from the central controller of the first component which is WBSN then the PPHS monitoring the data and send the data to the third component which is IMS

- **Intelligent Medical Server [IMS]**

    By using IMS the authorized user can login to the system to view the patient's history. Actually, the IMS includes three components.
    - **Central Database**: Includes Patient profile and health data.
    - **Data Mining Unit**: "processes the data and returns the feedbacks and results to the Feedback Unit".
    - **Feedback Unit**: send augmented feedback data to the PPHS.
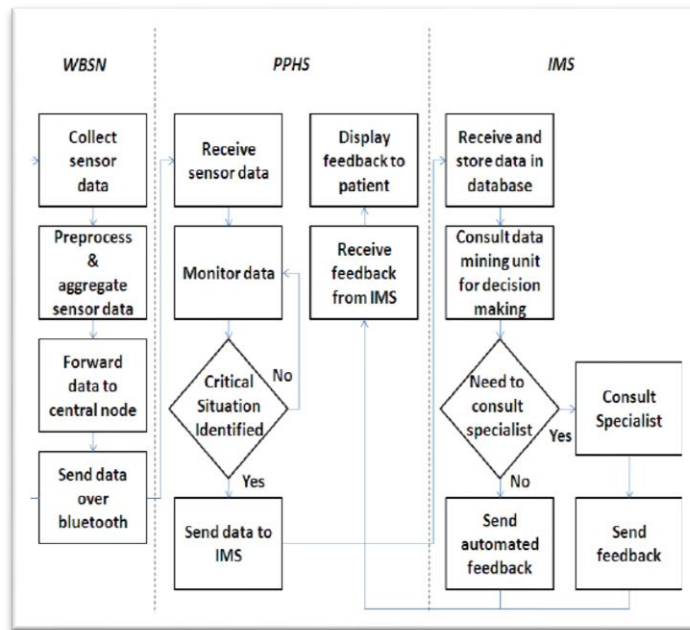
Figure (2.20): The Flow diagram of the system.[21]

Figure (2.21): Patient's Profile and Manual Data submission.[21]

Figure (2.22): View History of the system.[21]

Advantages:

- Usability .
- The system contains many sensors that can collect the different health's data at the same time, which mean the device can do more than one process at the same time such as:
    - ECG
    - Temperature
    - Non-invasive Blood pressure (NBP)
    - oxygen
- Support wireless technique to send a data from sensors to the mobile
- Include database to store all data.
- Includes Intelligent Medical Server that allows the authorized user to login the system and view the patient's history and health data.

Disadvantages

- No Alarm Device.
- To check or collect any health's data for any patient that needs to attaching the sensors on the body that will take consume time.

From the available literature review, most of the previous projects concerned with monitoring the health status of heart disease patients discussed how to send warning messages to the doctor, hospital, any mates or relatives, but they did not find any solution was used in the case of non-arrival of messages or in the absence of a reply or response from the Doctor or hospital.

In this thesis, the patient's condition will be followed up when his/her heart is in the abnormal situation and also warning messages will be sent to the competent authorities to follow up the healthy status of the patient. In the case of no response from these concerned parts .The proposed system will provide the patient with help tips which can alarm the patient before increasing the risk by Using SQLite knowledge base stored in the patient's phone.

Chapter 3

Proposed Design for An ECG Application.

3.1 Introduction

In this chapter, we present in details the methodology used in this thesis, we describe the requirements analysis of the system under development, presentation the software requirements   specifications (Using IEEE   STD 830-1993), describing the proposed design for an ECG application, and discuss the system model, UML uses cases and activity diagrams, followed by the Methodology's Phases.

3.2 Waterfall Methodology

The Waterfall Model was suggested by **Winston Royce** in 1970 [48]. This model consists of several steps and the phases can be adjusted depending on the project's requirements [47]. In this thesis, we will use this methodology because the requirements and the output are clear and understandable. Additionally, this methodology works well for a small Projects, In this thesis, the development steps consist of the requirement analysis, the application design, the implementation and testing. Figure 3.1 shows the Waterfall model.
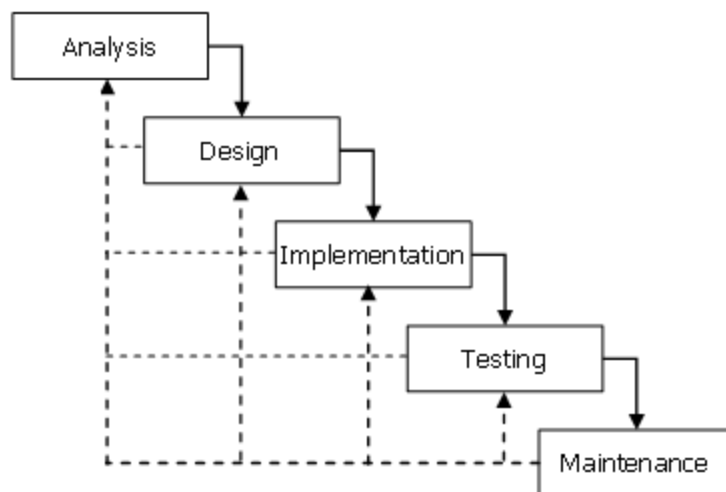

Figure (3.1):The Waterfall model [25].

The Waterfall approach works well for inexperienced developers that need to deliver an application or software on time and with specific predefined requirements. Additionally, the most important advantage of this approach is that contributes to better understanding of the product, because in the end of every phase, the requirements must be met in order to go on to the next phase [48]. These advantages can be summarized in the following:

- Simple and easy to understand and use

- Easy to manage due to the rigidity of the model .

- Each phase has specific deliverables and a review process.

- Phases are processed and completed one at a time.

- Works well for smaller projects where requirements are very well understood.

- Clearly defined stages.

- Well understood milestones.

- Easy to arrange tasks.

- Process and results are well documented.

3.3 Requirements analysis

This phase focuses on getting accurate information from stakeholders (heart patients/doctors) in the system, by conducting interviews with questions that are targeted to this problem and the key objective of the system that will be developed. Here the traditional technical interview with the doctor will be applied to ask the sensitive specific questions and to show that the main questions asked by requirement engineers to the stakeholders to get an initial understanding of the scope of the system and the system.

The questions below were the key questions in this thesis to apply the approach:

1. What are the expected patient's data requirements (system objectives) ?

- Easy access to patient data and easily track the status of the patient at any time.

- Accurate and up to date information about the patient through a graphical user interface.

- The ability to add or update the patient and doctor data easily.

- The existence of effective control over the patient's heartbeat from a distance.

- Possibility of sending messages SMS to the doctor and show notices alert to help.

2. Who are the beneficiaries of the system?

Doctors and heart patients , but the patients are most benefiting because they are helped by the system instead of going to hospital to measure the heart rate.

3. What are the key elements in this existing system?

The main elements (entities/objects) are patient and doctor where the system measuring the pulse rates of the patient using an ECG sensor(polar h7   heart rate sensor) .

4. The process of measuring pulse rate of the patient's heart?

According to the doctor's answer , in the traditional way followed in the hospital ECG process is measured by connecting the poles of the machine with the four parties to the patient lying on his back in a calm and relax and connect another six poles at certain points on the patient's chest.

The patient is connected to the device accurately and to improve the connection of electricity from the patient's body to the machine, a patient's skin should be wiped with a wet damp cotton or to put a small amount of Gel then the ECG rates on the screen .

However , according to this application , the patient puts the sensor (polar H7) on his/her chest and then runs the App. The First step is to press the start button to enter the App and connect the sensor with a mobile phone via the Bluetooth , and then he/she enters his/her personal information (patient's name, age.. etc) and the Data of the doctor (name of doctor and phone number . etc) . Next he/she enters the settings for measuring the pulse (the pulse rate and the number of pulses) . After that, the patient enters the ECG screen and presses the ECG measurement button to receive signals from the sensor by using the Bluetooth to displayed the signals and pulse rateon his/her mobile screen and if there are any abnormal pulse rates , they will be stored in SQLite database and warning messages will be sent to the doctor for medical assistance .

From the questions answered above, A stakeholder can be defined and a use case diagram drawn to visualize the system from the user's perspective.

Table (3.1) : Stakeholder's identification

Stakeholder_ID	Stakeholder_Name	Functionality
1	Patient	Enter all Patient information
2	Doctor	Enter all doctor information and enter medical assistance
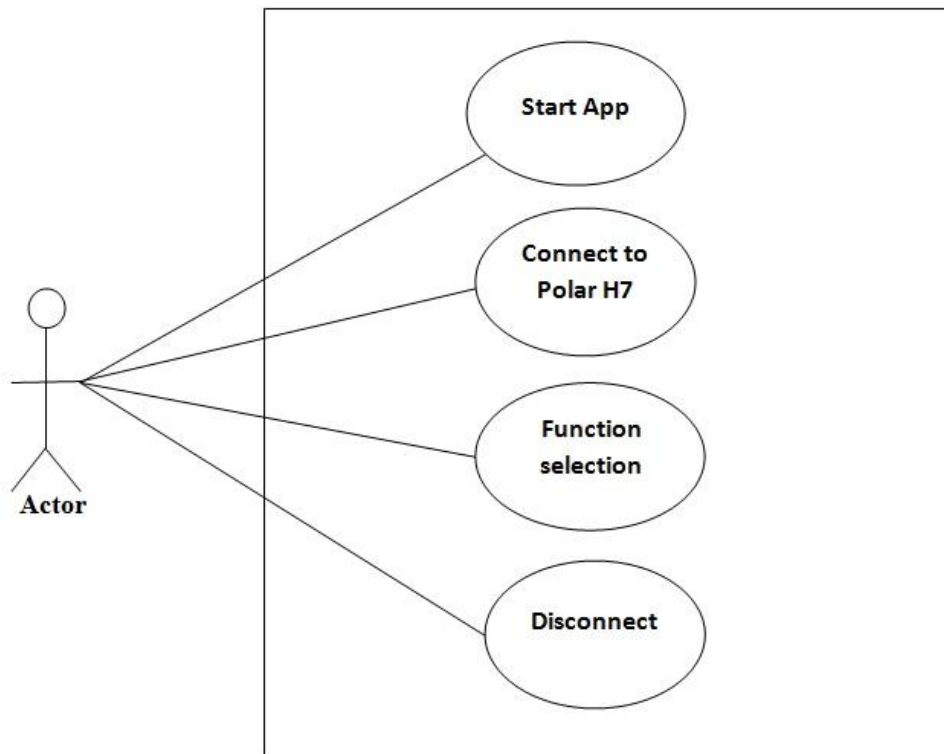
Figure (3.2) :Use Case Diagram of the application
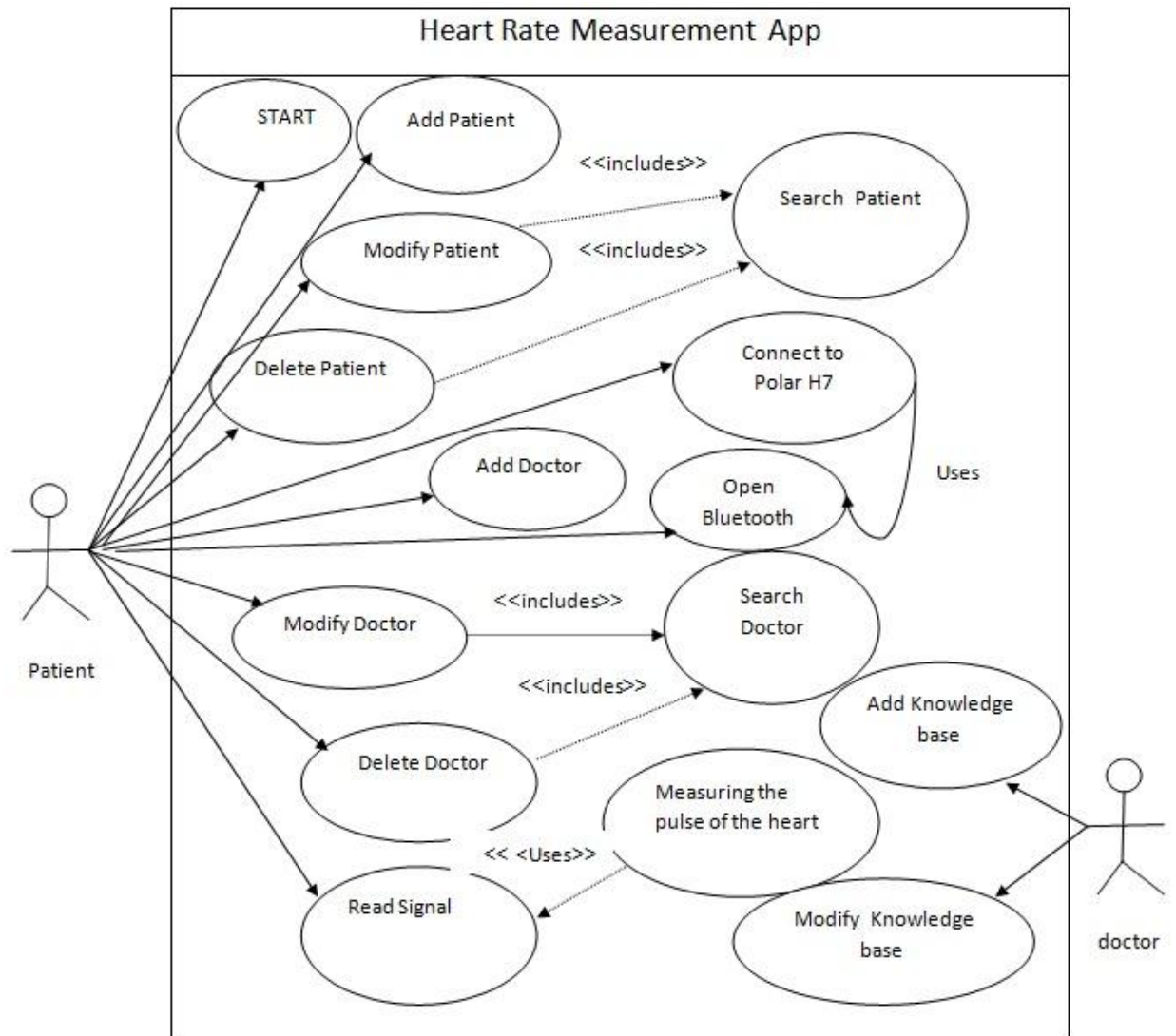
Figure (3.3): Use case diagram for Heart Rate Measurement App

3.3.1 Applying paper prototype to the extracted requirements

- **Start App**

The Patient is pressing the **Start button** to enter the App as shown in figure (3.4)
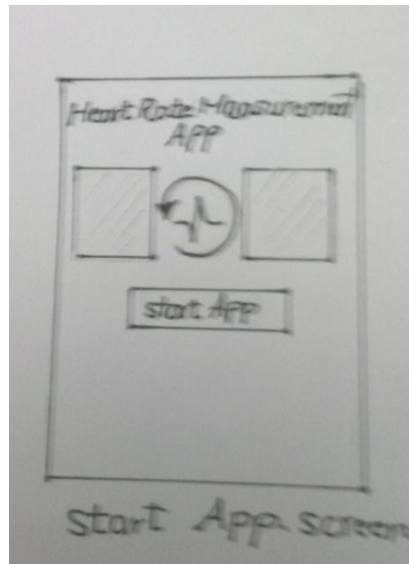
Figure(3.4): Start App prototype

- **Main list**

After the patient presses the **Start button** , a screen will be shown to choose what function could be performed as show in figure(3.5)
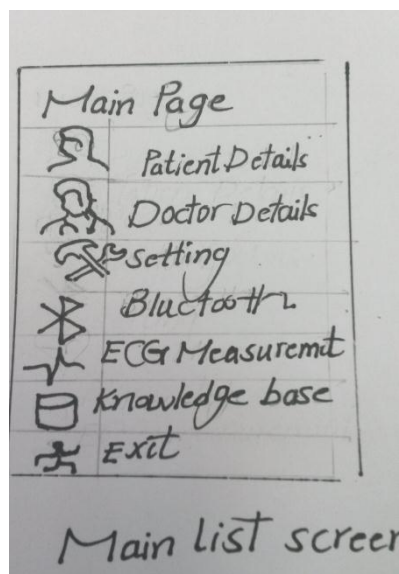
Figure(3.5): Main list prototype

- **Add Patient information**

The Patient clicks on **Patient Button** and enters his/ her personal information and then chooses add Patient , then this screen will appear as shown in figure(3.6)
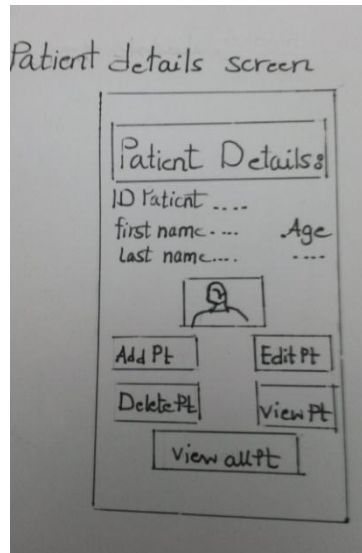
Figure(3.6): Add new Patient prototype

- **Update Patient information or delete**

The patient clicks on **Patient Button** and enters his / her ID : First Name ,last name and the age. Then   he/she chooses   the   update patient button then the following screen will appear as shown in figure(3.7)
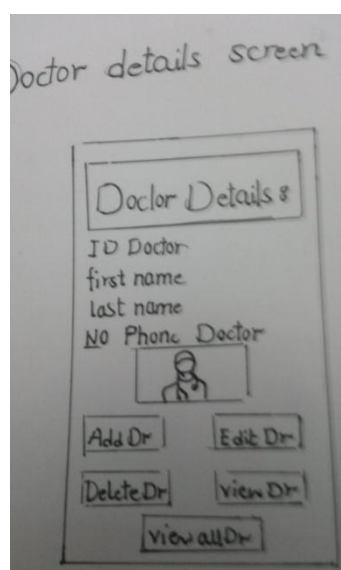
Figure(3.7): Update patient information prototype

- **Search Patient information :**

The patient clicks on **Patient Button** and then enters his / her ID then presses on the view Button to show his/her information . Then the following screen will appear as shown in figure(3.8)
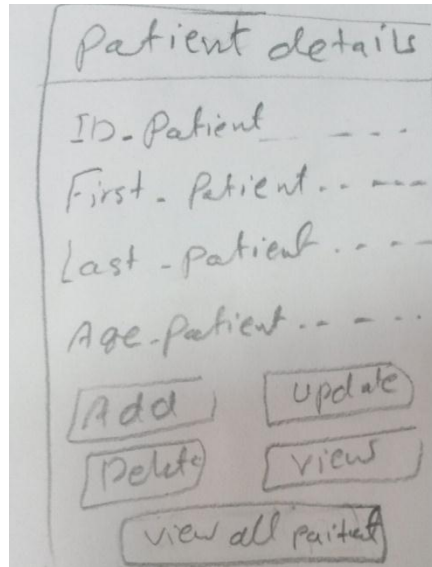
Figure(3.8): Search for Patient prototype

- **Add Doctor information**

The Patient clicks on **Doctor Button** and chooses add doctor , then this screen will appear as shown in figure(3.9)
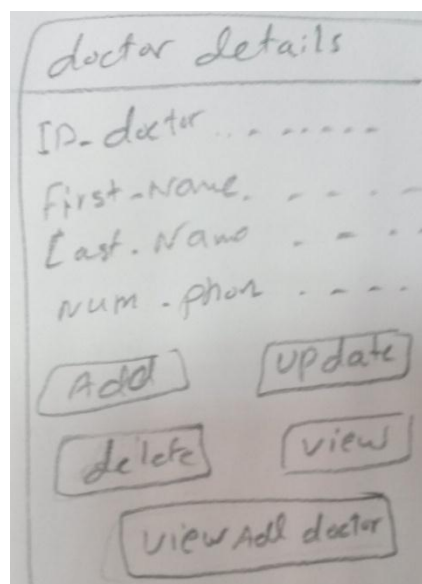
Figure(3.9): Add new doctor prototype

- **Update Doctor information or delete**

The patient clicks on **Doctor Button** and enters ID doctor , first name ,last name and doctor phone number and   chooses the   update doctor button then the following screen will appear as shown in figure(3.10)
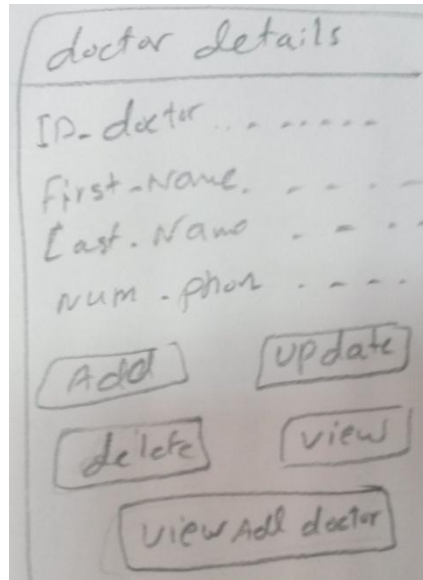
Figure(3.10): Update doctor information prototype

- **Search Doctor information :**

The patient clicks on **Doctor Button** and then   enters ID   doctor   then presses on view button to show information for the doctor then the following screen will appear as shown in figure(3.11)
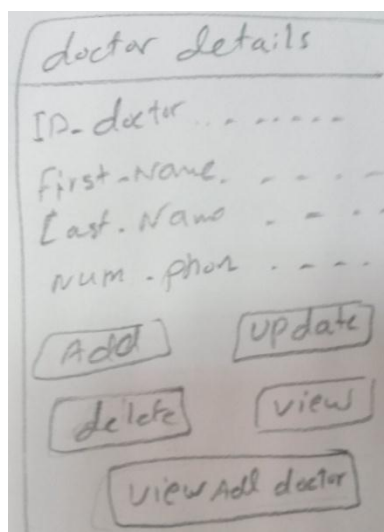
Figure(3.11): Search for doctor   prototype

- **Connect To Polar H7 :**

When a patient runs the **Bluetooth**, he / she can make connection between the Polar H7 and mobile device. The following screen will appear as shown in figure(3.12)
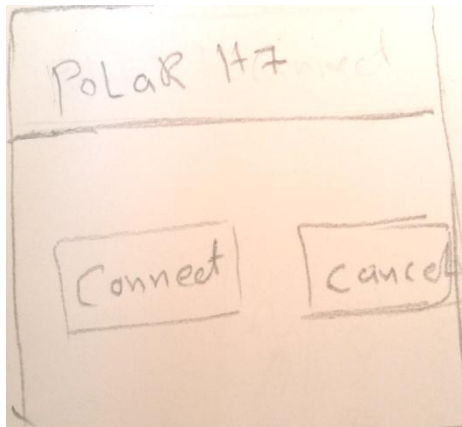
Figure(3.12): Connect To Polar H7prototype

- **ECG Measurement:**

When the patient clicks on **ECG Measurement Button** and presses the run key of the heart rate measurement .The following screen will appear as shown in figure(3.13)
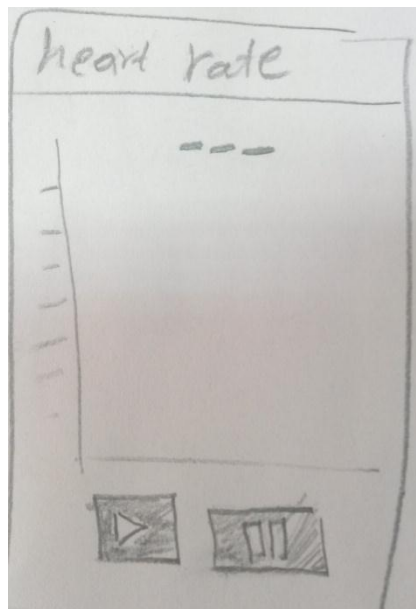
Figure(3.13): ECG Measurement prototype

- **Add Knowledge**

The Doctor clicks on **Knowledge Base Button** and choose Add Knowledge . Then this screen will appear as shown in figure(3.14)
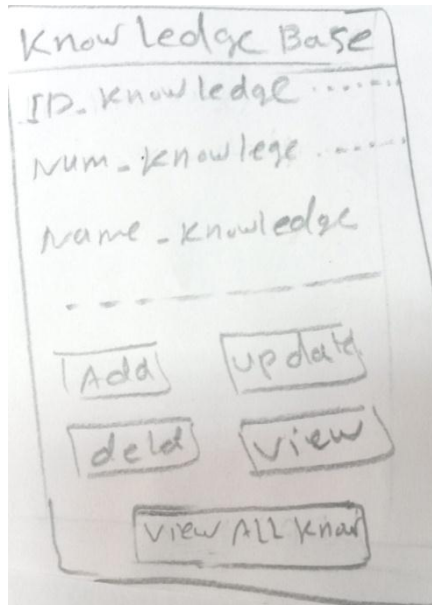
Figure(3.14): Add New Knowledge prototype

- **Update Knowledge**

The Doctor clicks on **Knowledge Base Button** and chooses Update Knowledge .Then this screen will appear as shown in figure(3.15)
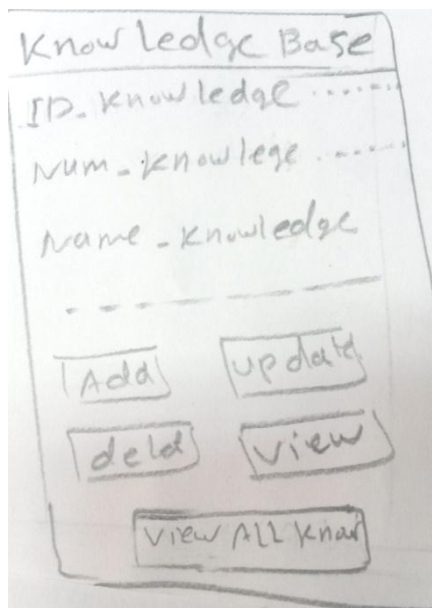
Figure(3.15): Update Knowledge prototype

3.3.2 Stakeholder traceability matrix:

here after the requirement are prototyped with corresponding stakeholder, we could develop a traceability matrix for the stakeholder and the requirement .

Table(3.2): Mapping requirements to stakeholders

Req ID	Requirement name	SK1	SK2
001	Login to system	Patient	
002	Add Patient information	Patient	
003	Update Patient information	Patient	
004	Delete Patient information	Patient	
005	Search for Patient information	Patient	
006	Add Doctor information	Patient	Doctor
007	Update Doctor information	Patient	Doctor
008	Delete Doctor information	Patient	Doctor
009	Search for Doctor information	Patient	Doctor
010	Connect to polar H7	Patient	
011	Open Bluetooth	Patient	
012	Read Signal	Patient	
013	Measuring the pulse of the heart	Patient	
014	Add knowledge information		Doctor
015	Update knowledge information		Doctor

3.3.3 Dependency traceability matrix:

After the initial analysis and validation of requirement using prototyping the functional requirements are getting clearer and clearer, so we develop a traceability matrix for extracting the relationship among the requirements.

Table (3.3): Extracting relationships among requirement.

ID.Req	002	003	004	005	006	007	008	009	010	011	012	013	014	015
002														
003				X										
004				X										
005														
006														
007								X						
008								X						
009														
010										X				
011														
012														
013											X			
014														
015														

3.3.4Use Case Process Description:

Using use case process description is helpful, it provides an insight of the behavior of each use case and who's interacting with it and related use cases that may be involved.

Table (3.4): Add Patient information use case description

	Use-case process description
Use case name	Add Patient information
Pre-conditions	The patient enters all patient information
Post-conditions	A new patient added to the system.
Description	The patient enters the patient information in patient dialog and saves the information to database.
actor	Patient
Related	None

Table (3.5): Update Patient information use case description

	Use-case process description
Use case name	Update Patient information
Pre-conditions	ID patient must be already in the system
Post-conditions	New Patient information.
Description	The patient enters the patient information in patient dialog and modifies the specified information and save the changes to database.
actor	Patient
Related	Search patient's information

Table (3.6): Delete patient information use case description

	Use-case process description
Use case name	Delete Patient information
Pre-conditions	ID patient must be already in the system
Post-conditions	Patient will be deleted from the system
Description	The patient enters the patient information in patient dialog and the system displays the patient information on the patient dialog, then patient deletes the patient and save the operation.
actor	Patient
Related	Search patient's information

Table (3.7): Add Doctor information use case description

	Use-case process description
Use case name	Add doctor information
Pre-conditions	The patient enters all doctor information
Post-conditions	A new doctor added to the system.
Description	The patient enters the doctor information in doctor dialog and saves the information to database.
actor	Patient or doctor
Related	None

Table (3.8): Update doctor information use case description

	Use-case process description
Use case name	Update doctor information
Pre-conditions	ID doctor must be already in the system
Post-conditions	New doctor information.
Description	The patient enters the doctor information in doctor dialog and updates the specified information and save the changes to database.
actor	Patient or doctor
Related	Search doctor's information

Table (3.9): Delete doctor information use case description

	Use-case process description
Use case name	Delete doctor information
Pre-conditions	ID doctor must be already in the system
Post-conditions	doctor will be deleted from the system
Description	The patient enters the doctor information in doctor dialog and the system displays the doctor information on the doctor dialog, then patient deletes the doctor and save the operation.
actor	Patient or doctor
Related	Search doctor' information

Table (3.10): Start App use case description

	Use-case process description
Use case name	Start App
Pre-conditions	None
Post-conditions	Patient will be a granted access to the App
Description	The Patient is pressing the Start button to enter the system
actor	Patient
Related	None

Table (3.11): Connect To Polar H7use case description

	Use-case process description
Use case name	Connect To Polar H7
Pre-conditions	Android device and Bluetooth support
Post-conditions	Prompting for device discovery and connecting
Description	The patient links between the mobile device and the PolarH7
actor	Patient
Related	Open Bluetooth

Table (3.12): Read signal use case description

	Use-case process description
Use case name	Read signal
Pre-conditions	Bluetooth communication is established
Post-conditions	Display ECG and heart rate in a mobile patient device
Description	The patient Clicks the signal read button that is sent from the Sensor (Polar H7) via Bluetooth technology to view the ECG ,calculates heart rate and then stored in a database
actor	Patient
Related	Connect To Polar H7

Table (3.13): Measuring the pulse of the heart use case description

	Use-case process description
Use case name	Measuring the pulse of the heart
Pre-conditions	Heart pulse signal that is already stored in the database
Post-conditions	abnormal Heart rates will be stored in the patient's Profile
Description	After reading a patient's heartbeat and calculating the rate of each pulse ,storing abnormal heart rates according to number of heart beat to be determined in settings file , short text messages will be send to the doctor's phone . the messages inform the doctor that pulses of the patient's heart are irregular and the time of each heart pulse
actor	Patient
Related	Read signal

Table (3.14): Add knowledge information base use case description

	Use-case process description
Use case name	Add knowledge base information
Pre-conditions	The patient enters all knowledge information
Post-conditions	A new knowledge base added to the system.
Description	The doctor enters the knowledge base information in knowledge base dialog and saves the information to database.
actor	doctor
Related	None

Table (3.15): Update knowledge base information use case description

	Use-case process description
Use case name	Update knowledge base information
Pre-conditions	knowledge base must be already in the system
Post-conditions	New knowledge base information.
Description	The doctor enters the knowledge base information in knowledge base dialog and updates the specified information and saves the changes to database.
actor	doctor
Related	Search knowledge base

3.3.5 Activity diagram:

- **Start App**
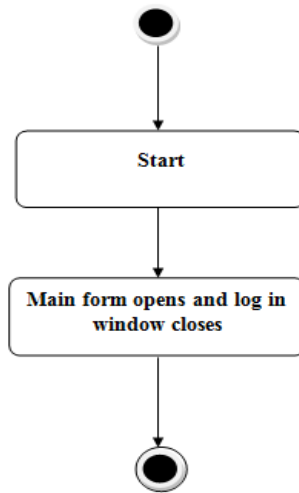
Figure(3.16): Start App activity diagram

- **Add Patient information**
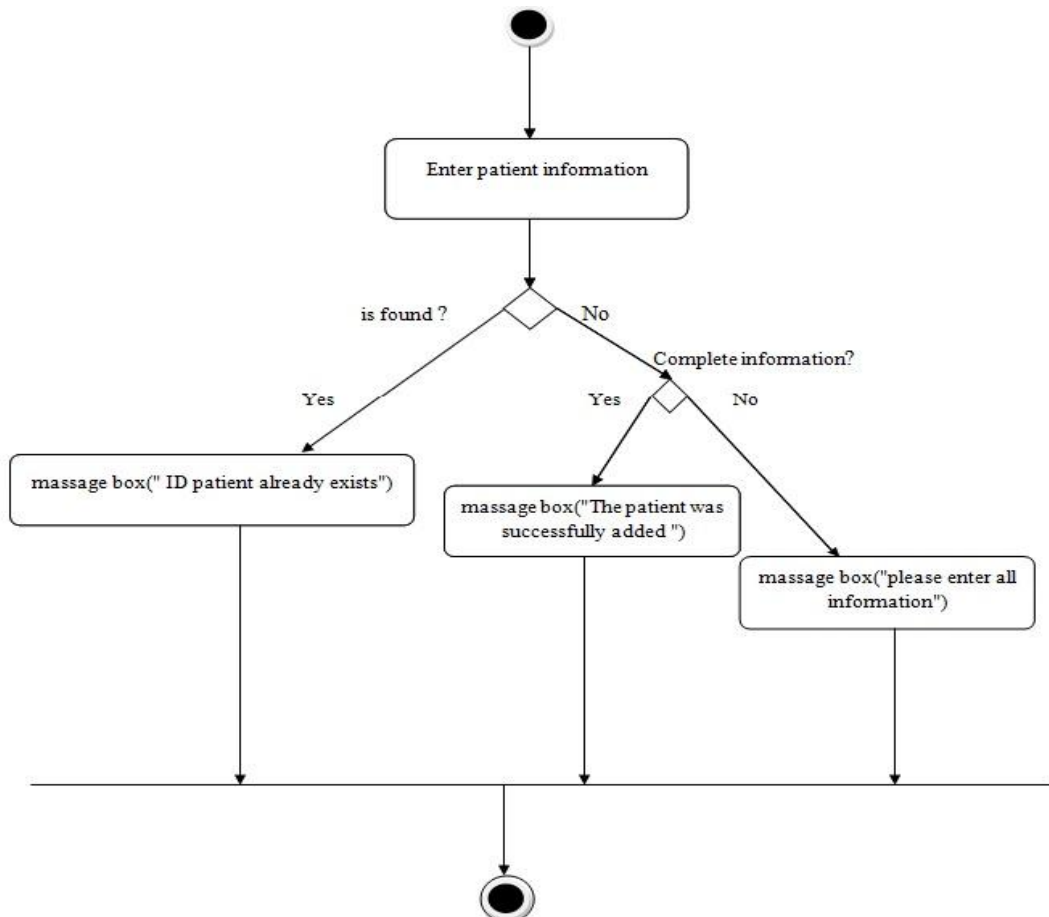

Figure(3.17): Add Patient activity diagram

The rest of Activity diagrams can be found in Appendix B .

3.4 Requirement Specification

3.4.1 Introduction

A software requirements specification (SRS) is the deliverable of the requirements phase, grounding later development phases.

Alan Davis [57] defines "A software requirement specification is a document containing a complete description of what the software will do without describing how it will do it." Another formal definition in [58] states "A software requirements specification is the document that clearly and precisely describes each of the essential requirements (functions, performance, design constraints, and quality attributes) of the software and the external interfaces."

During the specification step the requirements are formally documented. The requirements specification can take one of many forms. For example, on small projects all of the requirements information may be documented in a single Software Requirements Specification (SRS) document.

The IEEE standard (IEEE 830, 1993) is proposed to document the requirement specifications of the system being developed. So they can be communicated to all the product stakeholders. The template of this standard is shown in appendix A.

3.4.2 Purpose of the requirement document

The purpose of this document is to provide a system analysis and specification for Heart Rate Measurement App, and this document is created for patients, doctors, testers, developers, designers, analysts and App stakeholders.

3.4.3 Scope of the App

This App illustrates a system to monitor the heartbeat of patients while the patients are inside their homes or outside. This system reads and stores the signals by Polar H7 Smart Heart Rate Monitor via Bluetooth communication and in the case of abnormal indications ,it sends a warning SMS to doctors to help and Knowledge base to make recommendations to the patient, these recommendations are presented to the patient's mobile screen after every certain period of time as alerts, these alerts the user selects the time displayed on the mobile .

3.4.4 References

The method used to draw ECG in hospitals, doctors.

3.4.5 General description

3.4.5.1 Product perspective

This app is based on Android system. And also, it depends on the Polar H7 Sensor .

3.4.5.2 Product functions

This App aims to facilitate the process of reading the heartbeat and send short text messages to the doctor in case of an abnormal heartbeat and also give recommendations for heart patients after every certain period of time .

3.4.5.3 User characteristics

Before the development of the App, the Patient and the doctor must take a training session of how to use the App in efficient manner.

3.4.5.4 General constraints

The patient has to put the device(Polar H7 Sensor) on his/her chest and enters all the information and enters all the doctor data and determines the time of the emergence of the recommendations and then runs the App.

3.4.6 Specific requirement

3.4.6.1 External interface requirement

3.4.6.1.1 User interface

- **Start App Screen**
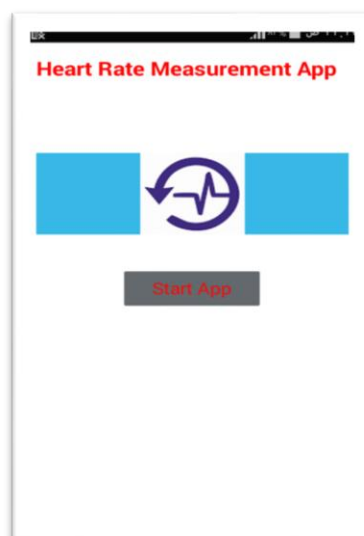
Figure(3.18): Start App screen

- **Main list Screen**
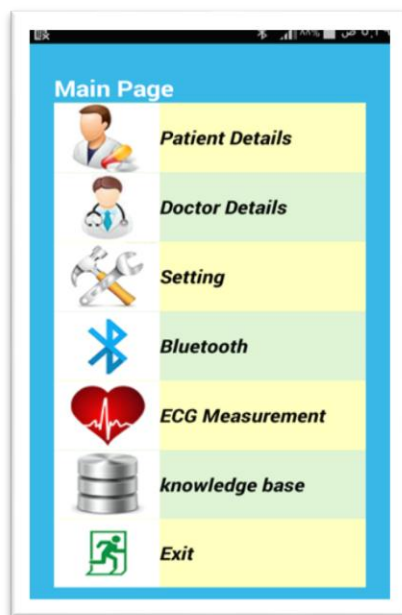
Figure(3.19): Main List screen

- **Patient details Screen**

Figure(3.20): Patient screen

- **Doctor details Screen**

Figure(3.21): Doctor screen

- **ECG Measurement Screen**
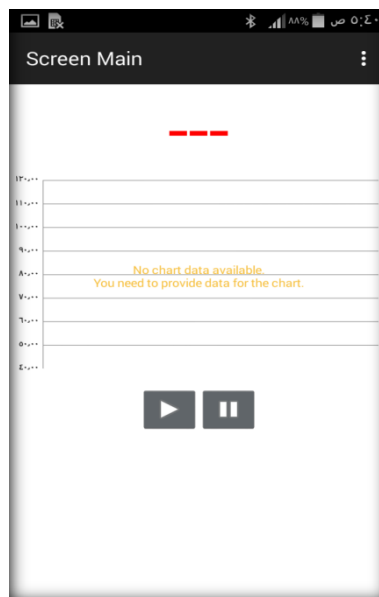
Figure(3.22): ECG Measurement screen

- **Knowledge base Screen**
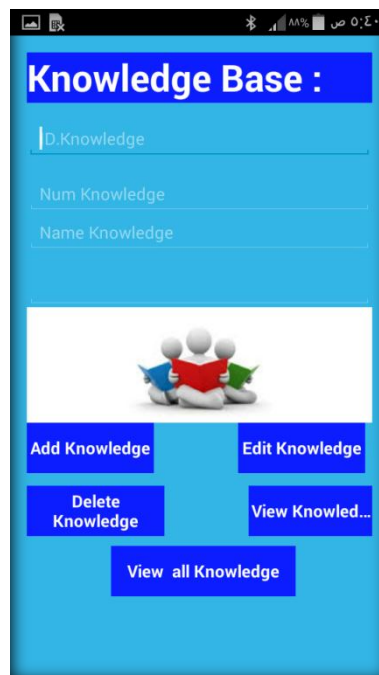
Figure(3.23): Knowledge base screen
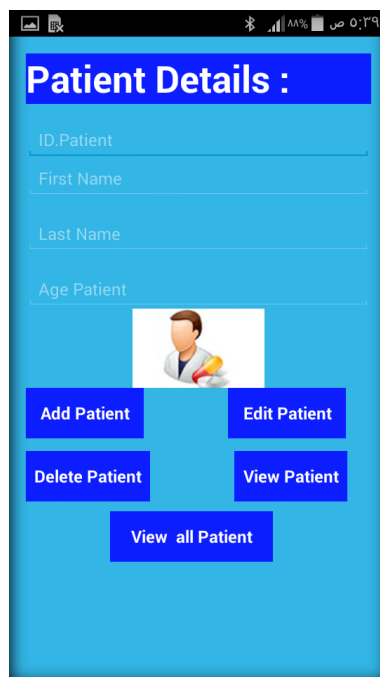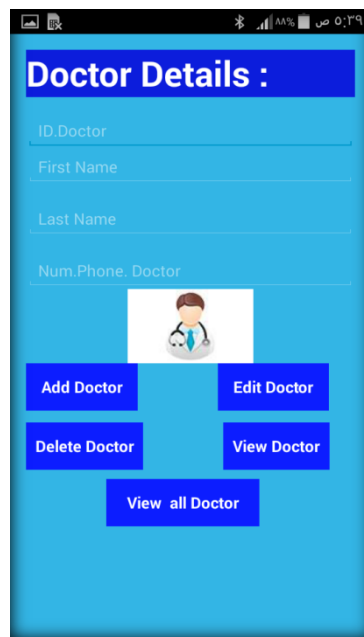
- **Setting Screen**
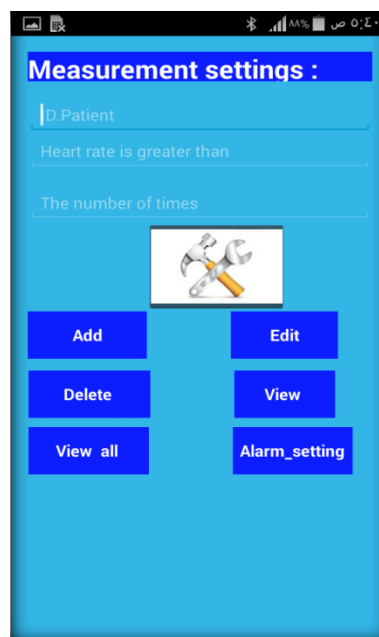
Figure(3.24): Setting screen.

- **Alarm Screen**
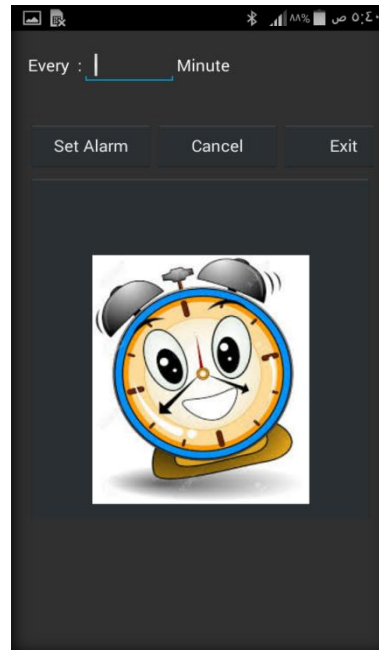
Figure(3.25): Alarm screen.

3.4.6.1.2 Hardware interface

The app used the mobile interface to display the heart beats rate .The app ran on Android mobile phones(Samsung Galaxy S4 was used in this thesis) and Polar H7 Sensor device .

3.4.6.1.3 Software interface

The main programming language used for this app is Java language. Since this thesis used Android as a main platform for the developed our application system, it required Java language as the main language in order to do a programming for android.

The app was developed and maintained in Android Studio environment. The software interfaces need the followings:

- JAVA JDK (Java Development Kit).
- Android Studio 1.2 .
- SQLite database.

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3.4.6.2 Functional requirement

3.4.6.2.1 Add New Patient:

Input: the user enters patient information in the patient screen .

Process: the app will validate the entered data and checks for duplication of the values, and alert the user if patient is already in the app, if not the patient will be added directly.

Output: a message with success of the operation.

3.4.6.2.2 Update Patient information:

Input: the user enters the ID Patient and click on search button.

Process: the app will retrieve the patient information if the patient's data is in the data base and displays the information on the patient dialog in order for the user to modify the specified information, after the modifying the information the user click on update button.

Output: a message with success of the operation.

3.4.6.2.3 Delete Patient information:

Input: the user enters the ID Patient and click on search button.

Process: the app will display the patient information on the patient dialog and the user clicks on delete button.

Output: a message with success of the operation.

3.4.6.2.4 Search for Patient information :

Input: the user enters the ID Patient and click on search button.

Process: the app will check if the ID patient is in the data base or not.

Output: if the for Patient information is found the app will display the patient information on the patient dialog, otherwise a message will tell the user the ID patient is not found.

3.5 Design Phase:

The requirement specifications from first phase are studied in this phase and system design is prepared. System Design helps in specifying hardware and system requirements and also helps in defining overall system architecture.

3.5.1 System Modeul

This system is composed of four parts:

- A portable device with an ECG sensor (polar h7heart rate sensor) for collecting data from patient.

- An Android mobile phone to be a processing center for detecting and sending SMS &alarms.

- Bluetooth technology to transmit ECG data from polar h7heart rate sensor device to Smart Phone .

- SQLite to Store the patient's Data and Knowledge base date .

The conceptual overview of the proposed system is shown in Figure 3.26
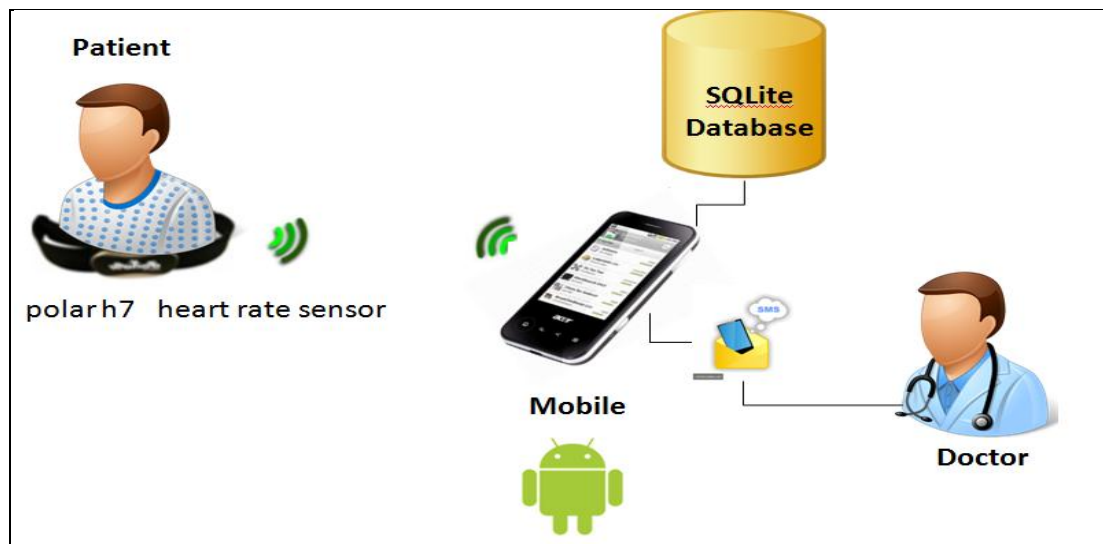
Figure (3.26):Conceptual Overview of The system

3.5.1.1 ECG sensor (polar h7   heart rate sensor).

Sensor is a hardware, a device that is designed to acquire information from an object and convert it into an electrical signal [60].

In this thesis , Polar H7 sensor   was chosen for the purpose of data acquisition from patient's Body , because   we belief that it is the best option to be used in this thesis. Polar H7 category and details are shown in Table 3.16 [41], and Polar H7 sensor   is shown in Figure 3.27

Table（3.16） : Polar   H7   Details

Category	Details
Measurements	Heart rate
Bluetooth Version	Bluetooth Smart (v4.0)
Wireless Encryption	Encrypted
Pairing mechanism / PIN	Proximity and sensor activation
Application Authentication	None
API	Bluetooth Heart Rate Profile
Message Frequency	Constant
Message size	Constant
Message type	Serial Data

Figure(3.27): Polar   H7 heart rate sensor.[26]

3.5.1.2 Android mobile phone

In this thesis Android phone used to receive and store ECG signal via Bluetooth technology has also been used to send warning messages to the doctor as well as the knowledge base containing medical guidance .

3.5.1.3 Bluetooth.

In this thesis Bluetooth v4.0 is used As a means of communication and the transfer of data   between   the polar h7 device   and   the Android   device. Also, this kind of Bluetooth support the polar h7 device.
 A Bluetooth connection to the polar h7 device is initiated from the ECG application on the Android device while the Polar h7 device is turned on. In case Bluetooth is not supported on the user's android device, the application will   give a notice. However, if the device has Bluetooth capability, the user will be prompted to connect to the polar h7 device. After establishing the Bluetooth connection with the device , the user should be able to see a heart beat rate and ECG graph on his mobile device.

3.5.1.4 Data Base

SQLite is an Open Source Database which is embedded into Android, easy to use and install. It is the most widely deployed SQL database engine in the world [24, 7]. So, it is the database that are used in the our proposed application.

3.5.2 Selected Technology

We have chosen Bluetooth as the transmission protocol as it is the one used by most commercial mobile devices. It is a short range technology that allows secure and robust communications, described in [6].For developing the application in the mobile device we have used android studio[49], the Android platform is a relatively new operating system that is based on Java Programming interface. It provides tools such as the emulator, the debugger and specific libraries that enable the developers to create Android applications easily.

3.5.3 System Design

This section describes in detail the structure of the system and how the system will be implemented. It represents the application components and determines their appropriate placement and use within the overall architecture.

This section depicts the design using the Unified Modeling Language. The following were the diagrams that are used to implement and test the application.

- Class diagram .
- Object diagram .
- Sequence diagram.
- Component diagram.
- Database .

3.5.3.1 Class diagram

A class diagram describes the static structure of a system. It shows how a system is structured rather than how it behaves. The main consists of a class diagram are classes and their relationship as shown in Figure(3.28):
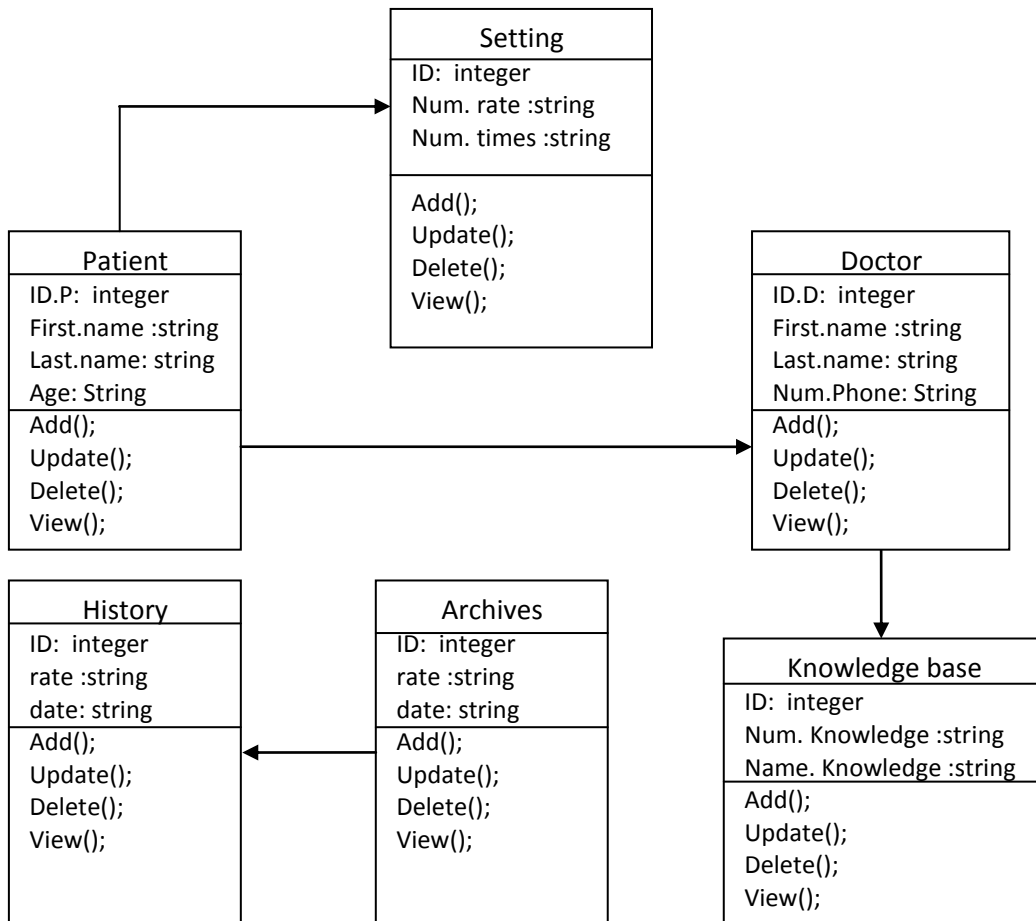
Figure(3.28): Class diagram of the App

3.5.3.2 Object diagram

An object diagram is made up of real-life instances of class diagrams or its parts. Such as an object diagram can be seen as an example of a real class value as shown in the figure below
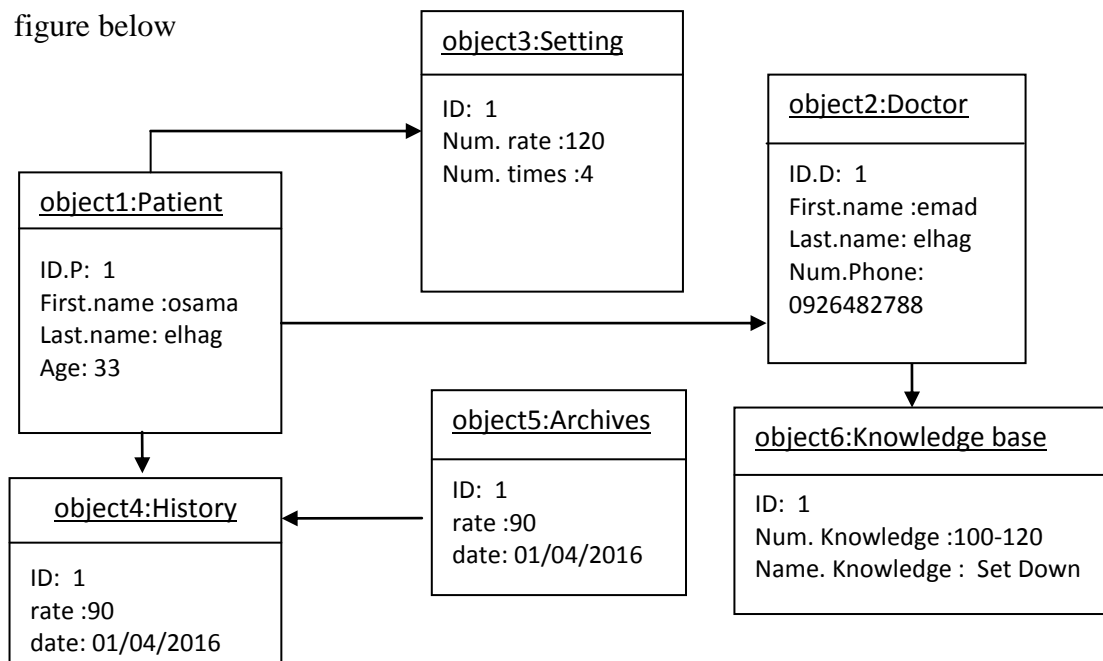
Figure(3.29): Object diagram of the App

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3.5.3.3 Sequence diagram

A Sequence diagram is an interaction diagram that shows how processes operate with one another and in what order. It is a construct of a Message Sequence Chart. A sequence diagram shows object interactions arranged in time sequence. It depicts the objects and classes involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario. Sequence diagrams are typically associated with use case realizations in the Logical View of the system under development. Sequence diagrams are sometimes called event diagrams or event scenarios.

A sequence diagram shows, as parallel vertical lines (lifelines), different processes or objects that live simultaneously, and, as horizontal arrows, the messages exchanged between them, in the order in which they occur. This allows the specification of simple runtime scenarios in a graphical manner.

- **Add patient sequence diagram.**
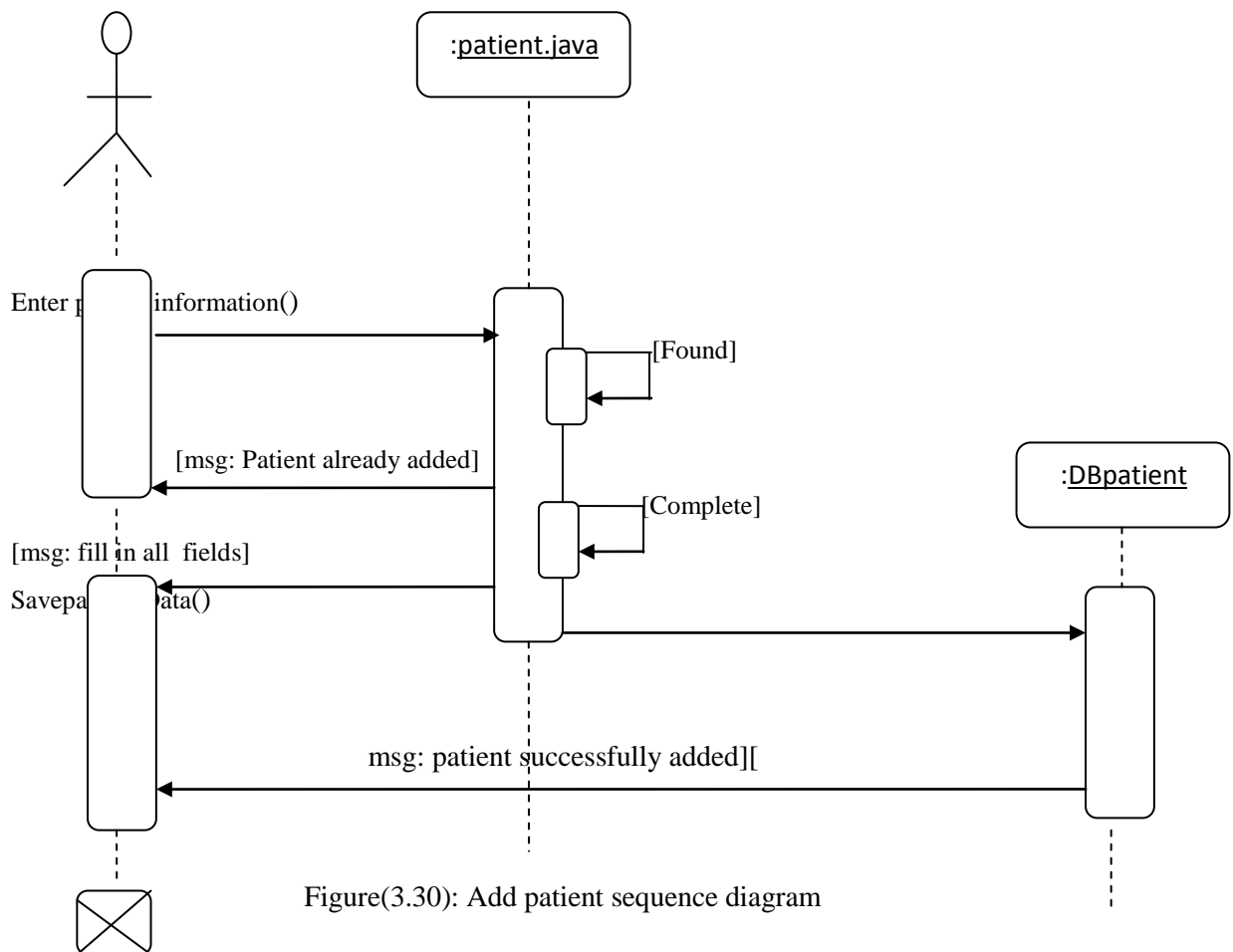
Figure(3.30): Add patient sequence diagram

- **Update patient sequence diagram.**
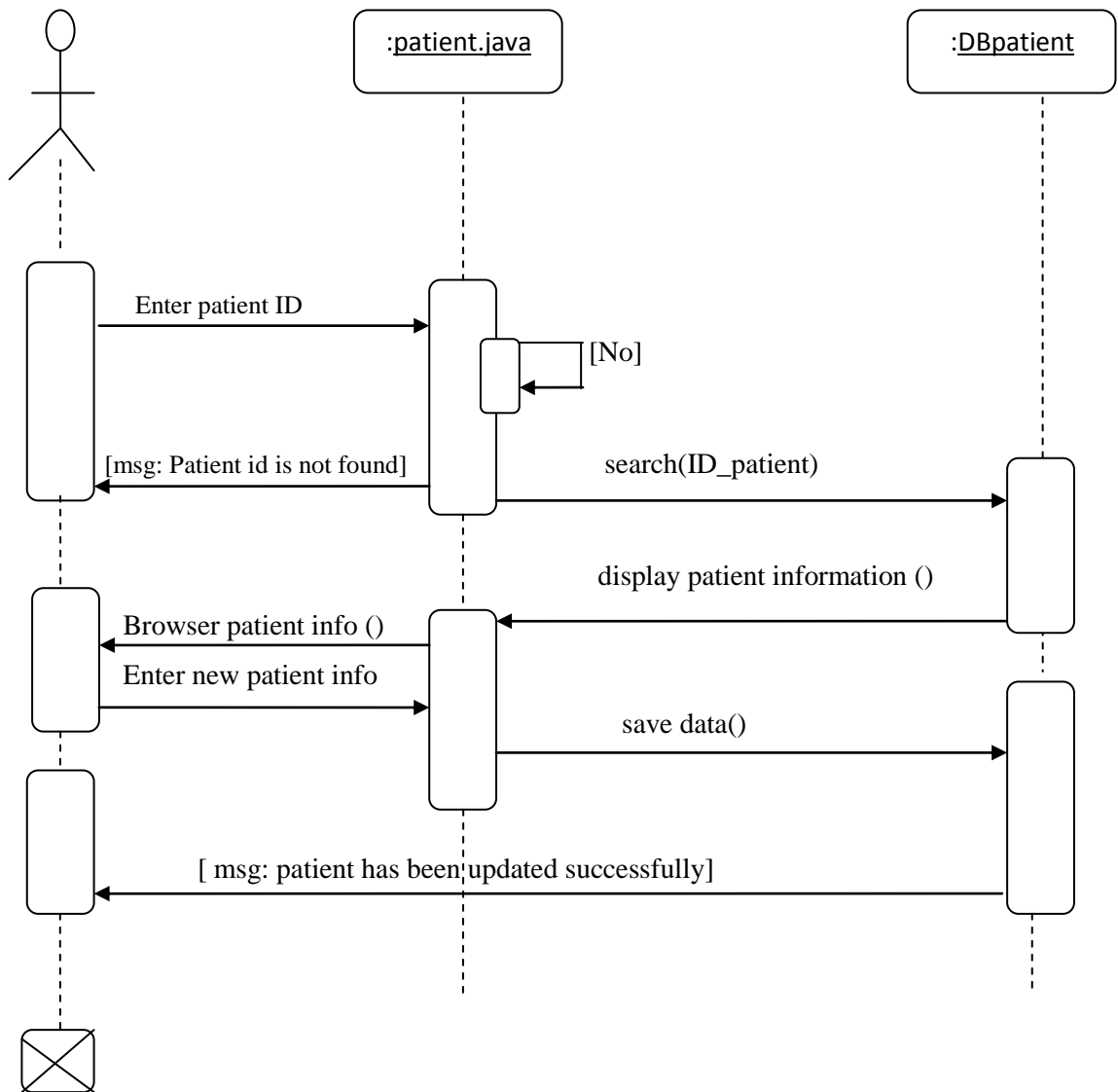
Figure(3.31): Update patient sequence diagram

The rest of sequence diagram can be found in Appendix C.

3.5.3.4 Component diagram:

The Component Diagram shows the relationship between software components, their dependencies, communication, location and other conditions. Component Diagrams are used to structure components in software systems. Figure(3.31) shown the relationship between software components
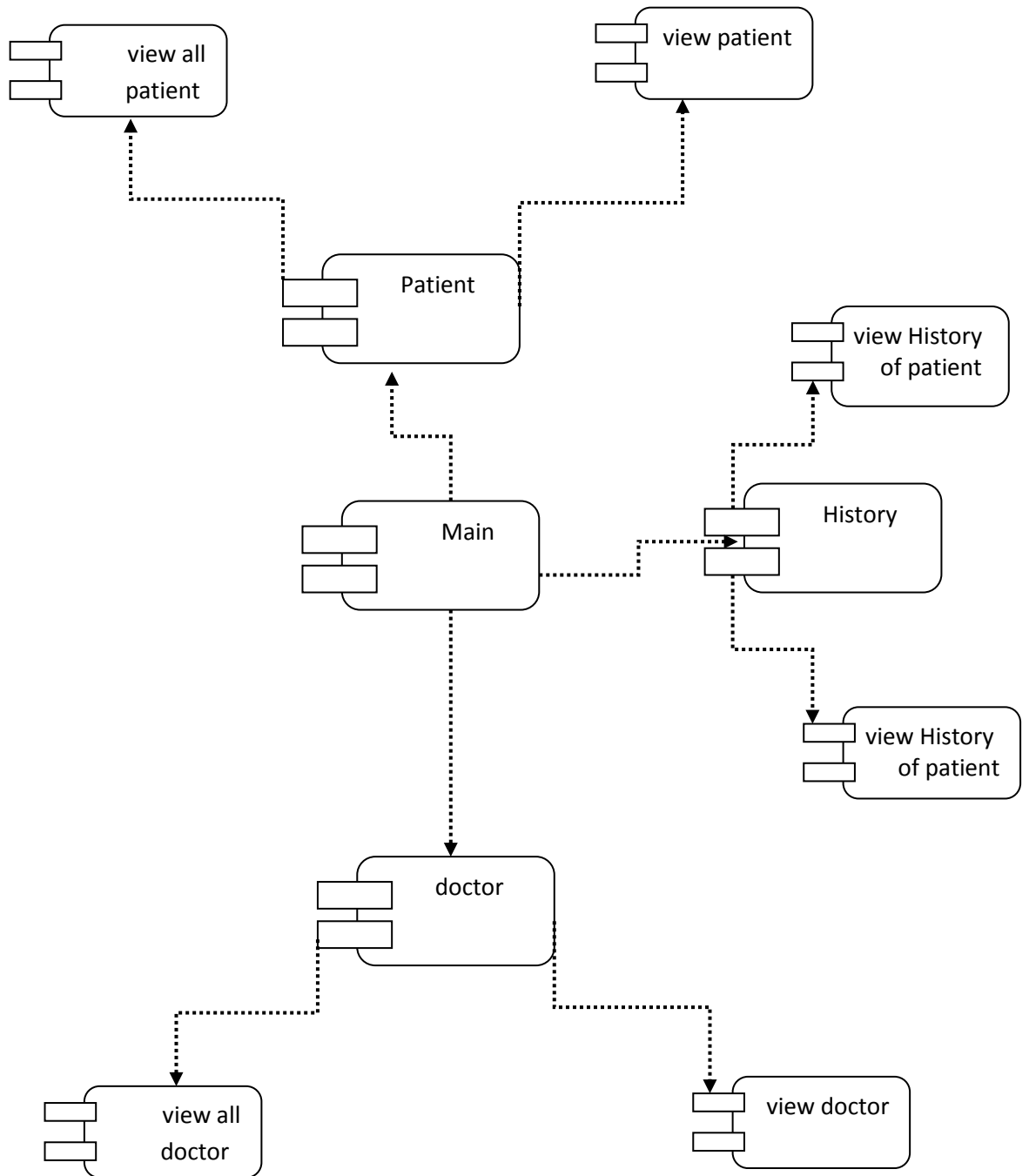
Figure(3.32): Components Diagram of application

3.5.3.5 Database design:

Table (3.17): Database Tables' Attributes

Table Name	**Patient**		
Attribute	**Type**	**Description**	
ID_Patient	Integer	The unique id of the Patient	
First Name	Text	The first name of the Patient	
Last Name	Text	The lastname of the Patient	
Age	Integer	The age of the Patient	

Table Name	**Doctor**		
Attribute	**Type**	**Description**	
ID_doctor	Integer	The unique id of the doctor	
First Name	Text	The first name of the doctor	
Last Name	Text	The last name of the doctor	
No.Phone	Text	The no.phone of the doctor	

Table Name	**History**		
Attribute	**Type**	**Description**	
ID	Integer	The unique id of the history	
Rate	Text	The rate of the Patient	
Date	Text	The date of the Patient	

Table Name	**Setting**		
Attribute	**Type**	**Description**	
ID	Integer	The unique id of the setting	
No. rates	Text	The rates of the Patient	
No. times	Text	The times of the Patient	

Table Name	**Archives**		
Attribute	**Type**	**Description**	
ID	Integer	The unique id of the history	
Rate	Text	The rate of the Patient	
Date	Text	The date of the Patient	

Table Name	**Knowledge base**		
Attribute	**Type**	**Description**	
ID	Integer	The unique id of the Knowledge base	
Info.No	Text	The info.no of the Knowledge base	
Info.name	Text	The Info.name of the Knowledge base	

Chapter 4

The Implementation and Case Study

4.1 introduction

In this chapter, the implementation of the application (Case Study) is demonstrated. The design issues extracted from the previous chapter are interpreted in a real world application. The system implementation refers to the development of the Android application, using a database for storing and extracting information, an external library for creating graphs. The application's interface and Manifest are developed in XML (extensible markup language), the actions performed by the buttons and other elements are developed in Java using the Android library, the database uses SQLite and the graphs are designed with the use of the MPchartlib library. Also, we will address to study a case of heart patient in Benghazi Medical Centre, this sample was taken from the cardiac clinic OPD of the ECG ward.

4.2 Programming Language

The main programming language used for this thesis Case study is Java language. Since this thesis uses Android as a main platform for the development of our app, it requires the Java language as the main language for using android programming .

The algorithm for developing Android Application Steps are as follows:

1. Android applications are primarily written in the Java programming language in Android Studio software.
2. The Java source files are converted to Java class files by the Java compiler.
3. The Android SDK contains a tool called dx which converts Java class files into a .dex (Dalvik Executable) file.
4. The .dex file and the resources of an Android project, like images and XML files. They are packed into an .apk (Android Package) file.
5. So finally whole Android application (.apk file) will be created and deployed.

4.3 The Used libraries

In the application of this thesis, there are two types of libraries that are used to develop the application, which are libraries of the media and SQLite. Media Libraries are used to design graphical user interface (GUI) such as image for user information and graphical interface for sensors while SQLite was used to store the data from the sensors to the phone memory before being transferred to the doctor as SMS and also SQLite is used to store data to be used as a base knowledge.

4.5 Views

Every Android application development starts from the layout development. Each layout consists of an XML file, in which the interface components are declared. These components can be Form Widgets (e.g., Buttons), Text Fields (e.g., password text field), Layouts (e.g., vertical or horizontal), Images, Composite (e.g., Tab Host), Time & Date views, Transitions (e.g., Image Switcher) and some advanced tools (e.g., zoom button).

When the Heart Rate Measurement App starts, the layout that is being displayed consists of a vertical layout, in which the background picture is declared and a two component, an Image View and an image button, which depicts the application logo. Figure 4.1 shows the initial screen. After pressing the Start button in the initial screen is being replaced by the main screen. The main layout consists of a vertical linear layout, seven text views, seven image buttons(patient details ,doctor details ,setting, Bluetooth ,ecg measurement, knowledge base and exit). It also includes the scroll view option, so it can be viewed in screens with different size. Figure 4.2 shows the Main screen.
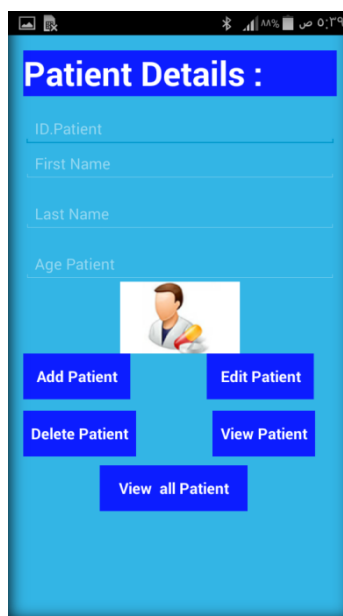

Figure(4.1): Start App screen

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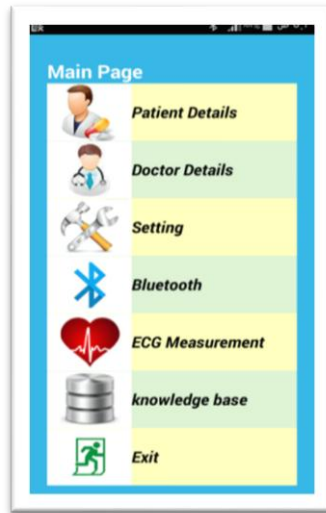
Figure(4.2): Main List screen

Figure 4.3 a shows the "Patient Details " screen. The Patient screen consists of a vertical linear layout , four Text Fields and a text view. Inside this layout there is a scroll view and a horizontal linear layout component which incorporates the five buttons that are used to process patient's data.


Figure(4.3): Patient screen

Figure 4.4 a shows the "Doctor Details " screen. The Doctor screen consists of a vertical linear layout , four Text Fields   and a text view. Inside this layout there is a scroll view and a horizontal linear layout component which incorporates the five buttons that are used to process doctor's data.
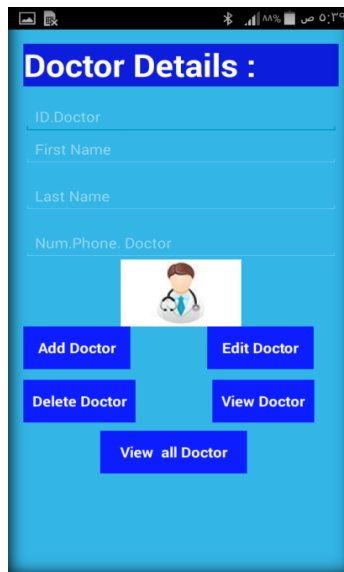
Figure(4.4): Doctor screen

Figure 4.5 a shows the "Setting " screen and Figure 4.6 a shows the "Alarm " screen. The setting screen consists of a vertical linear layout , three Text Fields and a text view. Inside this layout there is a scroll view and a horizontal linear layout component which incorporates the five buttons that are used to process setting's data.
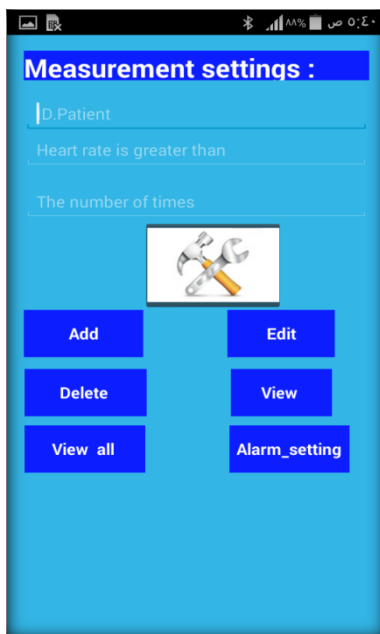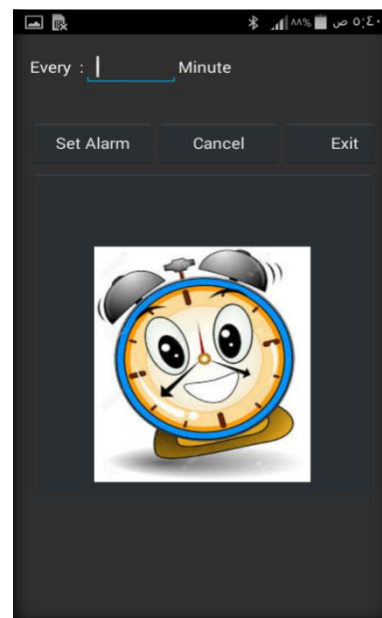

Figure(4.5): Setting screen .

Figure(4.6): Alarm screen .

Figure 4.7 a shows the "ECG Measurement " screen. The ECG Measurement screen consists of a vertical linear layout, a text view. Inside this layout there is horizontal

linear layout component which incorporates two image buttons and that are used to Start and stop for measurement patient's heart rate .
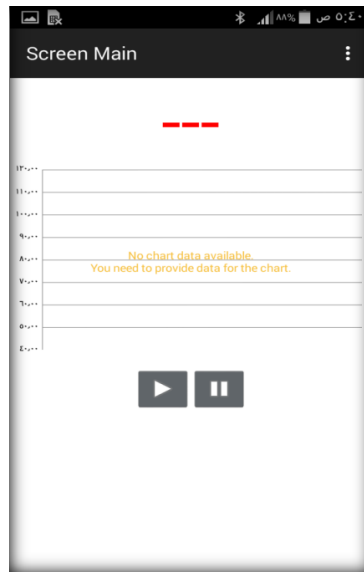
Figure(4.7): ECG Measurement screen

Figure 4.8 a shows the "Knowledge base " screen. The ECG Measurement screen consists of a vertical linear layout , a text view. Inside this layout there is horizontal linear layout component which incorporates five buttons , Knowledge base to make recommendations to the patient These recommendations are presented to the patient's mobile screen after every certain period of time as alerts These alerts the user selects the time displayed on the mobile.
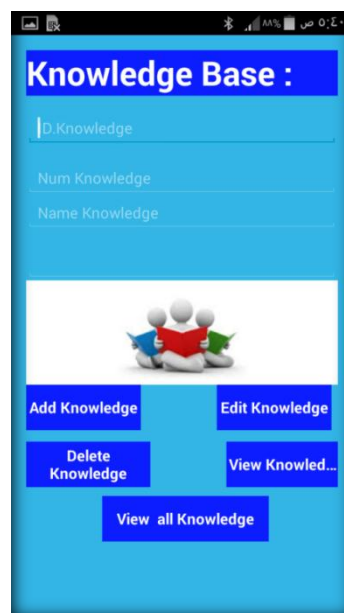
Figure(4.8): Knowledge base screen

4.6 SQLiteOpenHelper class

In an Android app, a database requires a "helper" class that creates a database and contains other SQLite commands. In My App this class is the SQLiteOpenHelper class. It contains methods for opening and closing the database as well as statements for creating the six tables (patient ,doctor ,history ,archive ,Knowledge base, and setting).Each of these tables extend from SQLiteOpenHelper own example, the patient file extends from DBPatient . The following bits of code show how the sex tables are created:

```
public class DBPatient extends SQLiteOpenHelper {
    private static final String TAG = "SQL LITE؛"
    static int DB_VERSION = 1؛
    static String DB_NAME = "patient_db؛"
    static String TABLE_patient = "patient؛"
    static String COLUMN_ID = "ID_P؛"
    static String COLUMN_Fname = "First_Name؛"
    static String COLUMN_Lname = "Last_Name؛"
    static String COLUMN_age = "Age؛"
    public DBPatient (Context context, String name, SQLiteDatabase.CursorFactory
factory, int version){
        super(context, DB_NAME, factory, DB_VERSION);
    }
    public void onCreate(SQLiteDatabase db ){
        String query = "CREATE TABLE " + TABLE_patient+ " )" +
            COLUMN_ID + " TEXT PRIMARY KEY+ " ،
            COLUMN_Fname + " TEXT, " + COLUMN_Lname + " TEXT," +COLUMN_age+"
TEXT+" "            ");
        db.execSQL(query) ;
    }
    public void onUpgrade(SQLiteDatabase db, int oldVersion, int newVersion)  {
        db.execSQL("DROP TABLE IF EXISTS " + TABLE_patient؛(
        onCreate(db);
    }
}
```

4.7 The Manifest File

The Manifest is a mandatory element of every Android app in order to run and to be able to be published in the Android market. It includes declarations for all the activity classes, the receiver, permissions and other details of the app.

```
<؟"xml version="1.0" encoding="utf-8؟>
"manifest xmlns:android="http://schemas.android.com/apk/res/android>
< "package="com.studentproject.heartrate
uses-feature>
"android:name="android.hardware.bluetooth_le
</ "android:required="true
</ "uses-permission android:name="android.permission.BLUETOOTH>
</ "uses-permission android:name="android.permission.BLUETOOTH_ADMIN>
</ "uses-permission android:name="android.permission.ACCESS_COARSE_LOCATION>
</ "uses-permission android:name="android.permission.ACCESS_FINE_LOCATION>
</ "uses-permission android:name="android.permission.WRITE_EXTERNAL_STORAGE>
</ "uses-permission android:name="android.permission.INTERNET>
</ "uses-permission android:name="android.permission.READ_EXTERNAL_STORAGE>
</ "uses-permission android:name="android.permission.READ_INTERNAL_STORAGE>
</ "uses-permission android:name="android.permission.ACCESS_NETWORK_STATE>
</ "uses-permission android:name="android.permission.WAKE_LOCK>
</ "uses-permission android:name="android.permission.SEND_SMS>
```

The above code is an excerpt from the Heart Rate Measurement Manifest file. It declares the name of the package. The Manifest gives permission to the app to use the **Bluetooth** (this is used for connecting to Device polar H7) and gives permission to the app to use the **SEND_SMS** (this is used to send SMS to the doctor).

After that, the application details must be declared. The name of the app and the launcher icon (the icon that is shown on the screen before opening the app) are included in this declaration.

```
<application
    android:allowBackup="true"
    android:icon="@mipmap/ic_launcher"
    android:label="Screen Main"
    android:theme="@style/AppTheme">
```

Inside the application, we declare every activity that is used by the app. Each activity is distinguishable by the activity name. A statement (noHistory=true) is also included which makes the app to "forget" in which screen was the user when he/she stopped

using the app. The action that has to be performed is also declared as well as the actions category. For instance,

```
<application >
<activity
        android:name=".Screen_Main"
        android:label="Screen Main >"
        <intent-filter        .
    < action android:name="android.intent.action.MAIN/ ">
    < category android:name="android.intent.category.LAUNCHER/ ">
        < /intent-filter>
    </activity>
    < activity
</ application >
```

All the other activities are declared in the same way.

4.8 Testing

4.8.1 Dynamic black box testing:

The main purpose of this test is to illustrate that the system works properly, and it can be used by end users. In this thesis, the black box testing is used to carry out the mobile application testing for the development work. Black Box testing is described as a method of software testing that is focused on functionalities of an application The tests carried out on android 4.4.2 Samsung Galaxy phone,Where it was tested following functions, add patient information, delete patient information, and Bluetooth functionalities like connectivity to reading ECG. The following tables show a list of tests carried out on the application.

The following is some samples of the system's user interfaces with real data entries.

- **Test case: add patient information**

Table(4.1): Test case for adding a patient

Title	Add Patient
Test case number	1
Test case description	Add new patient to the app
Pre-request	None
Input	Patient information
Steps	Enter patient id and information then click on add patient
Expected output	Message with success
Actual output	Message with success
Test case status	Pass

- **Test case: Delete patient information**

Table(4.2): Test case for deleting a patient

Title	Delete Patient
Test case number	2
Test case description	Delete the patients information from the app
Pre-request	Patient information must be already in database
Input	Patient ID
Steps	Enter patient id click search patient details will be displayed. Click on delete button.
Expected output	Message with success
Actual output	Message with success
Test case status	Pass

- **Test case: Bluetooth permission and Support**

Table(4.3): Test case for Bluetooth Permission and Support

| Title	Bluetooth permission and Support
Test case number	3
Test case description	The possibility of request for authorization to open the Bluetooth
Pre-request	Bluetooth Android device is turned on and Bluetooth support
Steps	Open Bluetooth Android device and Bluetooth Connection between the polar h7 and Samsung Galaxy
Test case status	Pass

## 4.9 Case Study (Heart Rate Measurement App)

The following section describes how the end-user (patient) can use this application to monitor the heartbeat by using smart phones as well as the obtained results and to compare these results with the ECG device located in the heart clinic.

4.9.1 Mechanism of Application

This thesis case study was applied on a patient from whom we obtained an ECG signal. He was a 59 year old male. His name is Ahmed Ali. The app used and ran on Android mobile phones (Samsung Galaxy S4) and Polar H7 Sensor device.

The following steps describe the mechanism of applying the App on the patient:

1. A Patient's skin was wiped with a wet damp cotton Then the device sensor (polar h7) was put on his chest .

2. The Start Button of the App was pressed to enter the app and the device sensor was connected to the mobile phone via the Bluetooth.

3. The personal information of patient (name, age. etc) and the Data of the doctor (name , phone number . etc) were entered .

4. The settings for measuring the pulse (the pulse rate and the number of pulses) were entered .

5. Using the ECG screen , measurement of the signal was received   from the sensor by using the Bluetooth to displayed the signals   and pulse rate on   the patient's   mobile screen.   Figure 4.9   shows a sample real-time ECG signal on Screen mobile .
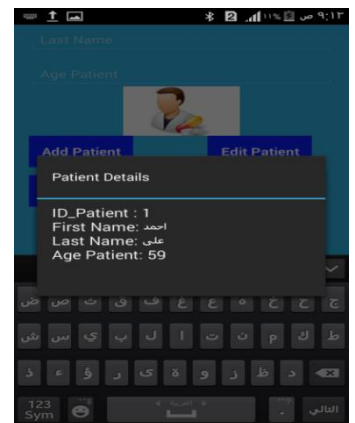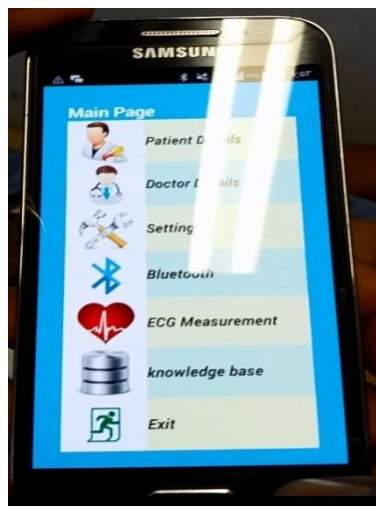

Figure(4.9): Heart Patient

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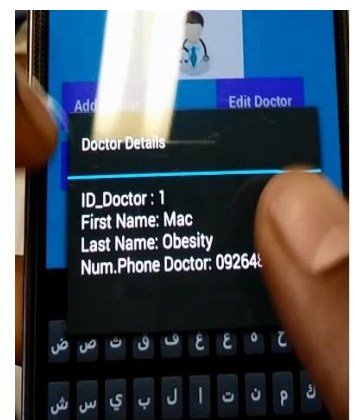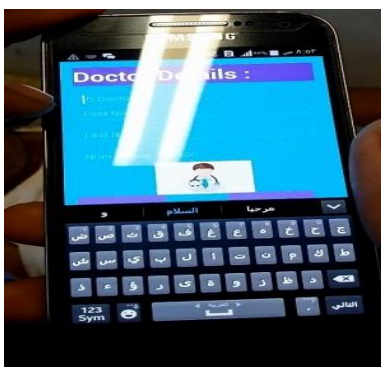
4.9.2 RESULT

The results were 97% identical, which were obtained from the patient by using a mobile application were 64 beats per minute, but the results obtained from ECG in the hospital were 62 beats per minute, which was a good result. Figure 4.10 and Figure 4.11 show a sample real-time ECG signal on Screen mobile and Figure 4.12 and Figure 4.13 show a sample real-time ECG signal on Monitor Device in the hospital
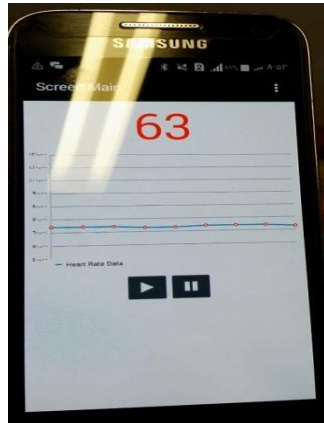
Figure(4.10): ECG Signal

Figure(4.11): ECG Signal
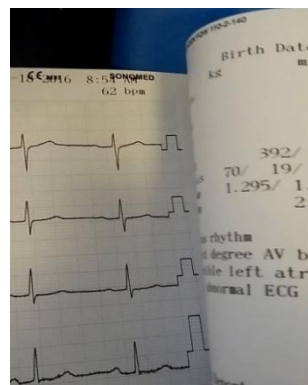
Figure(4.12): ECG Signal

Figure(4.13): ECG Signal

Reference

[1]. Heart Risk Warner (2015) *Heart Rate Variability,* [ONLINE] Available at: http://www.hrwproject.com/
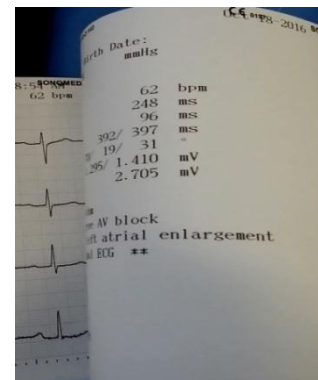[Accessed: 1st January 2013].

[2]. J. Parak, J. Havlik ,ECG SIGNAL PROCESSING AND HEART RATE   FREQUENCY DETECTION METHODS Department of Circuit Theory, Faculty of Electrical Engineering ,Czech Technical University in Prague

[3]. Linda Westfall.2005. westfallteam.[ONLINE] Available at:
http://users.csc.calpoly.edu/~csturner/courses/300f06/readings/%5B3%5D_%20The_Why_What_Who_When_and_How_of_Software_Requirements.pdf [Accessed 15 December 14].

[4]. Mahmud Hasan, Design of a PC-Based Electrocardiogram (ECG)Recorder as - Internet Appliance, Computer Science Program, Faculty of Science, University Brunei Darussalam Brunei

[5]. http://www.favoriteplus.com/blog/types-ecg-machines

[6]. http://www.ieee802.org/15 . [Accessed 10 January 16].

[7]. Lee, S., 2012. Creating and using databases for android applications. *International Journal of Database Theory and Application*, *5*(2), pp.99-106.

[8].SQLite.2016. Features. [ONLINE] Available at: https://www.sqlite.org/features.html. [Accessed 15 February 16].

[9]. Liane Cassavoy (2016) *Cellphones,* Available at:
http://cellphones.about.com/od/phoneglossary/g/What-Is-An-Android-Phone.htm (Accessed: 1st January 2014).

[10]. Smart Mobile Phone solutions.2016. Difference-between-android-phone-and-smartphone

[ONLINE] Available at: http://www.smartmobilephonesolutions.com/content/difference-between-android-phone-and-smartphone. [Accessed 15 December 15].

[11]. Woubshet Behutiye, "Android Ecg Application Development", Bachelor's Thesis, Oulu University of Applied Sciences, 2012. 21.

[12]. Gilgen, S. (2010). Mobile Healthcare on Android Devices. *University of Zurich Diploma Thesis*.

[13]. Upkar Varshney, Pervasive Healthcare and Wireless Health Monitoring, Springer.DOI 10.1007/s11036-007-0017-1. Available from: http://www.cens.ucla.edu/~mhr/cs219/varshney07.pdf.
[Accessed 10 November 15].

[14]. Android.2016. Data-Storage. [ONLINE] Available at:
http://developer.android.com/guide/topics/data/data-storage.html#db. [Accessed 15 January 16].

[15].Agilemodeling.usecasediagram*.* [ONLINE] Available at:
http://www.agilemodeling.com/artifacts/ usecasediagram.htm. [Accessed 10 December 15].

[16]. Jurik, A.D., Bolus, J.F., Weaver, A.C., Calhoun, B.H. and Blalock, T.N., 2009, April. Mobile health monitoring through biotelemetry. In *Proceedings of the Fourth International Conference on Body Area*

Networks (p. 12). ICST (Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering).

[17]. Akram, A., Javed, R. and Ahmad, A., (2013)Android Based ECG Monitoring System. In *Proceedings of the* International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064

[18]. Bedarkar, P.T. and Swamy, S., 2013. Design and implementation of wireless handheld device for android cell phone. In *Proceedings of the Conference on Advances in Communication and Control Systems 2013* (pp. 284-90).

[19]. Gay, V. and Leijdekkers, P., 2007. A health monitoring system using smart phones and wearable sensors. *International Journal of ARM*, *8*(2), pp.29-35.

[20]. Guo, X., Duan, X., Gao, H., Huang, A. and Jiao, B., 2013. An ECG monitoring and alarming system based on android smart phone. *Communications and Network*, *5*(03), p.584.

[21]. Shahriyar, R., Bari, M.F., Kundu, G., Ahamed, S.I. and Akbar, M.M., 2009. Intelligent mobile health monitoring system (IMHMS). In *Electronic Healthcare* (pp. 5-12). Springer Berlin Heidelberg.

[22]. Ian Sommerville, Software Engineering, 8th edition.

[23]. Vithani, T. and Kumar, A., 2014. Modeling the mobile application development lifecycle. In Proceedings of the International MultiConference of Engineers and Computer Scientists (Vol. 1).

[24]. SQLite.2016. [ONLINE] Available at: http://www.sqlite.org/.[Accessed :10 February 16].

[25]. learnaccessvba.2015 .Waterfall_method. [ONLINE] Available at: http://learnaccessvba.com/application_development/waterfall_method.htm.[Accessed :10 January 16].

[26]. Motionfitness.2016. Polar-H7-Single.[ONLINE] Available at: http://www.motionfitness.com/Polar-H7-Heart-Rate-Sensor-p/polar-h7-single.htm.[Accessed :15 February 14].

[27]. Yan, H., Huo, H., Xu, Y. and Gidlund, M., 2010. Wireless sensor network based E-health system implementation and experimental results. *Consumer Electronics, IEEE Transactions on*, *56*(4), pp.2288-2295.

[28]. Hernandez, A.I., Mora, F., Villegas, G., Passariello, G. and Carrault, G., 2001. Real-time ECG transmission via Internet for nonclinical applications. *Information Technology in Biomedicine, IEEE Transactions on*, *5*(3), pp.253-257.

[29]. Seabrook, H.J., Stromer, J.N., Shevkenek, C., Bharwani, A., de Grood, J. and Ghali, W.A., 2014. Medical applications: a database and characterization of apps in Apple iOS and Android platforms. BMC research notes, 7(1), p.573.

[30]. Romero, A., Heras, C., Vega, M., Naranjo, J. and Vázquez, C., ITESM Campus Toluca Eduardo Monroy Cárdenas# 2000 Toluca, México 50110 {a01050889, a1051214, a01050841, a01051072, carlos. vazquez. hurtado, arturo. preciado}@ itesm. mx. In *Proceedings of the 10th IASTED International Conference* (Vol. 674, No. 144, p. 304).

[31]. Khanja, P., Wattanasirichaigoon, S., Natwichai, J., Ramingwong, L. and Noimanee, S., 2008, November. A web base system for ecg data transferred using zigbee/IEEE technology. In *The 3rd International Symposium on Biomedical Engineering* (pp. 10-11).

[32].Symantec Corporation. 2013. *Symantec in Healthcare*.[ONLINE] Available at:https://www.symantec.com/content/en/us/enterprise/fact_sheets/b-symantec-in-healthcare-DS.pdf. [Accessed 15 December 15].

[33]. West, D.M., 2013. Improving health care through mobile medical devices and sensors. Brookings Institution Policy Report, 10, pp.1-13.

[34]. Sufi, F., Fang, Q. and Cosic, I., 2007, August. ECG RR peak detection on mobile phones. In Engineering in Medicine and Biology Society, 2007. EMBS 2007. 29th Annual International Conference of the IEEE (pp. 3697-3700). IEEE.

[35]. Wikipedia. 2016. Smartphone. [ONLINE] Available at: https://en.wikipedia.org/wiki/Smartphone. [Accessed 20 January 16]

[36]. Slideshare. 2016. *introduction-to-mobile-technology*. [ONLINE] Available at:http://www.slideshare.net/pria84/introduction-to-mobile-technology. [Accessed 15 January 16].

[37] . F. O. WebSite, \WAHOO BLUE HR HEART RATE STRAP, " http://www.wahoo_tness.com/wahoo-blue-hr-heart-rate-strap.html, [Online; accessed 19-June-2015].

[38] . R. O. WebSite, HEART RATE MONITORS, HEALTH and FITNESS SENSORS," http://www.digi_t.com/shop/heartratemonitors.asp. [Online; accessed 19-June-2015].
[39] . R. O. WebSite, RUNTASTIC BLUETOOTH SMART HEART RATE MONITOR," https://www.runtastic.com/shop/en/ runtastic-bluetooth-smart-combo-heart-rate-monitor. [Online; accessed 19-June-2015].

[40]. Journaldev.. Android-studio-project-structure-compiler-proguard.[ONLINE] Available at:http://www.journaldev.com/9319/android-studio-project-structure-compiler-proguard. [Accessed 15 March 16].

[41]. Runningwarehouse. Descpage-PH7BT. [ONLINE] Available at:http://www.runningwarehouse.com/Polar_H7_Bluetooth_Smart_Heart_Rate_Sensor/descpage-PH7BT.html. [Accessed 15 March 15].

[42]. Webuser . [ONLINE] Available at: http://webuser.hs-furtwangen.de/~heindl/ebte-08ss-bluetooth-Ingo-Puy-Crespo.pdf . [Accessed 15 December 15].

[43]. Singh, P., Sharma, D. and Agrawal, M.S., 2011. A Modern Study of Bluetooth Wireless Technology. International Journal of Computer Science, Engineering and Information Technology (IJCSEIT), Vol.1, No.3.

[44]. P. O. W. Site, H7 Heart Rate Sensor," http://www.polar.com/us-en/products/accessories/H7 heart rate sensor, [Online; accessed 05- June -2015].

[45] .Zephyr, BioHarness 3," http://www.zephyranywhere.com/products/bioharness-3/, [Online; accessed 07-June-2015].

 [46]. Scosche, RHYTHM Bluetooth Smart Heart Rate Chest Strap," http://www.scosche.com/rhythm-bluetooth-smart-heart-rate-chest-strap,[Online; accessed 01-June-2015].

[47].Winston W. Royce. Managing the development of large software systems. [ONLINE] Available at: http://www.cs.umd.edu/class/spring2003/cmsc838p/Process/waterfall.pdf. [Accessed 10 November 15].

[48]. Engineering Notebook. Iterative and Incremental Development. C++ Report[ONLINE] Available at: http://www.objectmentor.com/resources/articles/IIDI.pdf. [Accessed 10 November 13].

[49]. Android Development .Tutorial.[ONLINE] Available at: http://www.vogella.de/articles/Android/article.html#overview android. Version 7.8. [Accessed 10 December 15].

[50]. Android. Android Developers. [ONLINE] Available at: http://developer.android.com/guide/topics/fundamentals.html. [Accessed 29 November 16].

[51]. Garmin, Soft Strap Premium Heart Rate Monitor," https://buy.garmin.com/en-US/US/shop-by-accessories/_tness-sensors/soft-strap-premium-heart-rate-monitor/prod15490.html, [Online; accessed 07-June-2015].

[52]. Wei-Meng, L., 2011. Beginning Android Application Development.

[53]. Spencer, B.F., Ruiz-Sandoval, M.E. and Kurata, N., 2004. Smart sensing technology: opportunities and challenges. *Structural Control and Health Monitoring*, *11*(4), pp.349-368.

[54].Sama, S., 2014. Smartphone Supported Activity Level Estimation.

[55] . Dr. DrrpshikhaJamwal "Analysis of software Development Models", ISSN: 2229-4333 (print), ISSN:09768491 (online), vol. 1ISSUE 2.

[56].Baldauf, M., Dustdar, S. and Rosenberg, F., 2007. A survey on context-aware systems. *International Journal of Ad Hoc and Ubiquitous Computing*, *2*(4), pp.263-277.

[57]. A. M. Davis, Software Requirements: Objects, Functions and States, Second Edition. Prentice Hall PTR,2000

[58] .R. H. Thayer and M. Dorfman, Software Requirements Engineering, 2nd Edition. Wiley-IEEE Computer Society Pr, 2000.
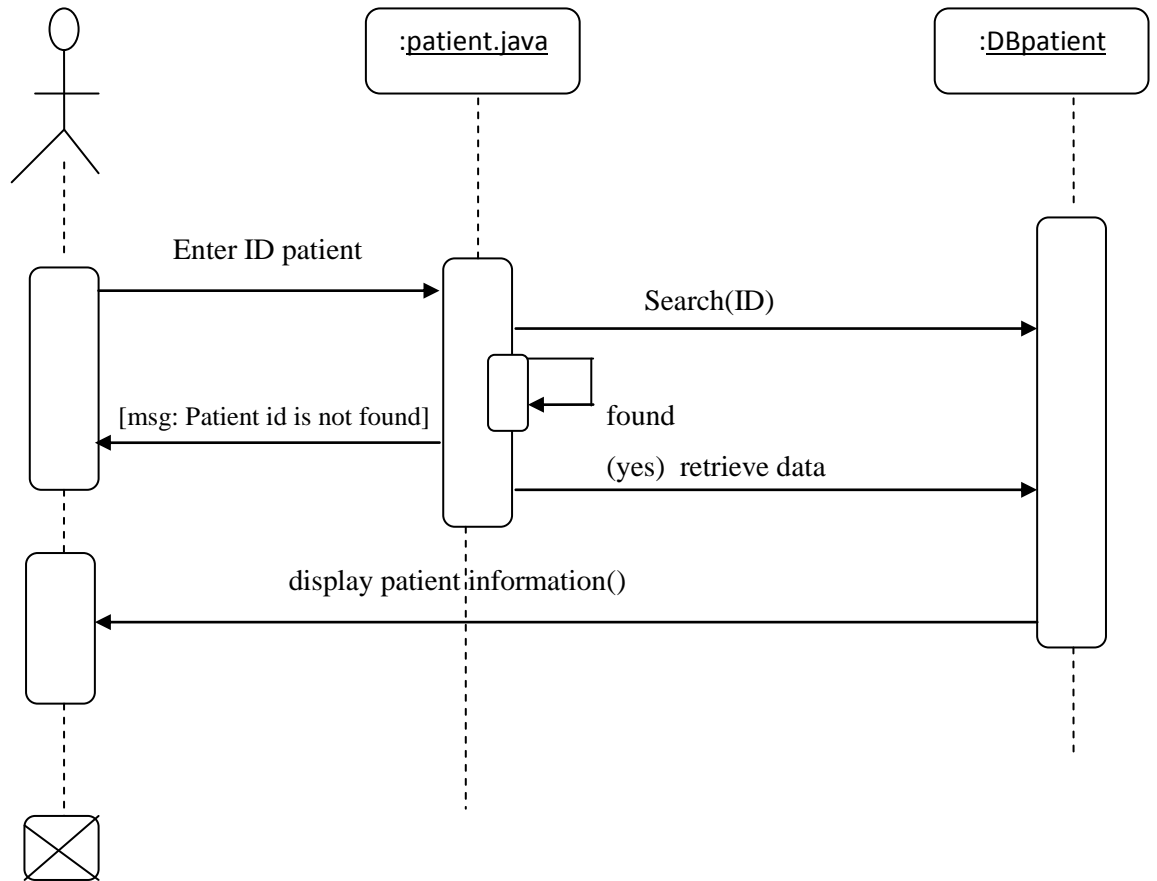
Appendix C : Sequence diagrams

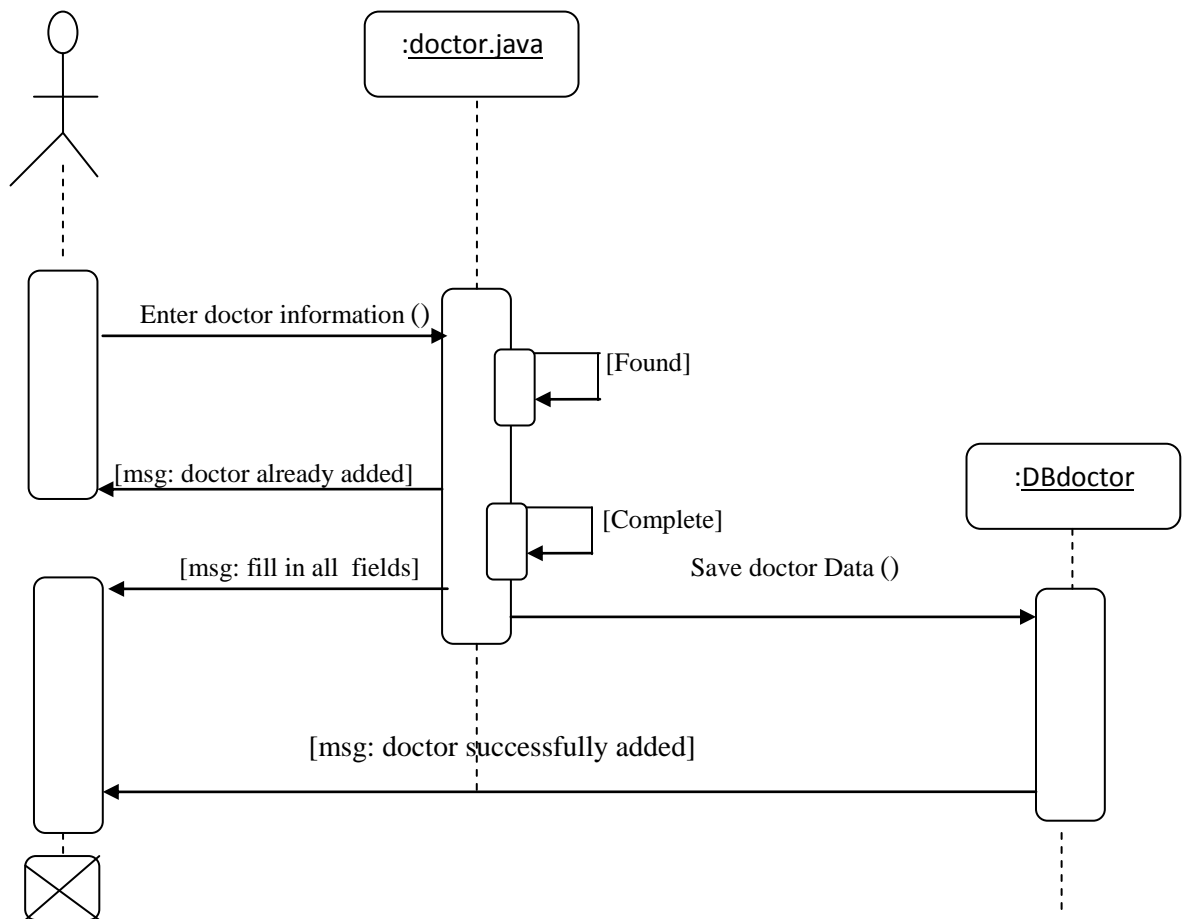- **Delete patient sequence diagram**
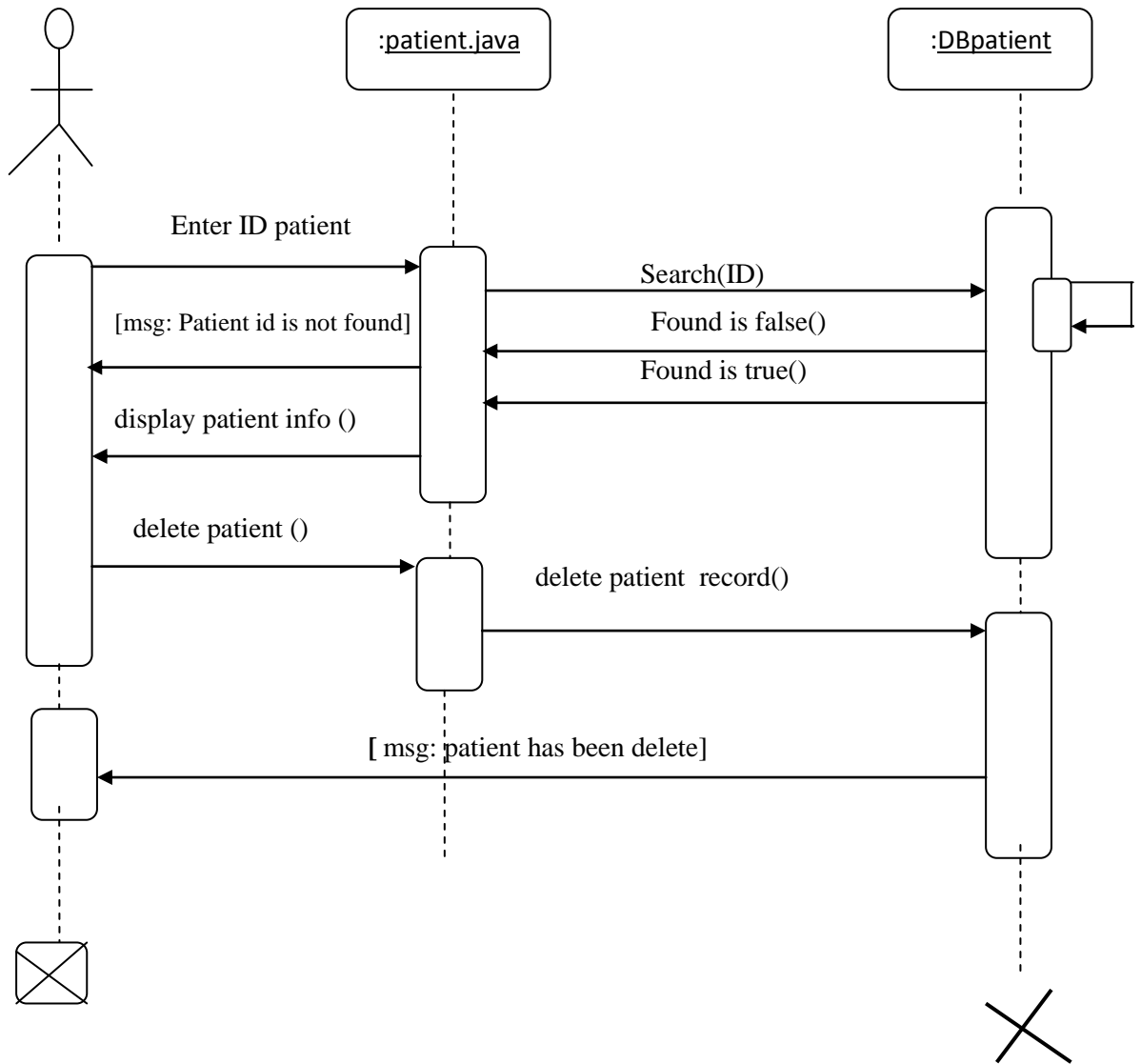
Appendix C.1: Delete patient sequence diagram
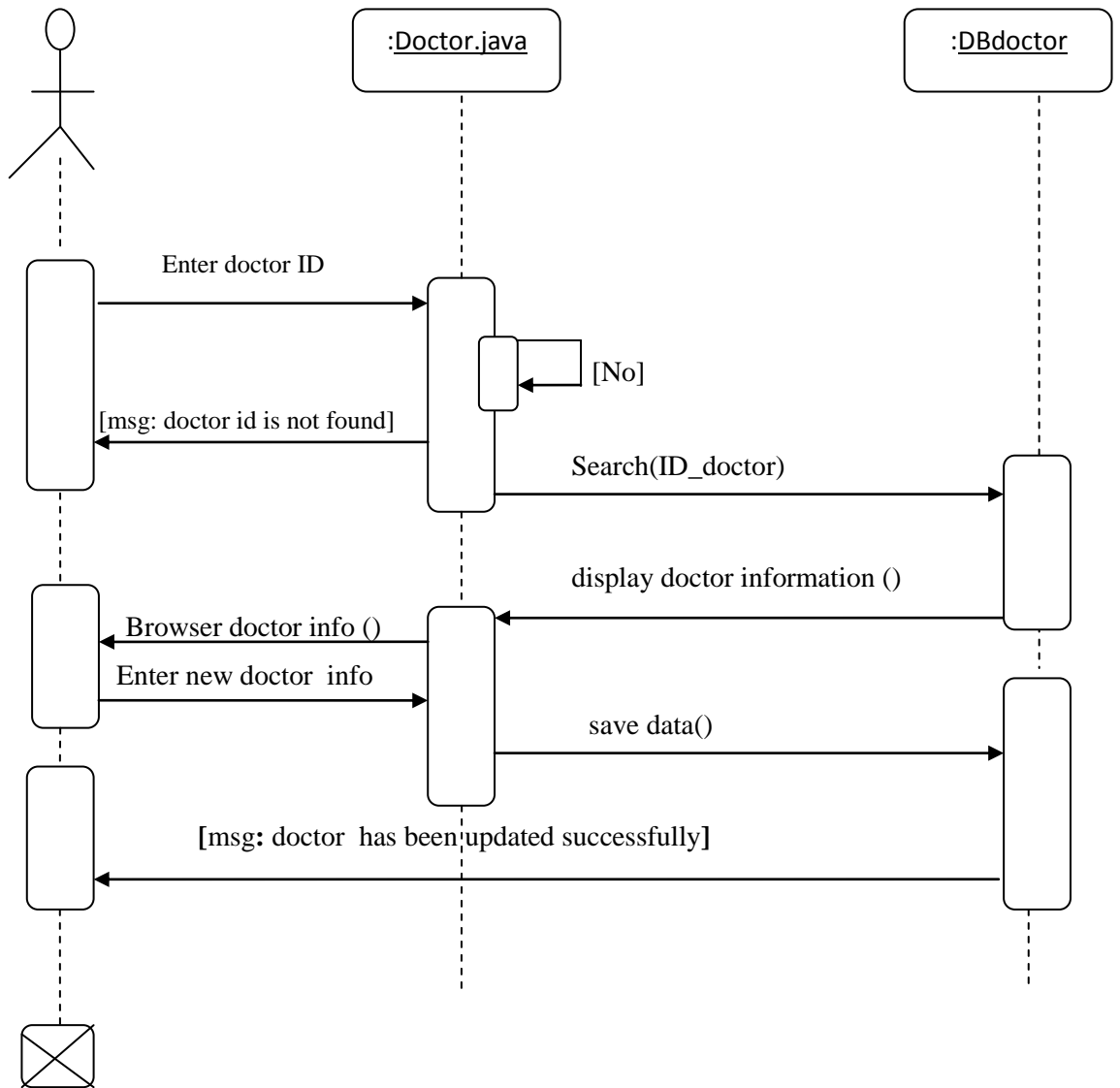
- **Search patient sequence diagram**

Appendix C.2: Search patient sequence diagram

- **Add doctor sequence diagram.**
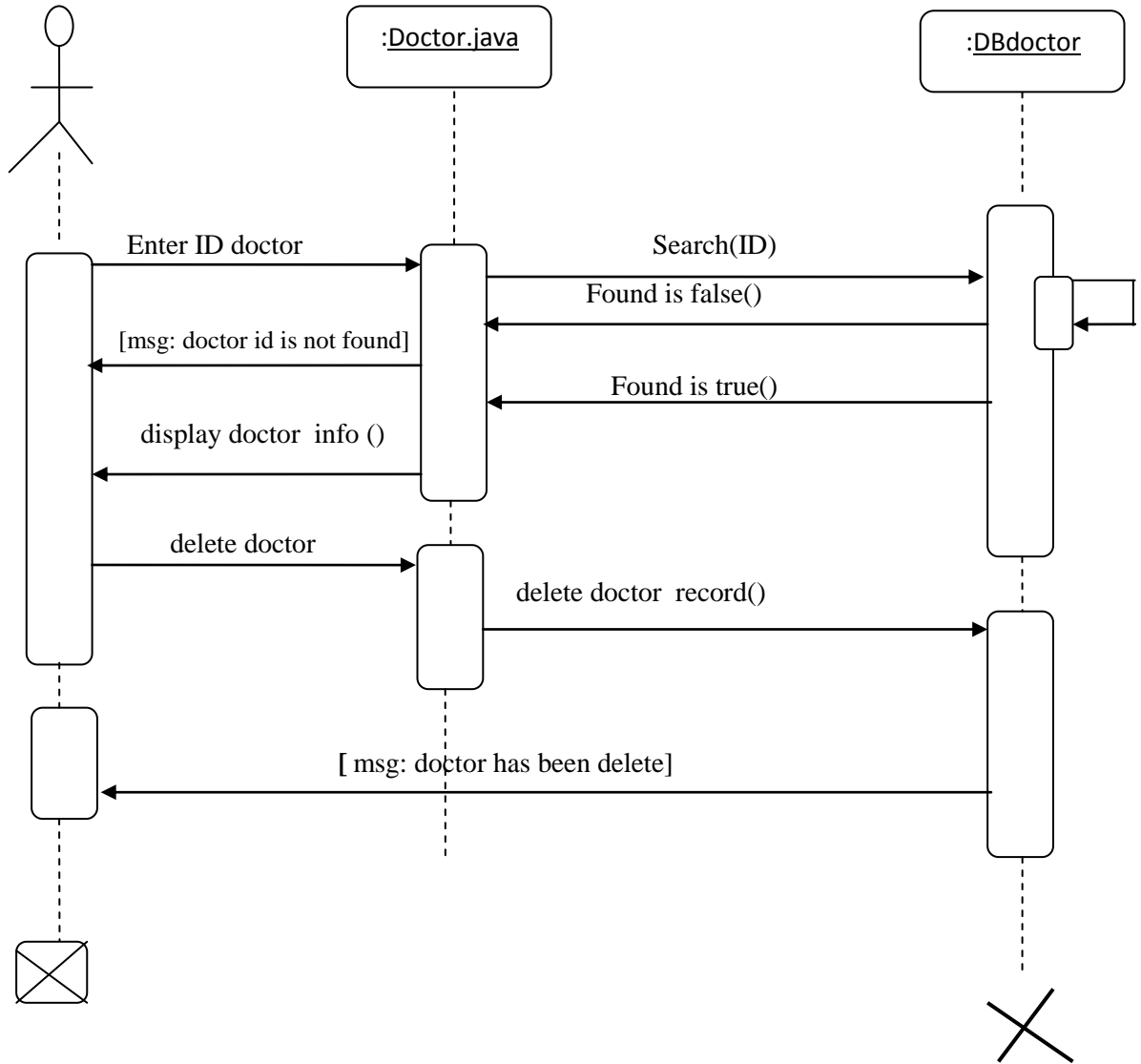

:doctor.java

Enter doctor information ()

[Found]

[msg: doctor already added]

[Complete]

:DBdoctor

Save doctor Data ()

[msg: fill in all fields]

[msg: doctor successfully added]

Appendix C.3: Add doctor sequence diagram

- **Update doctor sequence diagram.**

Enter doctor ID

[No]

[msg: doctor id is not found]

Search(ID_doctor)

display doctor information ()

Browser doctor info ()

Enter new doctor info

save data()

[msg**:** doctor has been updated successfully**]**

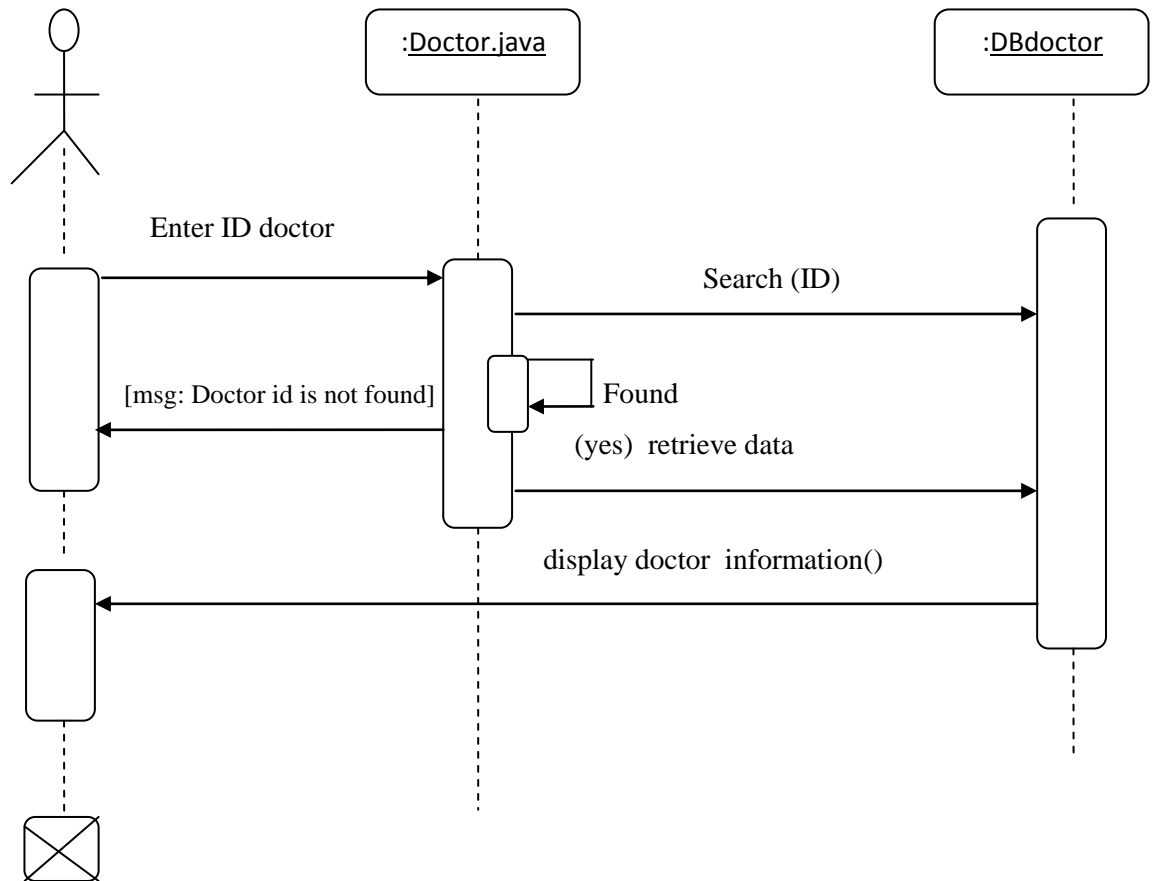:Doctor.java

:DBdoctor

Appendix C.4: Update patient sequence diagram

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- **Delete doctor sequence diagram.**
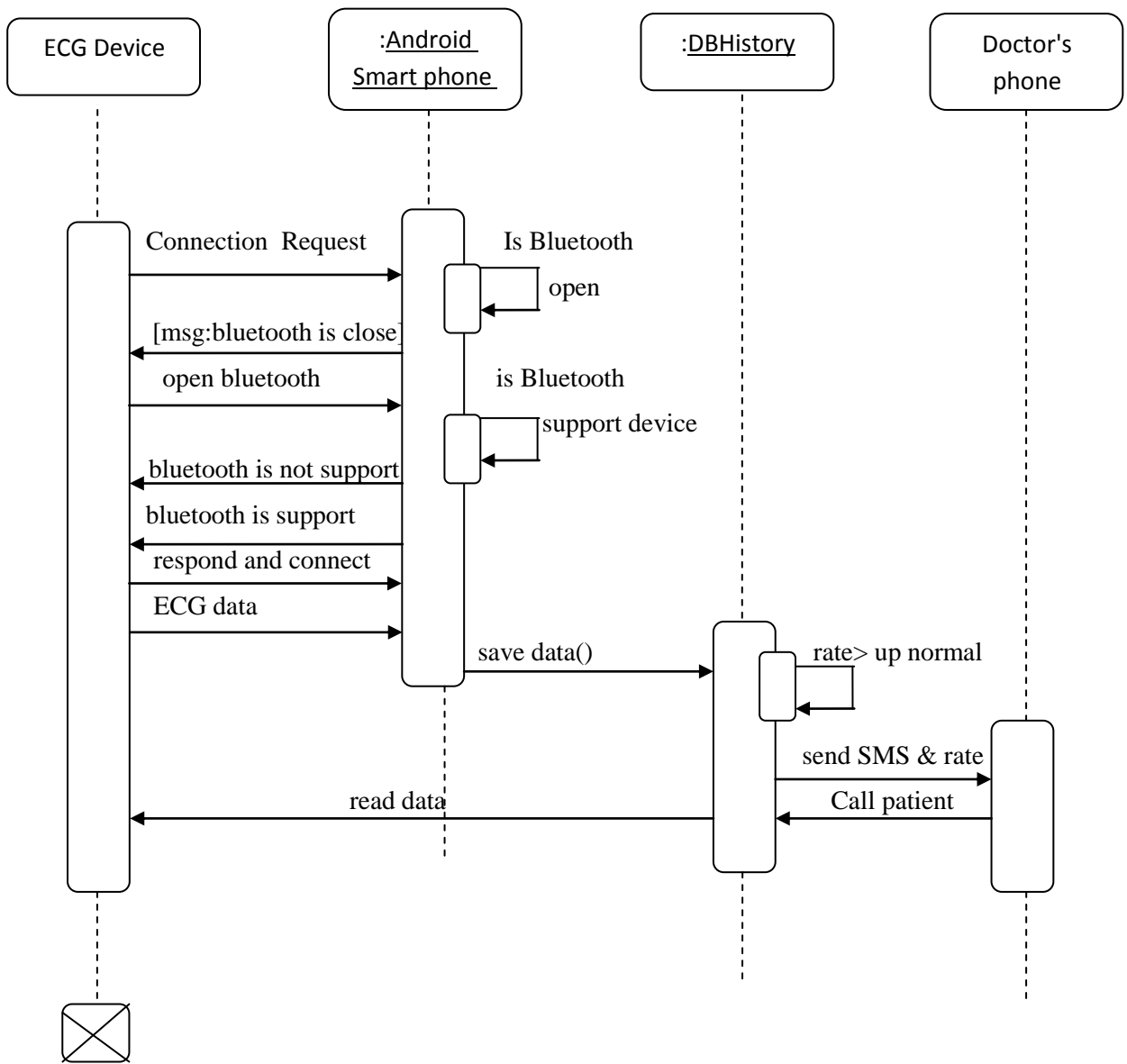

Appendix C.5: Delete doctor sequence diagram

- **Search doctor sequence diagram**
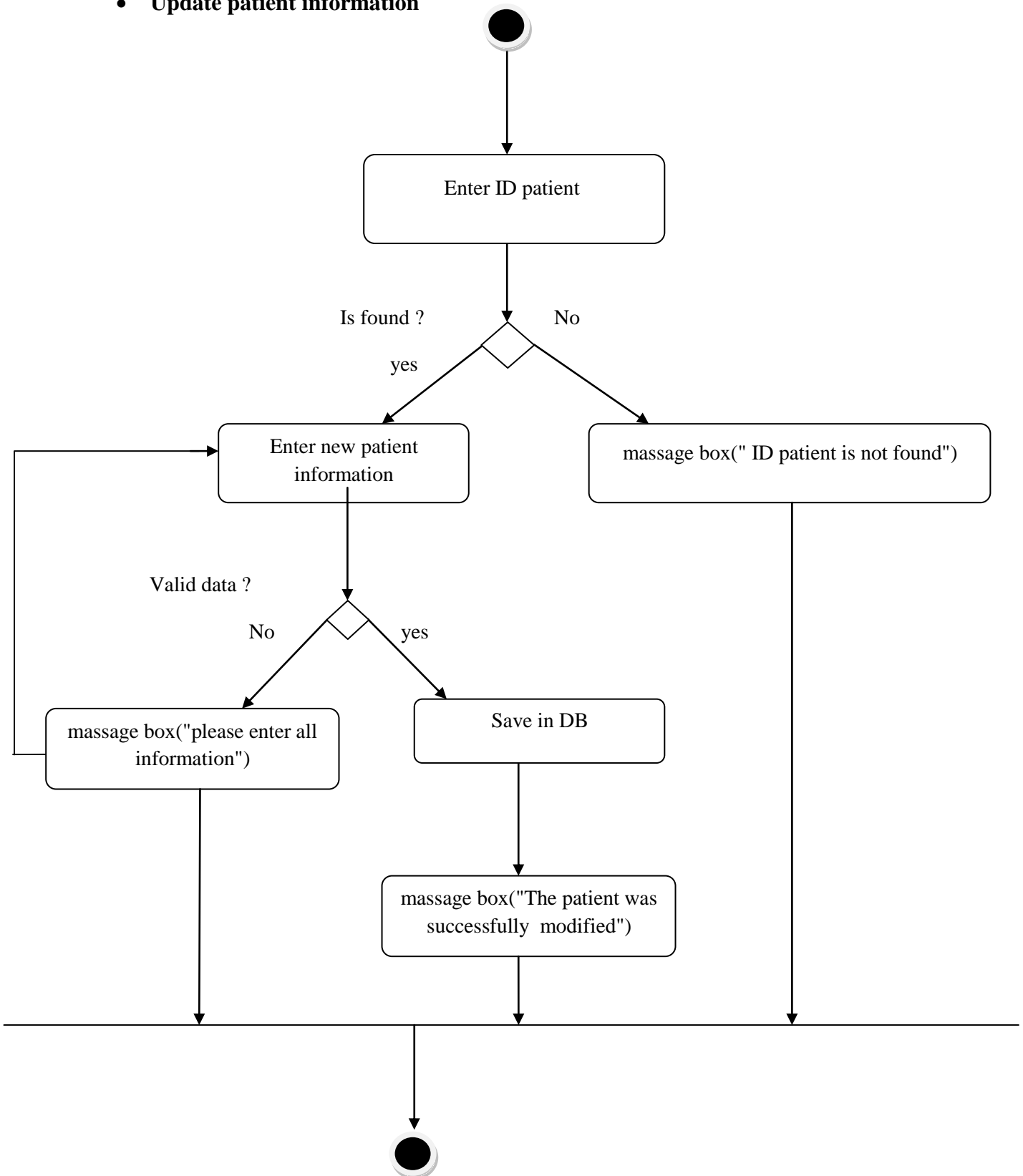

Appendix C.6: Search doctor sequence diagram

- **ECG Measurement sequence diagram**

Appendix C.7: ECG Measurement sequence diagram
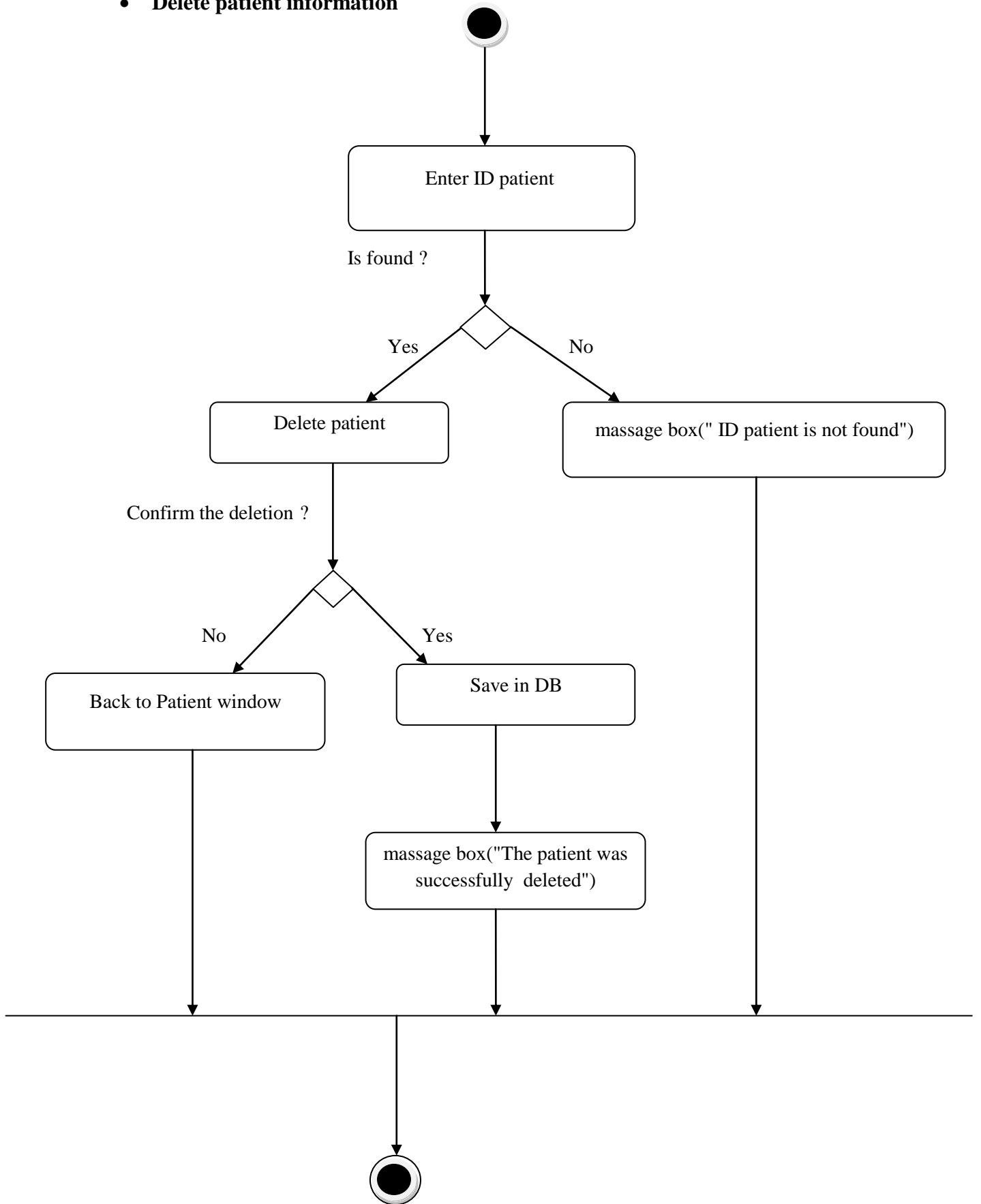
Appendix B : Activity diagrams

- **Update patient information**

Appendix B.1: Update patient activity diagram

- **Delete patient information**

Appendix B.2: Delete patient activity diagram

- **Search patient's information**
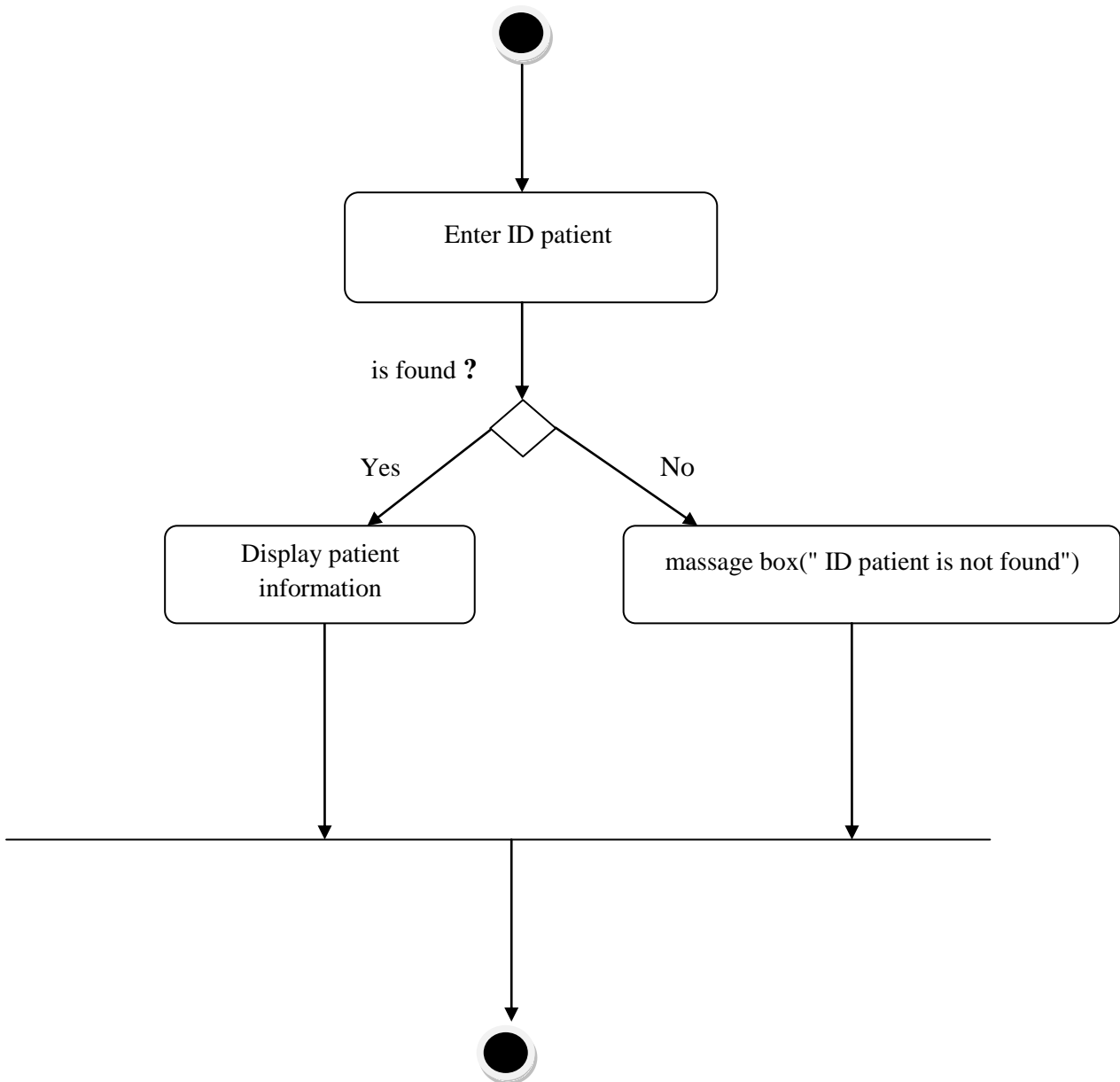
Appendix B.3: Search patient activity diagram

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- **Add doctor information**

Enter doctor information

is found ?

yes   No

Complete information?

yes   No

massage box(" ID doctor already exists")

massage box("The doctor was successfully added ")

massage box("please enter all information")
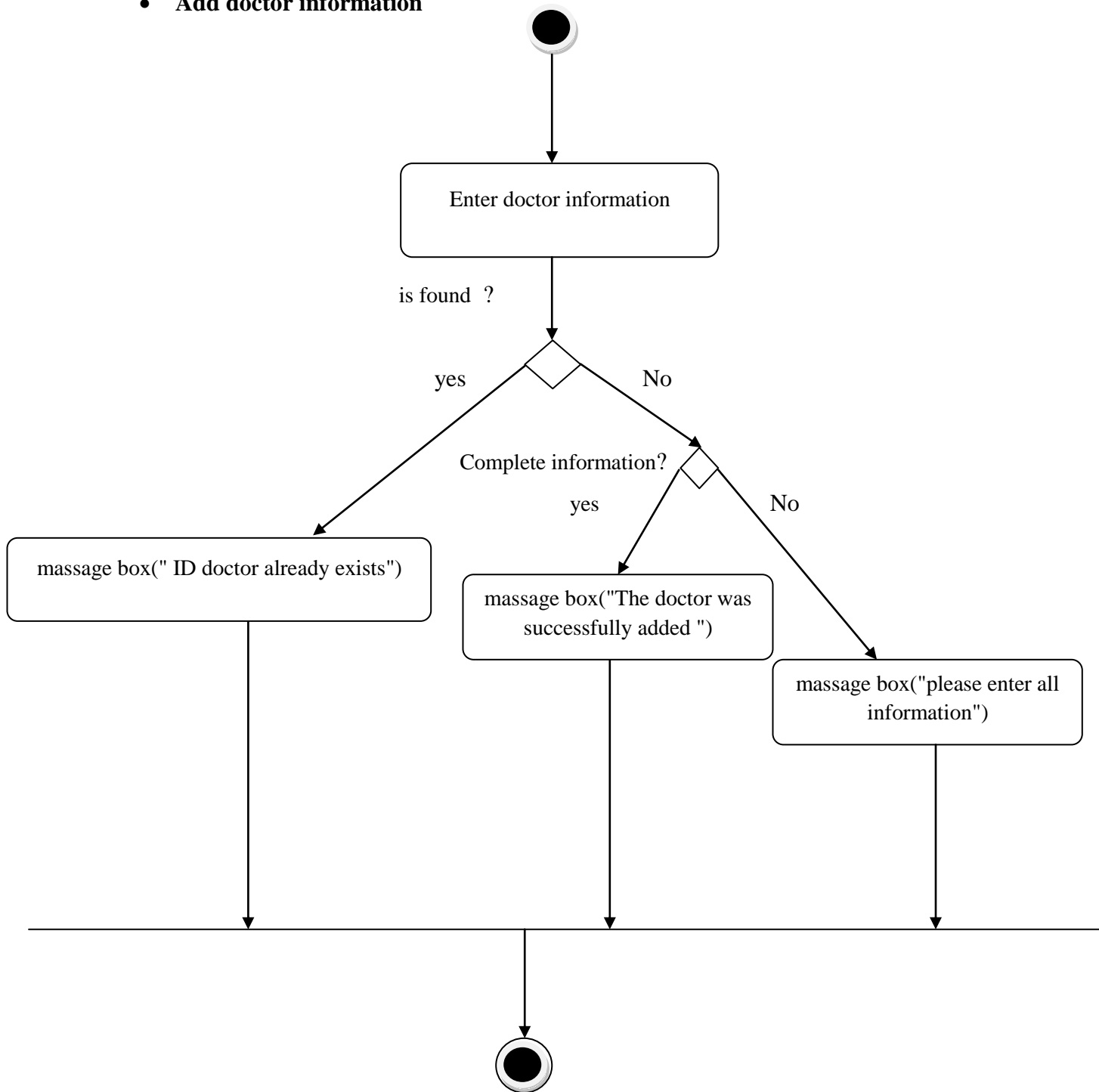
Appendix B.4: Add doctor activity diagram

- **Update doctor information**
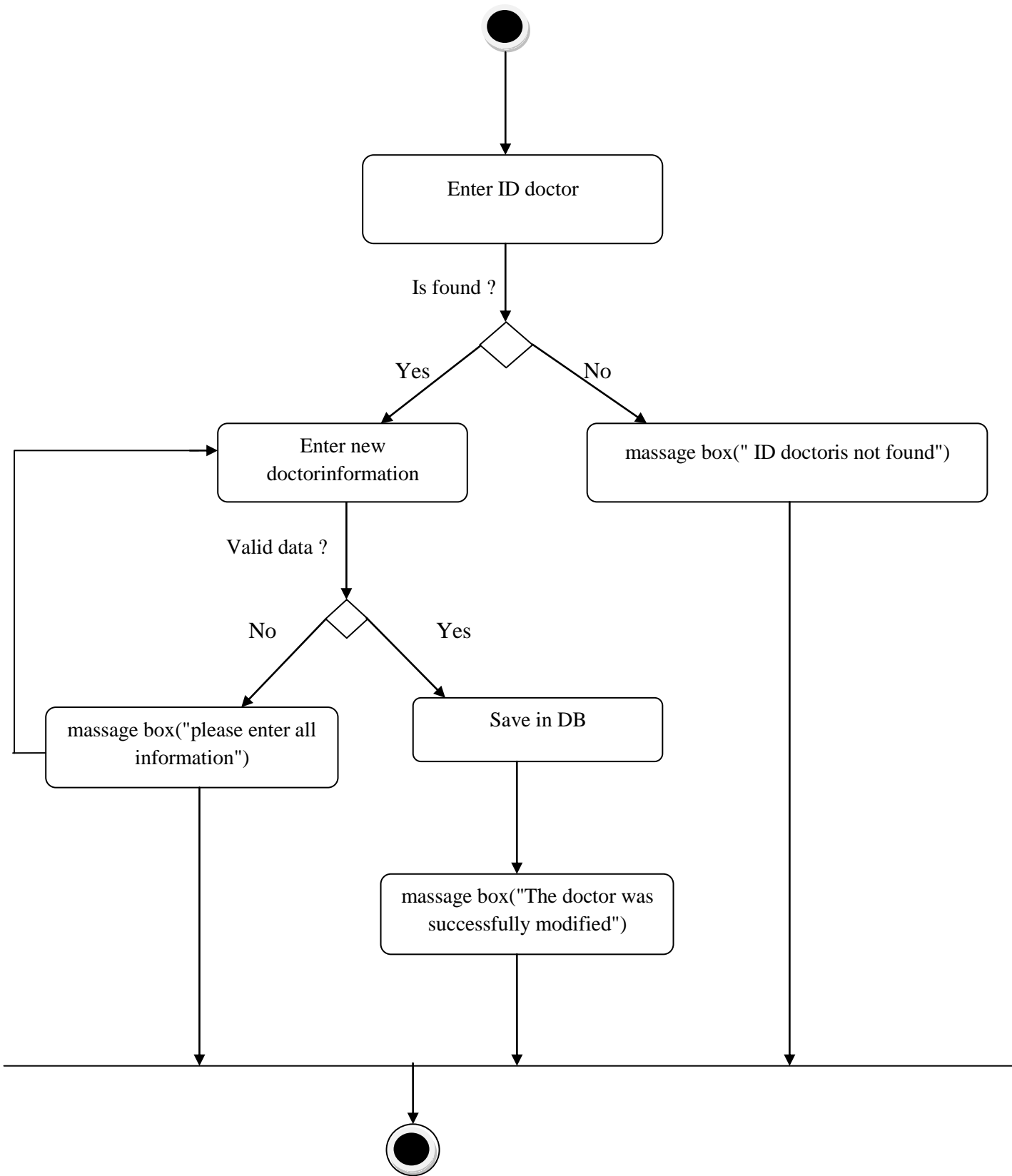
Appendix B.5: Update doctor activity diagram.

- **Delete doctor information**
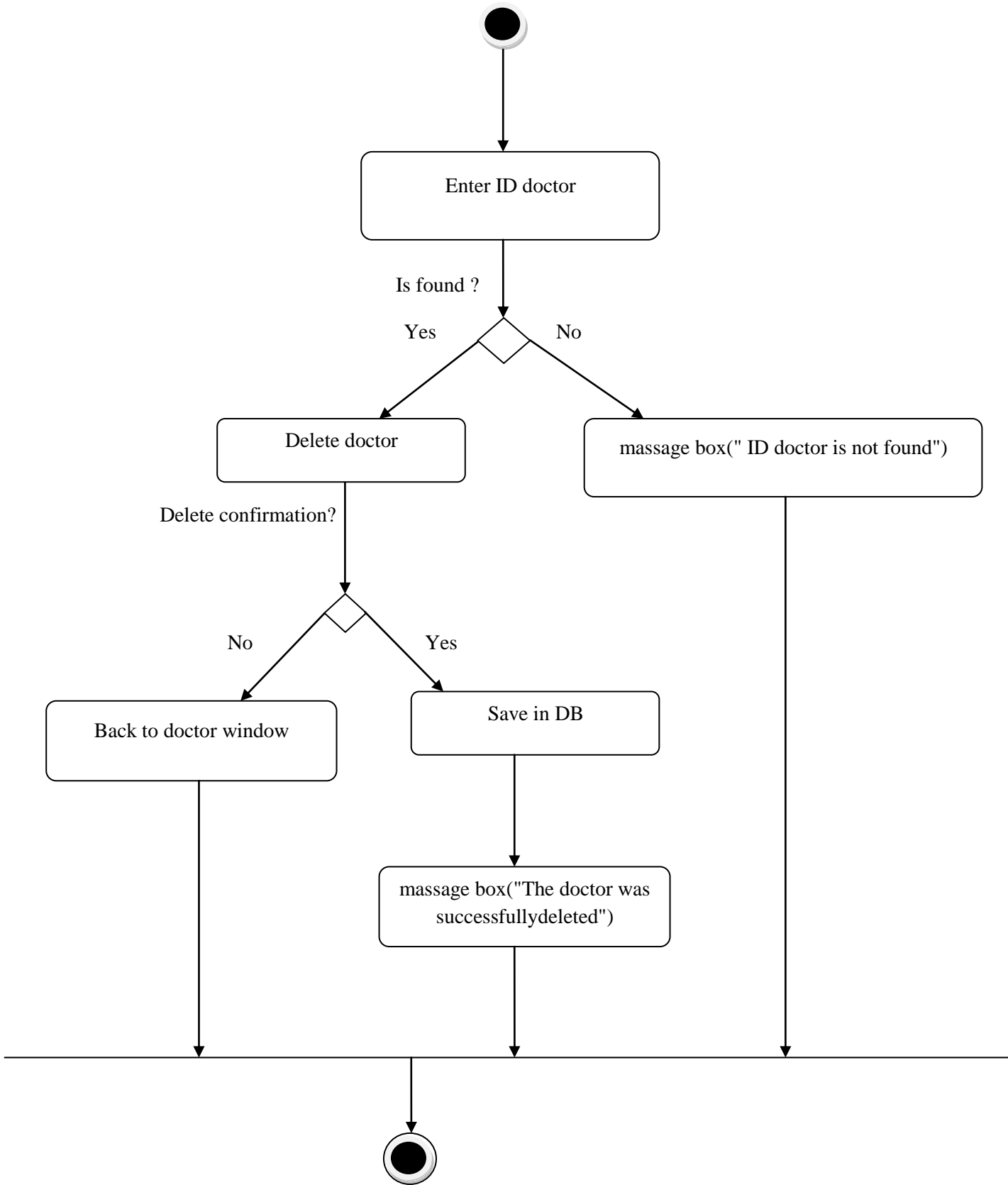
Appendix B.6: Delete doctor activity diagram.

- **Search doctor's information**
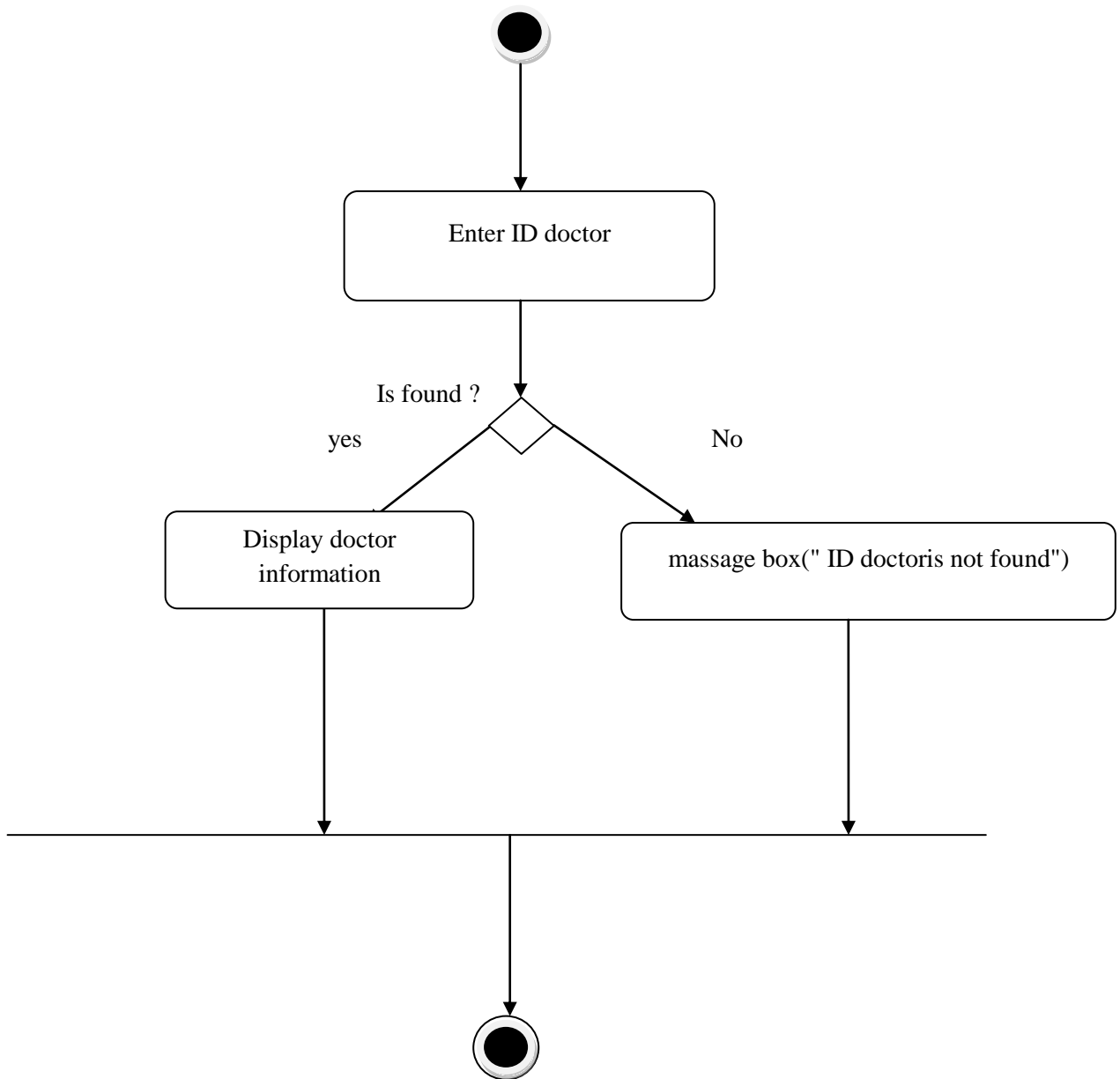
Appendix B.7: Search doctor activity diagram.

- **ECG Measurement**
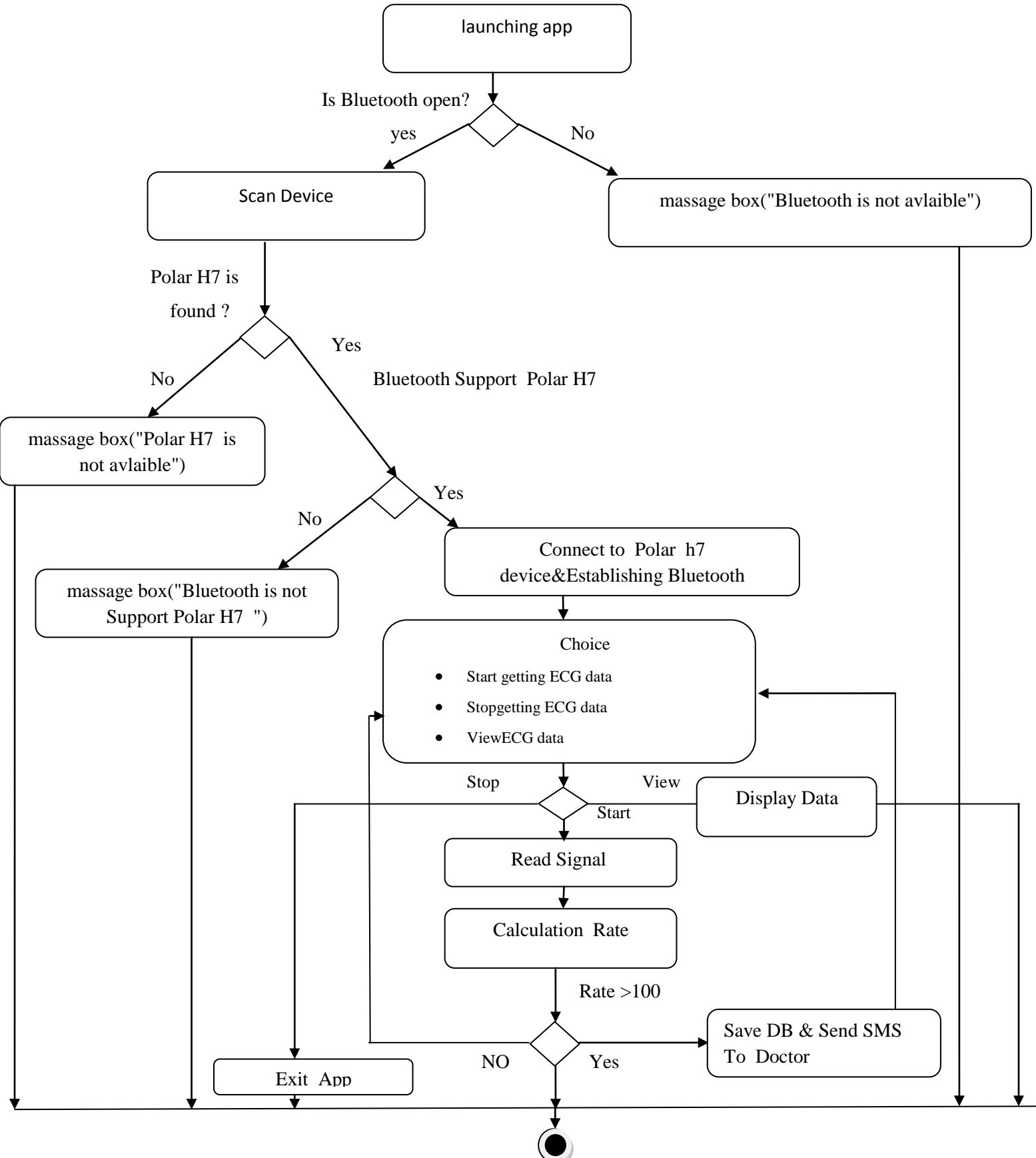
Appendix B.8: ECG Measurement activity diagram.

Appendix A : Software Requirements Specification

Template (IEEE 830, 1993)

Table of Contents

Revision History

Name	Date	Reason For Changes	Version

1. Introduction

1.1 Purpose

<Identify the product whose software requirements are specified in this document, including the revision or release number. Describe the scope of the product that is covered by this SRS, particularly if this SRS describes only part of the system or a single subsystem.>

1.2 Product Scope

<Provide a short description of the software being specified and its purpose, including relevant benefits, objectives, and goals. Relate the software to corporate goals or business strategies. If a separate vision and scope document is available, refer to it rather than duplicating its contents here.>

1.3 Definitions, Acronyms, and Abbreviations

<Provide the definitions of all terms, acronyms, and abbreviations required to properly interpret the SRS. This information may be provided by reference to one or more appendices in the SRS or by reference to documents. This information may be provided by reference to an Appendix.>

1.4 References

<List any other documents or Web addresses to which this SRS refers. These may include user interface style guides, contracts, standards, system requirements specifications, use case documents, or a vision and scope document. Provide enough information so that the reader could access a copy of each reference, including title, author, version number, date, and source or location.>

2. Overall Description

2.1 Product Perspective

<Describe the context and origin of the product being specified in this SRS. For example, state whether this product is a follow-on member of a product family, a replacement for certain existing systems, or a new, self-contained product. If the SRS defines a component of a larger system, relate the requirements of the larger system to the functionality of this software and identify interfaces between the two. A simple diagram that shows the major components of the overall system, subsystem interconnections, and external interfaces can be helpful.>

2.2 Product Functions

<Summarize the major functions the product must perform or must let the user perform. Details will be provided in Section 3, so only a high level summary (such as a bullet list) is needed here. Organize the functions to make them understandable to any reader of the SRS. A picture of the

major groups of related requirements and how they relate, such as a top level data flow diagram or object class diagram, is often effective.>

2.3 User Classes and Characteristics

<Identify the various user classes that you anticipate will use this product. User classes may be differentiated based on frequency of use, subset of product functions used, technical expertise, security or privilege levels, educational level, or experience. Describe the pertinent characteristics of each user class. Certain requirements may pertain only to certain user classes. Distinguish the most important user classes for this product from those who are less important to satisfy.>

2.4 Operating Environment

<Describe the environment in which the software will operate, including the hardware platform, operating system and versions, and any other software components or applications with which it must peacefully coexist.>

2.5 Design and Implementation Constraints

<Describe any items or issues that will limit the options available to the developers. These might include: corporate or regulatory policies; hardware limitations (timing requirements, memory requirements); interfaces to other applications; specific technologies, tools, and databases to be used; parallel operations; language requirements; communications protocols; security considerations; design conventions or programming standards (for example, if the customer's organization will be responsible for maintaining the delivered software).>

2.6 User Documentation

<List the user documentation components (such as user manuals, on-line help, and tutorials) that will be delivered along with the software. Identify any known user documentation delivery formats or standards.>

2.7 Assumptions and Dependencies

<List any assumed factors (as opposed to known facts) that could affect the requirements stated in the SRS. These could include third-party or commercial components that you plan to use, issues around the development or operating environment, or constraints. The project could be affected if these assumptions are incorrect, are not shared, or change. Also identify any dependencies the project has on external factors, such as software components that you intend to reuse from another project, unless they are already documented elsewhere (for example, in the vision and scope document or the project plan).>

3. External Interface Requirements

3.1 User Interfaces

<Describe the logical characteristics of each interface between the software product and the users. This may include sample screen images, any GUI standards or product family style guides that are

to be followed, screen layout constraints, standard buttons and functions (e.g., help) that will appear on every screen, keyboard shortcuts, error message display standards, and so on. Define the software components for which a user interface is needed. Details of the user interface design should be documented in a separate user interface specification.>

3.2 Hardware Interfaces

<Describe the logical and physical characteristics of each interface between the software product and the hardware components of the system. This may include the supported device types, the nature of the data and control interactions between the software and the hardware, and communication protocols to be used.>

3.3 Software Interfaces

<Describe the connections between this product and other specific software components (name and version), including databases, operating systems, tools, libraries, and integrated commercial components. Identify the data items or messages coming into the system and going out and describe the purpose of each. Describe the services needed and the nature of communications. Refer to documents that describe detailed application programming interface protocols. Identify data that will be shared across software components. If the data sharing mechanism must be implemented in a specific way (for example, use of a global data area in a multitasking operating system), specify this as an implementation constraint.>

3.4 Communications Interfaces

<Describe the requirements associated with any communications functions required by this product, including e-mail, web browser, network server communications protocols, electronic forms, and so on. Define any pertinent message formatting. Identify any communication standards that will be used, such as FTP or HTTP. Specify any communication security or encryption issues, data transfer rates, and synchronization mechanisms.>

4. System Features

<This template illustrates organizing the functional requirements for the product by system features, the major services provided by the product. You may prefer to organize this section by use case, mode of operation, user class, object class, functional hierarchy, or combinations of these, whatever makes the most logical sense for your product.>

4.1 System Feature 1

<Don't really say "System Feature 1." State the feature name in just a few words.>

4.1.1 Description and Priority

<Provide a short description of the feature and indicate whether it is of High, Medium, or Low priority. You could also include specific priority component ratings, such as benefit, penalty, cost, and risk (each rated on a relative scale from a low of 1 to a high of 9).>

4.1.2 Stimulus/Response Sequences

*<List the sequences of user actions and system responses that stimulate the behavior
defined for this feature. These will correspond to the dialog elements associated with
use cases.>*

4.1.3   Functional Requirements

*<Itemize the detailed functional requirements associated with this feature. These are the
software capabilities that must be present in order for the user to carry out the
services provided by the feature, or to execute the use case. Include how the product
should respond to anticipated error conditions or invalid inputs. Requirements should
be concise, complete, unambiguous, verifiable, and necessary. Use "TBD" as a
placeholder to indicate when necessary information is not yet available.>*

*<Each requirement should be uniquely identified with a sequence number or a meaningful
tag of some kind.>*

REQ-1:
REQ-2:

4.2 System Feature 2 (and so on)

5. Other Nonfunctional Requirements

5.1 Performance Requirements

*<If there are performance requirements for the product under various circumstances, state them
here and explain their rationale, to help the developers understand the intent and make suitable
design choices. Specify the timing relationships for real time systems. Make such requirements as
specific as possible. You may need to state performance requirements for individual functional
requirements or features.>*

5.2 Safety Requirements

*<Specify those requirements that are concerned with possible loss, damage, or harm that could
result from the use of the product. Define any safeguards or actions that must be taken, as well as
actions that must be prevented. Refer to any external policies or regulations that state safety
issues that affect the product's design or use. Define any safety certifications that must be
satisfied.>*

5.3 Security Requirements

*<Specify any requirements regarding security or privacy issues surrounding use of the product or
protection of the data used or created by the product. Define any user identity authentication
requirements. Refer to any external policies or regulations containing security issues that affect the
product. Define any security or privacy certifications that must be satisfied.>*

5.4 Software Quality Attributes

*<Specify any additional quality characteristics for the product that will be important to either the
customers or the developers. Some to consider are: adaptability, availability, correctness, flexibility,
interoperability, maintainability, portability, reliability, reusability, robustness, testability, and*

usability. Write these to be specific, quantitative, and verifiable when possible. At the least, clarify the relative preferences for various attributes, such as ease of use over ease of learning.>

5.5 Business Rules

<List any operating principles about the product, such as which individuals or roles can perform which functions under specific circumstances. These are not functional requirements in themselves, but they may imply certain functional requirements to enforce the rules.>

6. Other Requirements

<Define any other requirements not covered elsewhere in the SRS. This might include database requirements, internationalization requirements, legal requirements, reuse objectives for the project, and so on. Add any new sections that are pertinent to the project.>

Appendix A: Glossary

<Define all the terms necessary to properly interpret the SRS, including acronyms and abbreviations. You may wish to build a separate glossary that spans multiple projects or the entire organization, and just include terms specific to a single project in each SRS.>

Appendix B: Analysis Models

<Optionally, include any pertinent analysis models, such as data flow diagrams, class diagrams, state-transition diagrams, or entity-relationship diagrams.>

Appendix C: To Be Determined List

<Collect a numbered list of the TBD (to be determined) references that remain in the SRS so they can be tracked to closure.>

Chapter 5

Conclusion & Future works

5.1 Conclusion

This Thesis discusses challenges faced by heart patients in the use of electrical signals (ECG) in Computing Systems wearable, where heart patients can measure the pulse rate everywhere, particularly people with heart condition who are unable to go to the hospital for various reasons, such as, to check the condition of the heart, and to make sure that the heart is functioning normally.

The App shows how can the Polar H7 view ECG planning and calculates heart pulse rate of the patient by using mobile. It also sends the result of the patient's ECG to the doctor via the mobile or through the recommendation of the stored Database SQLite (Knowledge Base) to be given to the patient.

The major goal of this App is to create interaction between doctors and patients, to meet the needs of the patients. Patients can follow up their health condition with doctors. The doctor can check the patient's heartbeat, verify whether the beats are regular or not and give his advice and directions accordingly. The App has a remarkable feature; that is to issue a prescription to a patient by a Knowledge database entered by the doctor, Which in turn leads to reduce the cost of patient's service and provides a vital communication link between doctor and patient.

5.2 Future works

This App can be improved in the future by adding the following functions:

- Extending to Apple IOS.
- Create two separate Apps, one for the patient and other for the doctor ,connected with the web server.
- Sharing the medical test reports of patients with doctors through this App.
- Supporting video calls & Viber to discuss the problems with doctors.
- A web site that contains a schedule of the available doctors who can communicate with patients.