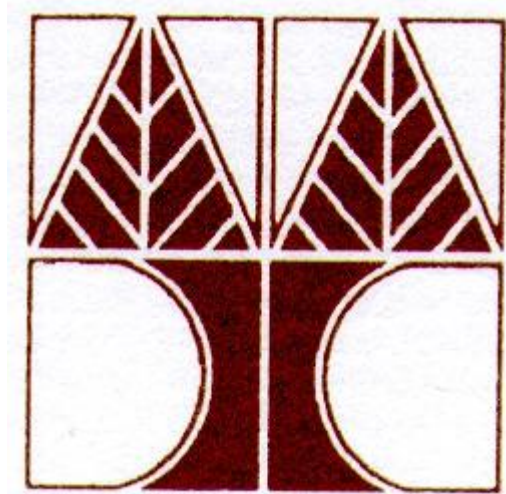


# Android Home Monitor System for Post Cardiosurgery Patients

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**ΠΑΝΕΠΙΣΤΗΜΙΟ ΚΥΠΡΟΥ**



**ΤΜΗΜΑ ΠΛΗΡΟΦΟΡΙΚΗΣ**

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# Chapter 1 Introduction

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1.1 Overview Narrative

1.2 E-Health

1.3 M-Health

1.4 Project Purpose

1.5 Project Structure

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## 1.1 Overview Narrative

While technology grows it gives the opportunity and to other areas to be evolves. For example as technology evolves it gives more opportunities to medicine to help patients, providing them better life. Medical equipment is evolving to provide better and more accurate diagnosis, better medical pills, etc.

Beside that other categories may grow that with a combination with medicine may provide a better life for all of us. For example surgeries may be conducted through VoIP conference between doctors helping each other how to proceed with the surgery. Furthermore mobile telephones were evolved to Smartphone's telephones. This give much more potentials combine with medicine to provide to patients better life support. Upon this telemedicine, m-Health was developed.

Telemedicine combine telecommunication with information's technologies in order to provide distance clinical health care. It provides access for communities that do not have direct access to health care and provide them access through telemedicine. It provides a

communication between patient and doctor and the exchange between them of medical and health information's [24].

Moreover telemedicine it provides access for patients in remote locations in healthcare. Patient will have a number of monitor devices at home in which the results will be sending to the corresponding doctor for analysis. It provides vital information's of the patient as long as the equipment is being using. Depends on the patient condition, doctor can check those vital information's on a daily or weekly basis to determine the best treatment.

Telemedicine manage to reduce the cost of healthcare both for hospitals and patients, and increase efficiency through better management of chronic diseases, shared health professional staffing, reduce travel time, reduce cost, and fewer or shorter hospital stays [26].

## **1.2 E-Health**

### **E-health Services**

- Electronic health records: enabling the communication of patient data between different healthcare professionals such as GPs, specialists etc.
- Telemedicine:
- Consumer health informatics: use of electronic resources on medical topics by healthy individuals or patients
- Health knowledge management: e.g. in an overview of latest medical journals, best practice guidelines or epidemiological tracking
- Virtual healthcare teams: consisting of healthcare professionals who collaborate and share information on patients through digital equipment
- mHealth or m-Health
- Medical research using Grids: powerful computing and data management capabilities to handle large amounts of heterogeneous data.
- Healthcare Information Systems: also often refer to software solutions for appointment scheduling, patient data management, work schedule management and other administrative tasks surrounding health [26].

## **1.3 M-Health**

M-Health in mobile devices have the appropriate application in order to help the practice of medicine and public health. It referred to the support of medicine from mobile devices, tablets and PDAs. M-Health provide to the increase of access to healthcare and health-related information's, also improve the ability to diagnose and track diseases and expanded access to ongoing medical education and training for health workers.[25,38]

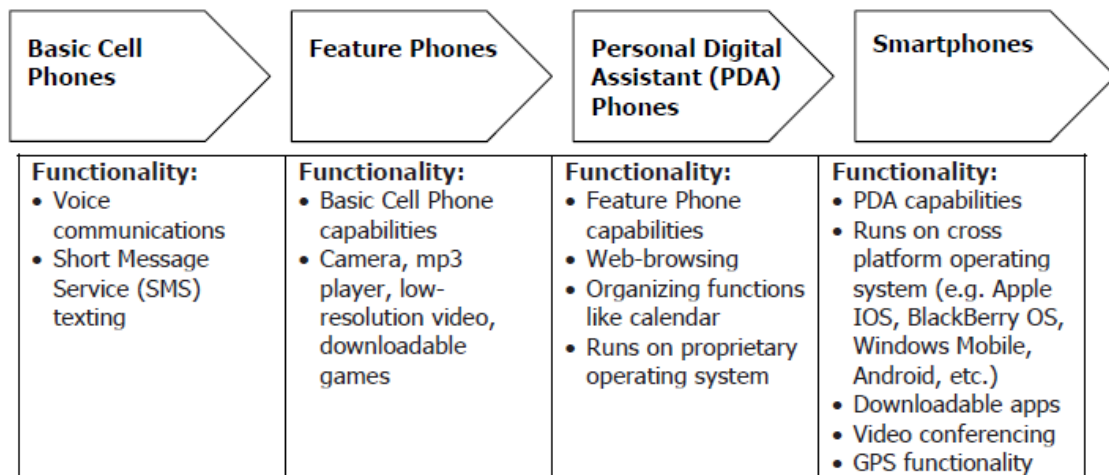
Two factors motivate the development of m-health. The first one was the many constraints that exist in healthcare systems of developing nations, such as high population growth, low health care, limited financial resources to support healthcare, Chronic Disease, etc. The second motivation promoted on developing m-health, where mobile phones, the rapid raise of mobile phones to large segments of the healthcare workforce. In any segment of the country, you have a mobile access with low information and transaction cost in order to deliver healthcare [39].

Cells phone can be described according their functionalities from basic cell phones to Smartphone's. M-health procedures can work on any type of cell phone or in depending the type of application to certain types only. Wide range of procedures were developed for user from the basic cell phones that its functions are voice communication and Short message service (SMS). Popular health-related functions of SMS include health behaviours reminders, request for schedule or confirm of an appointment, notifications or laboratory results, request for data, encouragements or motivations to maintenance a position behaviour and educational and information resources to improve self-efficiency.

### **Mobile Phones**

Comparing ref. Fig. 1.1 basic cell phone, feature phone, PDA or Smartphone's they provide more advance multimedia applications, specialty applications. Using Smartphone does provide extra advantage to the user for real time application's with two way communications. Moreover can collect vital information's on real time and send them to their doctor in which doctor can collect the data, analyse them and respond immediately back to the patient providing medication.

Moreover m-health can improve communication between patients, caregivers and providers with video conferencing communications that are beginning to emerge and are built in to these mobile technologies [27].



Reference 1.1: Cell phones types

## M-health Applications

- Education and awareness

The main concept was providing mass information's from source to recipients through SMS. SMS are sending directly to user phone device to inform them about several subjects including testing and treatment methods, etc. The main advantage of SMS is that is distinctive, offering patient confidentiality in societies where diseases such as HIV and AIDS are taboo. Beside that it provide information's to users that may have limited access to public health care information's, health clinics, etc.

“Project Masiluleke and Text to Change use SMS message campaigns to provide HIV/AIDS education in South Africa and Uganda, respectively. Project Masiluleke takes advantage of the 120 spare characters on free ‘please call me’ SMS messages to provide HIV/AIDS education and awareness, while Text to Change employs an SMS-based quiz to test users’ HIV/AIDS knowledge and encourage testing and counseling.” [28]

- Helpline

Is a phone number that any one may have access to that phone number. It provide access to range of medical services which include phone consultants, counselling, service complaints and information's about drugs, equipment and available mobile health clinics.

- Diagnostic and treatment support, Communication and training for healthcare workers

It provides healthcare workers about diagnosis and treatment of patients. It equips them to a source of information's through their mobile phone. This involves connecting healthcare workers with other health care workers, medical institutions, ministries of health, or other houses of medical information's. This involves using mobile phones to better organize and target in person training. Beside that it improves communication projects to increase knowledge transfer among healthcare workers and improve patient outcomes through such programs.

- Communication and Training for Healthcare Workers

“In the Primary Healthcare Nursing Promotion Program, the National School for Nurses in Coban, Guatemala used an innovative combination of mobile phones, landline phones, and tele-writers to train nurses in this rainforest community.” [28]

- Diagnostic and Treatment Support

“Researchers from the University of Melbourne are creating diagnostic and analytical tools specifically for mobile phones for health workers in Mozambique. These tools include a built-in calculator for determining drug dosage and reference materials stored in the phone's memory.” [28]

- Disease and epidemic outbreak tracking, Remote monitoring, Remote data collection

The main goal is to use mobile functionality in order to collect and transmit data quickly, cheaply and efficiently. Those vital information's according the location level of specific diseases such as malaria, HIA/AIDS, TB, Avian Flu can provide help to medical systems, ministries of health's or other organizations identify the source of problem, and provide better target medical resources to areas of greatest need. That kind of project it would be useful during emergencies in order to identify where the greatest medical need within the country is.

- Remote Data Collection

“Hundreds of health workers have used PDAs provided by the Ugandan Health Information Network to collect health data in the field. Not only has this



solution resulted in significant cost savings—25% in the first six months—but health workers report increased job satisfaction due to the greater efficiency and flexibility provided by the technology.” [28]

- Remote Monitoring

“TB patients in Thailand were given mobile phones so that healthcare workers (themselves former TB patients) could call these patients on a daily basis to remind them to take their medication. Medicine compliance rates reached 90% due to the introduction of this remote monitoring application.” [28]

- Disease and Epidemic Outbreak Tracking

“Incidents of Japanese Encephalitis were tracked real-time in Andhra Pradesh, India, via a combination of mobile phones and web-based technologies. The government used the information to better prioritize vaccinations based on evidence of clusters of outbreaks.” [28]

- Treatment support and medication compliance for patients, including chronic diseases

Additional to that remote monitor and treatment support provide better involvement in medical care of the patients. In countries, areas with limited resources such as beds or medical clinics, remote monitor provide to workers a better feedback about patient conditions, medication regimen adherence and follow-up schedule. The use of remote monitor is being using more in areas if medication adherence of AIDS and diabetes [26].

## **M-Health Objectives**

- increased access to healthcare and health-related information (particularly for hard-to-reach populations)
- improved ability to diagnose and track diseases
- timelier, more actionable public health information
- expanded access to ongoing medical education and training for health workers

## **M-Health Advantages**

- Reduced hospitalizations of patients

- Increased patient satisfaction
- Reduced costs both for patients, not need to be at the hospital every day and for hospitals because patients will be less and equipment will be used less
- Increased self-management, equipment will be used directly from the patient
- Improved health and wellness
- Increased quality of life
- Reduce the caregiver burden
- Increased communication and coordination between patients, clinicians, and caregivers

### **M-Health – To whom it concerns**

- Hospitals
- Clinics
- Nurses - Health Workers
- Doctors
- Patients
- Insurance Companies

## **1.4 Project Purpose**

Heart surgery or other cardio logical diseases that affect patient life, needs to provide them some solutions that will help them to continue their lives. After a surgery, patients need to attend on the hospital every day in order the doctor to make the appropriate exams to ensure that there are no any complications for the patient. That's vital information's are the ECG, weight, blood pressure, and oxygen saturation. This exam in order to be done every day it need a lot of time both from patient and doctor. Some of the patients due to age, distance or other factors might not be able to be moved every day to the hospital.

Technology gets in our life day by day with its benefits and with disadvantages. Gathering only the benefits we will provide a system that will support both patient and doctor. It gives the ability to patient to make the cardiac test from home and for the doctor to exam the patient without to be face to face with the patient. The patient will be provided with tools that are necessary in order to measure by its self all the vital information's that are

need and then will send them to the doctor. The doctor then will download the data and check for any arrhythmia on the data.

Population aging is progressing rapidly in many industrialized countries, but those developing countries whose fertility declines began relatively early also are experiencing rapid increases in their proportion of elderly people [1].

Needs of older peoples according health are becoming more demanding and more usual. They have needs for a range of resources that they provide them support in order to be actively members of the community they leave.

Moreover in middle income and low income countries face a huge problem in their healthcare system. These countries their main problem is the lack of human and physical resources and the huge number of diseases. Healthcare access to all reaches of society is generally low in these countries.

The main goal of this project is to provide a functional application that will handles the electrocardiogram in distance. The application with a combination with advance medical devices will provide huge advantage in order to avoid episodes that may set into danger the patient life. With the certain application we can select the ECG signal, heart rate, oxygen saturation, blood pressure, weight, plethysmogram in real life time analyze, sending the information's to the appropriate personnel and immediately check them for any arrhythmia in data. This procedure is vital especially for patients with heart surgery, or chronic diseases. For those patients is essential to have fast and continuously inspection of the data in order to prevent any contingency that will harm patient life.

Furthermore the vital information's that will be collect, the ECG, oxygen saturation, patient weight, plethysmogram, heart rate they will be transfer to the appropriate personnel using a combination of Wi-Fi and web-services, in which in turn the personnel will download those information's either on the portal specify for doctors in which it will process and will act accordingly to the situation.

The solution that will be providing for both patients and doctors will be two separate android application portals the ECG application. Patient will login on the patient portal system, capture all the vitals information's that are needed from the appropriate medical

personnel. On the other side the medical personnel will login on the doctor portal system that in order to download the data the review them.

## **1.5 Project Structure**

The chapter's structure is:

### **Chapter 2 – Theoretical Background:**

This chapter will provide some necessary information's about ECG, how ECG works and explain in theoretical for heart, ECG, ECG rhythms.

### **Chapter 3: - System Requirements**

Provides the technologies that are going to be used and devices that are need in order to implement the application.

### **Chapter 4: - Analysis of Previous work**

In this chapter we will search on previous works that have been implemented according to our subject. Also we will compare some of those works with our and what it will be improve depend the other works.

### **Chapter 5: - Analysis and System specifications**

In this chapter is been descript the life cycle of the project the phases that is been follow in order to analysis, design, and implement the application.

### **Chapter 6: - Implementation Phase**

It provide the programming language that were used in order to implement the application, and the steps that where followed

.

### **Chapter 7: - System Evaluation Phase**

It will be describing the tests that were following in order to check the correctness of the application. Beside that it will discuss the modularity of the system for future upgrades.

### **Chapter 8: - Installation Phase**

Describe the steps that have to be follow in order to install the application in Android Devices and how the needed files will be copied on the memory card of the device.

## Chapter 9: - Conclusion and Future work

This is the last chapter of this thesis. In this chapter will be discuss what have we done and what can be done in order to implement a better application and what external application are need in order to help for creating more useful application.



# Chapter 2 Theoretical Background

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2.1 Human Heart

2.2 Electrocardiography (ECG)

2.3 Placement of electrodes

2.4 Characteristics of Normal ECG

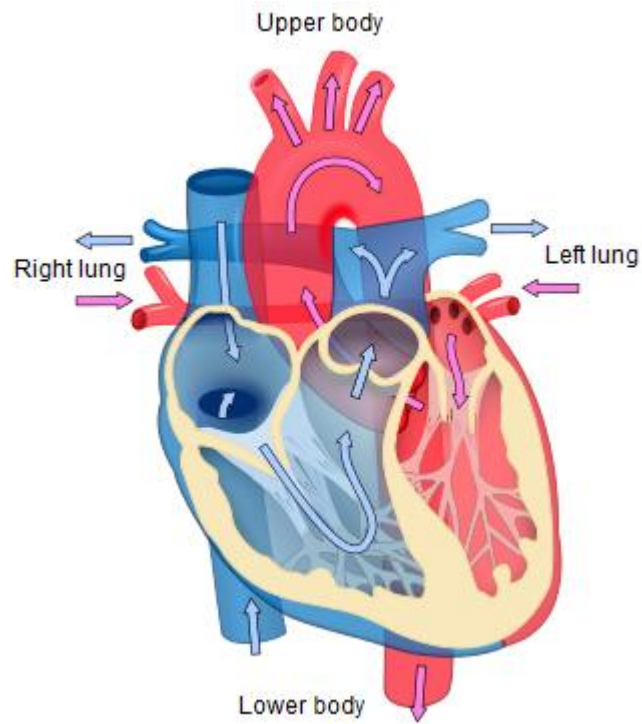
2.5 ECG Rhythms

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## 2.1 Human Heart

Human heart is the main organ of the human body. Its role is to provide continuous blood through the cardiac cycle. Heart is divided into four chambers, two upper chambers and two lower chambers. The upper chambers are the left and right Atrium and the lower chambers are the left and right Ventricle. The heart is divided into two with the septum that is a thick wall in order to separate the right from the left side. Normally with each beat the right ventricle pumps the same amount of blood into the lungs that the left ventricle pumps into the body.

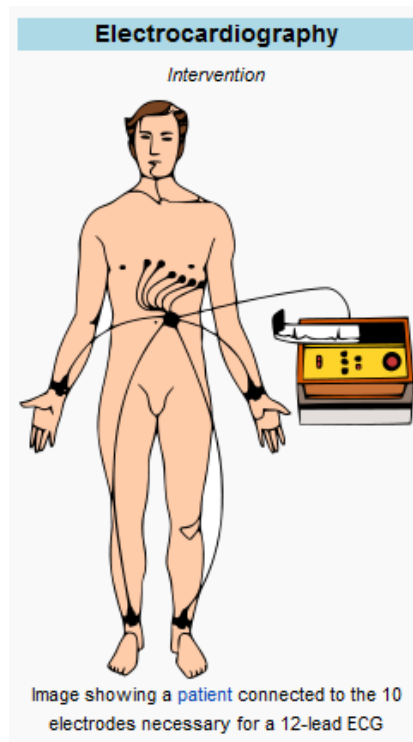
Furthermore the heart acts like a double pump. The right side of the heart is configured in order to collect the de-oxygenated blood from the body via the right ventricle into the lungs so that carbon dioxide can be dropped off and oxygen picked up. The left side collects oxygenated blood from the lungs into the left atrium in which it's turn it channel it to the left ventricle which pumps it out to the body. The lower ventricles on both sides are thicker and stronger than the upper atria. The muscle wall that surround the left ventricle is thicker than the wall that surround the right ventricle, this is due to that the higher force that needed to pump the blood through the systemic circulation [29] ref fig 2.1.1.



Reference 2.1.1: Human Heart [29]

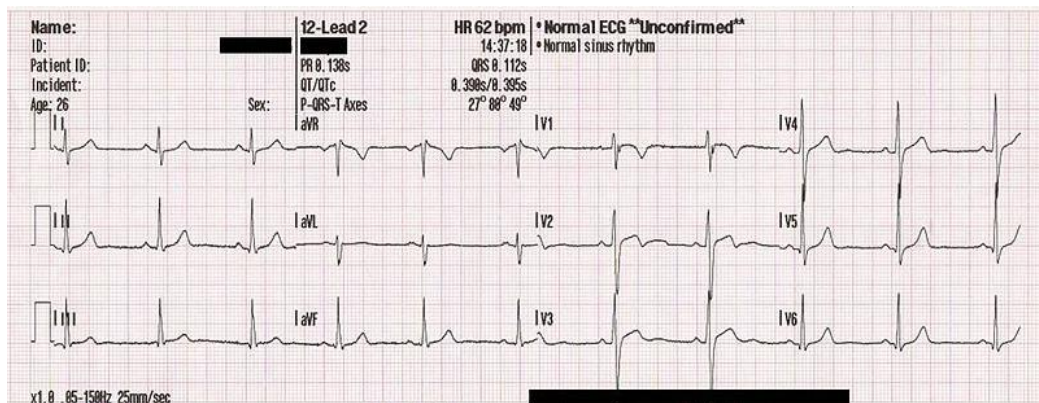
## 2.2 Electrocardiography (ECG)

Electrocardiography (ECG) is a transthoracic (across the thorax or chest) interpretation of the electrical activity of the heart over a period of Time, as detected by electrodes attached to the outer surface of the skin and recorded by a device external to the body [2] refer to fig 2.2.1. The ECG it measure the rate and regularity of heartbeats, the size and position of the chambers, the presence of any damage to the heart, the effects of drugs or devices used to regulate the heart.



Reference 2.2.1: 12-leads ECG

The ECG device detects the electrical changes that are caused when the heart muscle depolarizes during each heartbeat. Each heart muscle cell has a negative charge across its outer wall, increasing this negative charge to zero is the depolarization, in which it activates the mechanism in the cell that cause it to contract. A healthy heart during the heartbeat will have an orderly progression of wave of depolarisation that is triggered by the cells in the sinoatrial node, spreads out through the atrium, passes through intrinsic conduction pathways and then spreads all over the ventricles. It's been explain as a rises and falls in the voltage between the two electrodes places either side of the heart which is presented as a wavy line. Delineate the rhythm of the heart and the weaknesses of the heart [2], ref fig. 2.2.2.



Reference 2.2.2: 12 EKG of a 26-year-old male.



In order to capture an ECG rhythm it usually uses more than 2 electrodes and they are combined into a number of pairs. Those pairs can be defined for the three pairs as LA+RA, LA+LL and RA+LL in which the LA-Left Arm, RA-Right Arm and LL-Left Arm. Each output pair is defined as a lead. Each lead looks at the heart from a different angle. The types of leads are referred to the pairs of electrodes that are recording, e.g. 3-leads, 5-leads, 12-leads. The 3 and 5 leads are usually used to monitor continuously and to be viewed only on a screen of an appropriate monitor device such as on an ambulance during transport or during an operation. On 12 leads there are 12 different electrical signals that are recorded at the same time and often used as one-off recording of an ECG and usually are printed out as a paper copy.

This is the best way to measure and diagnose abnormal rhythms of the heart, particularly abnormal rhythms caused by damage to the conductive tissue that carries electrical signals or abnormal rhythms caused by electrolyte imbalances. For example in myocardial infarction the ECG can identify if we have a heart muscle that is been damaged in specific areas, even not all heart areas can be covered. Unfortunately, ECG is not reliable for measuring the pumping ability of the heart for which ultrasound-based or nuclear medicine tests are used. It might be possible to have cardiac arrest but still have a normal ECG, the known pulseless electrical activity condition [2].

### **2.3 Placement of electrodes**

Ten electrodes are used for a 12-lead ECG. They are placed on the patient's body as below [2], see fig. 2.2.1.

RA: On the right arm, avoiding thick muscle.

LA: In the same location that RA was placed, but on the left arm.

RL: On the right leg, lateral calf muscle

LL: In the same location that RL was placed, but on the left leg.

V<sub>1</sub>: In the *fourth* intercostal space (between ribs 4 & 5) just to the *right* of the sternum (breastbone).

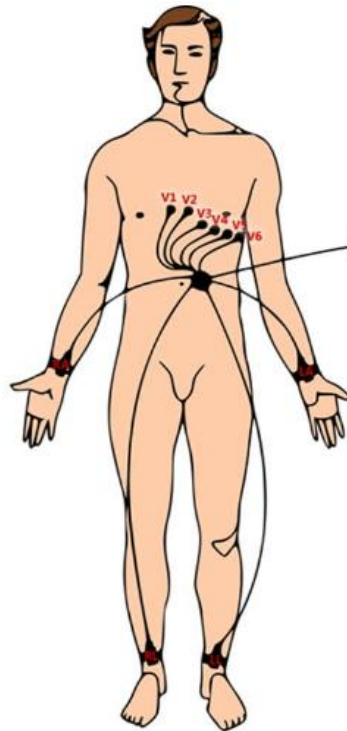
V<sub>2</sub>: In the *fourth* intercostal space (between ribs 4 & 5) just to the *left* of the sternum.

V<sub>3</sub>: Between leads V<sub>2</sub> and V<sub>4</sub>.

V<sub>4</sub>: In the fifth intercostal space (between ribs 5 & 6) in the mid-clavicular.

V<sub>5</sub>: Horizontally even with V<sub>4</sub>, but in the anterior axillary line.

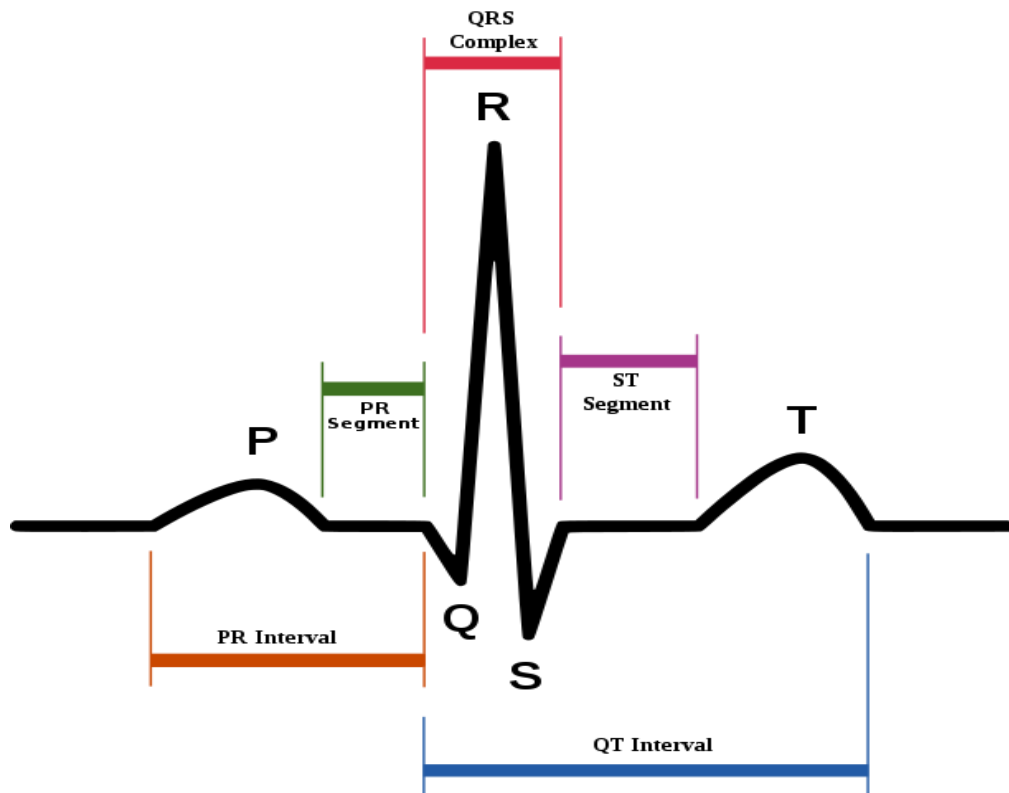
V<sub>6</sub>: Horizontally even with V<sub>4</sub> and V<sub>5</sub> in the midaxillary line. The midaxillary line is the imaginary line that extends down from the middle of the patient's armpit.



Reference 2.3.2: ECG Leads

## 2.4 Characteristics of Norma ECG

The normal ECG is composed of a P wave, a QRS complex and a T wave. The P wave represents the electrical impulse travelling across the atria of the heart. Abnormalities of the P wave, therefore, reflect abnormalities of the right and/or left atrium. The QRS complex represents the electrical impulse as it travels across the ventricles. Abnormalities of the QRS are often seen when there has been prior damage to the ventricular muscle, such as in a prior myocardial infarction (heart attack.) The "T" wave represents the recovery period of the ventricular muscle after it has been stimulated ref. Fig 2.4.1, ref. Fig 2.4.2 [3].



Reference 2.4.1: Normal ECG

The portion of the ECG between the QRS complex and the T wave is called the ST segment. Abnormalities of the ST segment and the T waves are often seen when the heart muscle is ischemic - that is, when it is not getting enough oxygen, usually because there is a blockage in a coronary artery.

The P – waves starts before the QRS complex.

The P – R Interval is a reflection of the length of time the atrium takes to pump blood from the atrium to the ventricle. The P – R interval starts with the beginning of the P wave and ends with the beginning of the QRS complex. Its length varies based on the heart rate and the function of the AV node. Atrial contraction begins at the peak of the P wave and continues to the beginning of the QRS complex. At this point the atrioventricular valves (mitral and tricuspid) close. Blood is trapped in the ventricle with all valves closed. The pressure rises.

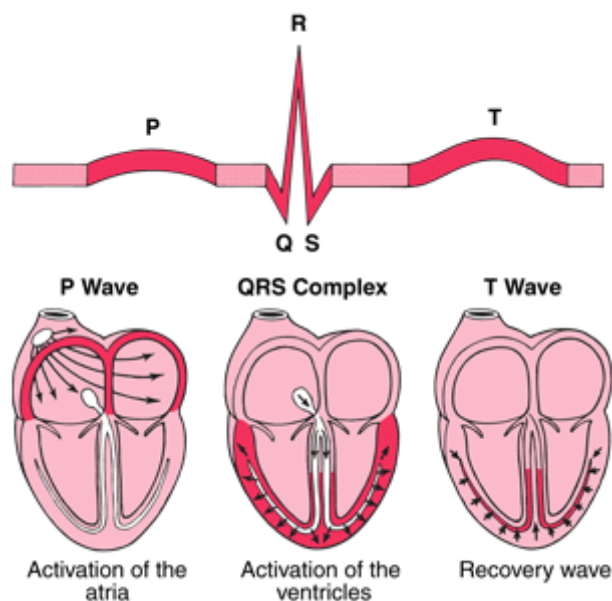
The QRS complex represents depolarization of the ventricle. Ventricular contraction corresponds to the peak of this complex and continues through the ST segment and the T wave. Pressure builds in the ventricle until the semilunar valves (aortic and pulmonic) open. Blood rushes out with the ventricular contraction and the pressure in the ventricle

drops. The aortic and pulmonic valves close. The semilunar valves open at the onset of the ST segment. The semilunar valves slam shut at the conclusion of the T wave [5].

QT interval is measured from the beginning of the QRS complex to the end of the T wave. A prolonged QT interval is a risk factor for ventricular tachyarrhythmias and sudden death. It varies with heart rate and for clinical relevance requires a correction for this [5].

The PR segment connects the P wave and the QRS complex. The impulse vector is from the AV node to the bundle of His to the bundle branches and then to the Purkinje Fibers. This electrical activity does not produce a contraction directly and is merely traveling down towards the ventricles and this shows up flat on the ECG. The PR interval is more clinically relevant.

The ST segment connects the QRS complex and the T wave. The ST segment represents the period when the ventricles are depolarized.



Reference 2.4.2: Normal ECG [4]

## 2.5 ECG Rhythms

Arrhythmia we define every heart rhythm disruption that disorder (eg the appearance of some emergency cardiac contractions) or heart rate, whether the decrease (bradycardia) or higher (tachycardia) beyond the normal range. Arrhythmias occur mainly in middle age and the likelihood increases with age. This does not exclude adolescents or young adults, although the etiology varies by age group. The cause, however, is not always detectable and certainly an arrhythmia not always conceals a heart problem.

An arrhythmia may not be felt by the patient, but can be found from a preventive check. Sometimes it can take the form of "fluttering" or chest accompanied by dyspnea, substernal pain, dizziness or unconsciousness. Of course there are cases that leads directly into cardiac arrest and, if not mediate direct effects (cardiopulmonary resuscitation, defibrillation) to death. As a general principle, however, here is concern that the patient should be commensurate with the severity of symptoms, taking into account and their medical history.

The electrocardiogram (ECG), if done during the arrhythmia, it can detect and provide us with sufficient evidence to its nature. However, since the arrhythmia may be transient and not displayed during the test, they are and other methods such as exercise stress test and 24-hour heart rhythm in order to check patient heart [7].

### 2.5.1 Normal Sinus Rhythm (NSR)

In a normal heart rhythm, the sinus node generates an electrical impulse which travels through the right and left atrial muscles producing electrical changes which is represented on the electrocardiogram (ECG) by the p-wave. The electrical impulse then continues to travel through specialized tissue known as the atrioventricular node, which conducts electricity at a slower pace. This will create a pause (PR interval) before the ventricles are stimulated. This pause is helpful since it allows blood to be emptied into the ventricles from the atria prior to ventricular contraction to propel blood out into the body. The ventricular contraction is represented electrically on the ECG by the QRS complex of waves. This is followed by the T-wave which represents the electrical changes in the ventricles as they are relaxing. The cardiac cycle after a short pause repeats itself, and so on ref. Fig. 2.5.1.1 [6].

#### Characteristics:

**Rate:** 60-100 per minute

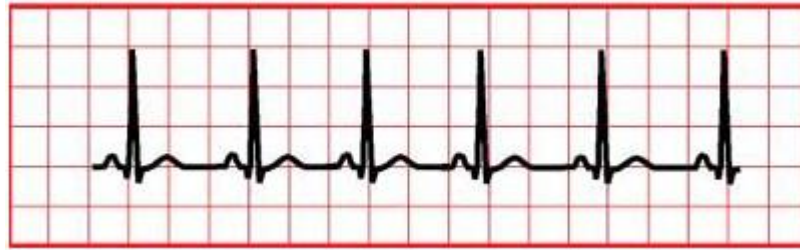
**Rhythm:** R- R =

**P waves:** Upright, similar

**P-R:** 0.12 -0 .20 second & consistent

**qRs:** 0.04 – 0.10 second

**P:qRs:** 1P:1qRs

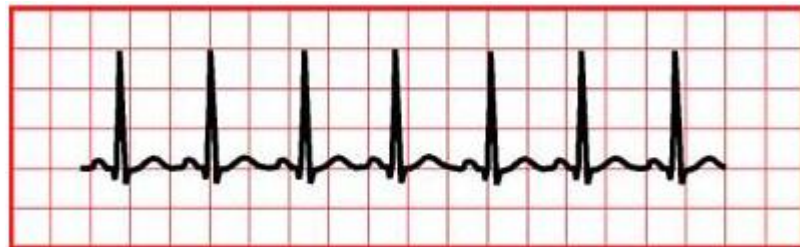


Reference 2.5.1.1: Normal Sinus Rhythm

### 2.5.2 Fast Heart Rate (Tachycardia)

This means that the impulse generating the heart beats are normal, but they are occurring at a faster pace than normal. This is termed sinus tachycardia and is seen normally with exercise, fever, anxiety, hypovolemia, hypoxia, myocardial infarction, and responses to stimulant drugs [5], [6].

Supraventricular tachycardia (SVT). In this abnormal heart rhythm the impulse stimulating the heart is not generated by the sinus node, but instead comes from a collection of tissue around and involving the atrioventricular (AV) node. These electrical impulses from this abnormal site are generated at a rapid impulse, which may reach 280 beats per minute ref. Fig. 2.5.2.1 [6].



Reference 2.5.2.1: Supraventricular tachycardia

In this abnormal rapid heart rhythm the abnormal tissue generating the rapid heart rate is also in the atria, however, the atrioventricular node is not involved. Since the atrioventricular node is slow conduction tissue and it is not involved in this type of abnormal heart rhythm the heart rate in this case (atrial flutter) would be faster than that in supraventricular tachycardia where the atrioventricular node is involved in generating the abnormal heart rhythm and will cause it to be slower ref.fig.2.4.2.2 [6].

#### Characteristics:

**Rate:** > 100

**Rhythm:** R- R =

**P waves:** Upright, similar

**P-R:** 0.12 -0.20 second & consistent

**qRs:** 0.04 – 0.10 second

**P:qRs:** 1P:1qRs



Reference 2.5.2.2: Atrial flutter

### 2.5.3 Slow Heart Rate (Sinus Bradycardia)

The heart may slow down, yet maintain the normal pattern of rhythm. In this case the heart rate can be less than 60 beats per minutes. In a case of athletes in some case it might be normal, but on other cases it may be due to vagal stimulation, sleep, ischemia to the SA node, beta blockers, digitalis toxicity, increased ICP [5, 6] ref. Fig. 2.5.3.1.

#### Characteristics:

**Rate:** < 60

**Rhythm:** R- R =

**P waves:** Upright; similar

**P-R:** 0.12 -0.20 second & consistent

**qRs:** 0.04 – 0.10 second

**P:qRs:** 1P:1qRs



Fig 2.5.3.1: Slow Heart Rate

### 2.5.4 Atrial Flutter

Is an abnormal heart rhythm that occurs in the atria of the heart. When it first occurs, it is usually associated with a fast heart rate or tachycardia (beats over 100 per minute), and falls into the category of supra-ventricular tachycardia's. While this rhythm occurs most often in individuals with cardiovascular disease ,Hypoxia, Acute MI, Dig Toxicity, Mitral or Tricuspid valve disease, Pulmonary embolism [2,5] ref fig 2.4.4.1.

#### Characteristics:

**Rate:** Atrial rate 250-350 Vent 150 common

**Rhythm:** Atrial = Regular, Vent = Reg. or irregular

**P waves:** Not identifiable

**F waves:** Uniform (sawtooth or picket fence )

**PRI:** not measurable

**qRs:** 0.04 – 0.10 second



Reference 2.5.4.1: Atrial Flutter

### 2.5.5 Atrial Fibrillation

Is the most common cardiac arrhythmia, irregular heart beat. It may cause no symptoms, but it is often associated with Ischemic heart disease, Hypoxia, Acute MI, Digitalis toxicity, Mitral or tricuspid disease. Heart rate will be greater than 100 beats per minute. Blood pressure will be variable, and often difficult to measure as the beat-by-beat variability causes problems for most digital non-invasive blood pressure monitors. It may be identified clinically when taking a pulse and the presence of AF can be confirmed with an electrocardiogram (ECG) which demonstrates the absence of P waves together with an irregular ventricular rate[2,5] ref fig. 2.5.5.1.

#### Characteristics:



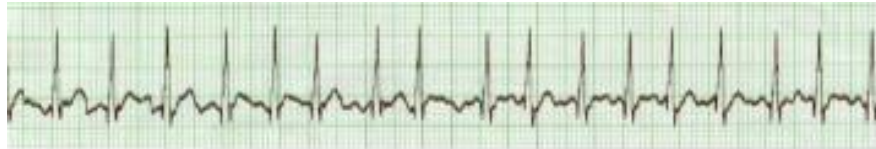
**Rate:** Atrial: 400-700, Vent. 160-180/minute

**Rhythm:** Atrial: irregular; ,Vent.: irregular

**P waves:** No identifiable Ps

**f waves:** may be seen.

**PRI:** unable to measure, No identifiable P



Reference 2.5.5.1: Atrial Fibrillation

# Chapter 3 System Requirements

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- 3.1 Introduction
  - 3.2 Programming Language and Tools
  - 3.3 Network and Communications
  - 3.4 Smartphone's
  - 3.5 Medical Devices
  - 3.6 System Operations and Functions
- 

## **3.1 Introduction**

In this section we will be concentrating to the technologies that we use in order to complete the thesis. We will concentrate in the programming language that is going to be used, the communications protocols that were used, and the devices that we use in order to complete the thesis. Furthermore on the communication between the device application and the main server.

## **3.2 Programming Language and Tools**

The programming tool that will be used for the implementation of the system both for patient portal and doctor portal will be eclipse using the Android Development Tools (ADT) Plugin [30]. Is an open source community that develops open platforms and products. It includes all the necessary libraries for simple projects. It gives the ability to the user to create the form and the design of the application. The application will be using Android Platform 2.3.3 with API Lever 10. For the implementation of the cardiac plot we will use the Android Plot library in witch is a Java API for creating dynamic and static charts within an android application. This library is build exclusively for the Android platform [8].

The system will be developing for Android devices. Android is a software stack for mobile devices that includes an operating system, middleware and key applications. The Android

SDK provides the tools and APIs necessary to begin developing applications on the Android platform using the Java programming language.

### **3.3 Networks and Communications**

#### **3.3.1 Wi-Fi Network**

Wi-Fi is a popular technology that allows an electronic device to exchange data wirelessly using radio waves over a computer network, including high-speed Internet connections [35]. Devices that include Wi-Fi such as a personal computer, Smartphone, etc, can connect to the internet using a wireless network access point. Connecting the devices with a Wi-Fi network gives the ability to the user to use several functionalities of the internet if the device supports those functionalities. Such functionality is the VoIP, it gives the ability to the user to make telephone calls through internet using some tools.

A Wi-Fi-enabled device can connect to the Internet when within range of a wireless network connected to the Internet. The coverage of one or more (interconnected) access points—called hotspots—comprises an area as small as a few rooms or as large as many square miles. Coverage in the larger area may depend on a group of access points with overlapping coverage. Wi-Fi allows cheaper deployment of local area networks (LANs). Also spaces where cables cannot be run, such as outdoor areas and historical buildings, can host wireless LANs. Manufacturers are building wireless network adapters into most laptops [11].

The main issue with wireless network security is its simplified access to the network compared to traditional wired networks such as Ethernet. Most business networks protect sensitive data and systems by attempting to disallow external access [36]. Enabling wireless connectivity reduces security if the network uses inadequate or no encryption. An attacker who has gained access to a Wi-Fi network router can initiate a DNS spoofing attack against any other user of the network by forging a response before the queried DNS server has a chance to reply [11].

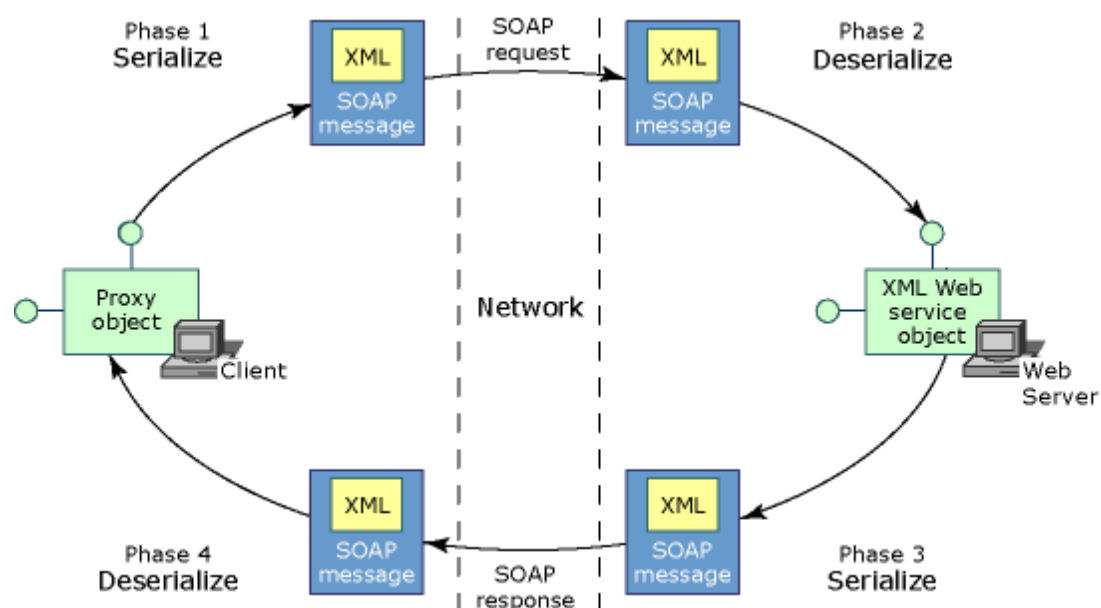
#### **3.3.2 Bluetooth**

Bluetooth is a proprietary open wireless technology standard for exchanging data over short distances (using short-wavelength radio transmissions in the ISM band from 2400-2480 MHz) from fixed and mobile devices, creating personal area networks (PANs) with high levels of security. Bluetooth uses a radio unlicensed technology called frequency-hopping spread spectrum, which chops up the data being sent and transmits chunks of it on up to 79 bands (1 MHz each; centered from 2402 to 2480 MHz) in the range 2,400-2,483.5 MHz (allowing for guard bands).

A master Bluetooth device can communicate with a maximum of seven devices in a piconet an ad-hoc computer network using Bluetooth technology, though not all devices support this limit. At any given time, data can be transferred between the initial device and one other device [10].

### 3.3.3 Web Services

A Web service is a method of communication between two electronic devices over the web. The W3C defines a "Web service" as "a software system designed to support interoperable machine-to-machine interaction over a network". It has an interface described in a machine-processable format (specifically Web Services Description Language, known by the acronym WSDL) [12]. Other systems interact with the Web service in a manner prescribed by its description using SOAP messages or KSOAP for Android platform, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards [37] ref fig 3.3.3.1.



Reference 3.3.3.1 [31]

SOAP, originally defined as Simple Object Access Protocol, is a protocol specification for exchanging structured information in the implementation of Web Services in computer networks. It relies on Extensible Markup Language (XML) for its message format, and usually relies on other Application Layer protocols, most notably Hypertext Transfer Protocol (HTTP) and Simple Mail Transfer Protocol (SMTP), for message negotiation and transmission. SOAP can form the foundation layer of a web services protocol stack, providing a basic messaging framework upon which web services can be built [9] ref fig 3.3.3.1.

### 3.4 Smartphone's

A Smartphone is a mobile phone built on a mobile computing platform, with more advanced computing ability and connectivity than a feature phone. The Android operating system for Smartphone was released in 2008. Android is an open-source platform backed by Google, along with major hardware and software developers [13].

The current ECG Application will be develop using HTC Desire. The operating system that is using is Android OS 2.1 upgraded to Android 2.3 (Gingerbread). The phone uses a 1 GHz ARMv7 "Snapdragon" processor, WLAN Wi-Fi 802.11 b/g, Bluetooth v2.1 with A2DP. Display screen type AMOLED or SLCD, 16M colours Size 480 x 800 pixels, 3.7 inches with touch screen [14] ref fig. 3.4.1.



Reference 3.4.1: HTC Desire

### 3.5 Medical Devices

Dyna-Vision is a high-quality medical device used to collect record and transmit a range of vital signs. These can be monitored in real-time using software on a computer, tablet PC or Smartphone. The Dyna-Vision unit is classified as a class IIb medical device and is allowed for use in intensive care environment. The patient is connected using sensors and cable wires.

The units are used on patients that need to be monitored in hospitals, at home, while travelling or during transportation in ambulances.

The device has the ability to collect ECG up to 12 leads (3, 5, 12 leads). Also can record heart rate, plethysmogram, heart oxygen and record up to 100 samples per second [15] ref. Fig. 3.5.1.



Reference 3.5.1: Dyna-vision device

### 3.6 System Operations and Functions

#### 3.6.1 Patient Functionality

Patient will have to gather his/her vital information's according to the doctor advice. The system will be placed on the patient house. That information's will be uploading to the Application Server that is hosting the database. In order to upload the patient data the system will have built in a function that will work with the web service of the Application Server. The methods that are being using inside the web service in order to upload the data to the server are: AddBloodPressure in which is be used in order to send the data of blood pressure. The AddECGAnalyzed12Lead, AddECGAnalyzed3Lead and AddECGAnalyzed5Lead in order to send the patient ECG according to the leads that were selected. AddHeartRate to send patient heart rate. The AddOxygenSaturation for uploading the Oxygen Saturation, the AddPlethysmogram for sending the patient Plethysmogram and the AddWeight for patient weight.

Furthermore the user has the functionality of Stand Alone Mode. By selecting this mode user will be able to collect all the vitals information's that are needed, to be view on the display screen but will not be able to upload the data on the Database server.

### 3.6.2 Doctor Functionality

On the other side, on the Doctor side, the Doctor has the ability to view the information's of the patient. Using the web service that is located on the Server will download the data for a certain patient selecting what information's will be downloading and then display that information on the graph of its Smartphone.

The web services functions that are going to be used are: getBatchTimeStamps it will display all the dates and times that the certain patient upload data on the server database. The getBloodPressure will download the patient Blood Pressure. getEcgAnalyzed function according what the doctor has define on the leads with download the values for the appropriate leads. The getHeartRate will provide to the doctor the Heart Rate values. The getOxygenSaturation it download the Oxygen Saturation. Moreover the getPlethysmogram will download the Plethysmogram values and last the getWeight it download the patient weight.

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# Chapter 4 Analysis of Previous Work

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4.1 Introduction

4.2 Previous Systems

4.3 Compare existing systems with proposed system

4.4 Development of existing system

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## 4.1 Introduction

In this section we will analysis previous jobs upon this subject. A small research about other systems or papers that strengthen our opinion on mobile ECG for distance medical care. Beside we will analyze the functionalities of previous systems that take in mind in order to build the new system and what are the changes that were made in order to increase the functionalities and to be more useful.

## 4.2 Previous Systems

### 4.2.1 AliveCor

AliveCor is an ECG system design explicit for iPhone v4 device. For the capture of the heart rate of the patient it using an iPhone device and a low power, wireless case of the iPhone that it clips on it, turning the iPhone to a wireless clinical cardiac recorded device. The cover contain two electros that are be using by holding your hands on it or by adding the phone on your chest. Beside that there is and the iCard compatible version for iPhone v3 [18]. The iCard is not connected with a Bluetooth session but is connected directly to the iPhone device ref fig 4.2.1.1.

The certain device can be used from anyone in order to record their ECG live. After recording that information's they can be turned into a pdf that can be sent to any doctor anywhere in the world, in which what cardiac patients need is. Beside that can be used as a feedback device for people that want to train them self to relax on getting their heart rate down.





Reference 4.2.1.1 iPhone connected with iCard

#### 4.2.2 Human++ BAN

Dutch researchers have hacked electrocardiogram (ECG) sensors to Android phone using an ultra-low-power short-range network. The app tracks & displays the Live readings with a pretty graph of your own heart activity. The graph's behaviour is monitored by the application and the application can take actions when it thinks it the time. If your heart stops or lags for a bit, the app can immediately contact a doctor, or the emergency services, via Wi-Fi or 3G.

It aims to achieve highly miniaturized and autonomous sensors systems that enable people to carry their personal body area network. The body area network will provide medical, lifestyle, assisted living, sports or entertainment functions. The system is using low consumption sensors for electrocardiogram. Those sensors monitor the activities of the organs of the patient and transmit the data to a hub or on the patient device. Furthermore the results are sending to the doctor and also alarm can sound in order to notify the patient that something is not well and need to return to the normal health position.

In addition, app can support other sensors that can attach easily with Body Area Network. With the right straps, electroencephalogram is also made possible, and the app would track changes in your neurological condition. The app can be extended, as per the authors, to even support other medical checkups like blood Pressure, sugar levels, etc [19] ref. Fig. 4.2.2.1.

According to the researches the only problem is that is working with Bluetooth transmission. This is has as a disadvantage to squeeze the battery just in one day. The next step of the project is to use low power transmitter with a combination with the sensors.



Reference 4.2.2.1: ECG Human++ BAN

#### 4.2.3 Post-Cardiosurgery Home Monitoring System

The Post-Cardiosurgery Home Monitoring System is one of the systems that we will have in mind in order to develop our system. Some of the functionalities that have been implementing and implemented on later stages will be used again in our system.

The system collects the vital information's that is necessary that the doctor may review his/her patients. Additionally more information's are collected according the patient, demographic information's, medical background, hospitalization information's, calls and visits, questionnaire that is answered before and after the treatment. Additionally to this, the system includes some typical functionality that makes it more usefulness. Those are the user management, patient information, and last but not least the patient vital information report and graph.

Monitoring of the patients is being done through a web site when patient is at home. This is being done in order to provide better life support for patients that have cardiac surgery. Those patients need to be monitor for a certain period of time and using this application gives the ability to the patient not to be moving to the hospital every day.

Despite the facts that is a very useful and a great system it can be used only from doctors. An external system have to be develop in order to collect the vital information of the patient, ECG, weight, blood pressure and oxygen saturation and send them automatically to the doctor [20] ref. Fig. 4.2.3.1.

The screenshot displays the 'Patients' e-Health System interface. At the top, there is a navigation bar with a home icon, the system name 'Patients' e-Health System', the user name 'Panayiota', and a 'Logout' button. A left-hand navigation menu includes options like Home, Patients, Medical Background, Hospitalization List, Calls & Visits, Questionnaire, Follow UP, Vital Info, View ECG, ECG Analysis Details, Scores, Scores Chart, My Account, Change Password, Help, About, and Contact us.

The main content area is titled 'Home' and features a large ECG waveform visualization. Below this, there are three data tables:

- Electrocardiography - ECG**: A table with columns for Date, AHI ID, Name, Telephone, and View. It lists several ECG records from 2011-04-02.
- Patients' Oxygen Saturation**: A table with columns for Date, Name, Oxygen Sat., and View. It shows oxygen saturation levels for various dates in 2011.
- Patients' Blood Pressure**: A table with columns for Date, Name, Sys., Dis., and View. It displays blood pressure readings for 2011.
- Patients' Weight**: A table with columns for Date, Name, Weight, and View. It shows a weight record for 02/04/2011.

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Designed by Giorgos Matheou and Panayiota Chimonidou

### Reference 4.2.3.1: Patient Portal

## 4.2.4 PatMon -DocMon

### 4.2.4.1 PatMon

PatMon application is a widow's personal computer application. It can be installing on a patient personal computer and be used at home without need to be in the hospital every day. Patient captures the vital information that is needed and uploads them on the application server. This application is very easy because it help the user step by step what must be done. It connect with a Bluetooth device on an ECG device, receive the data from the ECG device and then with a Wi-Fi network it upload all the data to the server.

The application can collect using some advance devices the vital information's of the patient that are necessary for the medical stuff. That vital information's are the ECG 3-12 leads, weight, blood pressure, oxygen saturation, plethysmogram, and heart rate. According to the record time the application will start record and save those information's in order to send them to the doctor.

Despite the advantage of PatMon it lags into one thing. During the upload of the patient information it makes the analysis of the patient ECG. Upon this, the system slow down and it takes a long time until it upload the data to the server due to the huge volume of data. It should be more preferable the analysis to be done on the application server than on the patient station in order for the patient to save time [21] ref. fig. 4.2.4.1.1.

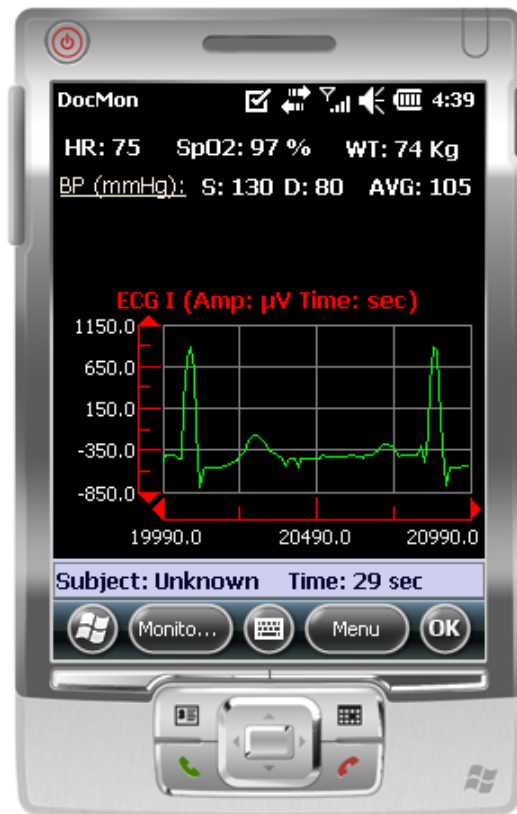


Reference 4.2.4.1.1: PatMon

#### 4.2.4.2 DocMon

DocMon is exclusively doctor application. Is an application only for Windows mobile devices. The main function of this application is the representation of all biosignals of the patient in a centre screen. The doctor through a web-service can download the vital information's of a certain patient and display them on a graph. On the other hand it does not have the ability to display more than one plot in the graph each time [21] ref. Fig. 4.2.4.2.1.

Can download all the vital information's of the patient according to the need of the doctor the information's that can be seen from the doctor are the ECG 3-12 leads, weight, blood pressure, oxygen saturation, plethysmogram, and heart rate.



Reference 4.2.4.2.1: DocMon

#### 4.2.5 Multicenter randomised trial on home-based telemanagement to prevent hospital readmission of patients with chronic heart failure

The aim of the study was to determine whether a home-based telemanagement (HBT) programme in CHF patients decreased hospital readmissions and hospital costs in comparison with the usual care (UC) follow-up programme over a one-year period.

Four hundred-sixty CHF patients (pts), aged  $57 \pm 10$  years were randomised to two management strategies: 230 pts to HBT programme and 230 pts to UC programme. The HBT pts received a portable device, transferring, by telephone, a one-lead trace to a receiving station where a nurse was available for interactive teleconsultation. The UC pts were referred to their primary care physicians and cardiologists. The primary objective of the study was one-year hospital readmission for cardiovascular reasons. The rate of hearth failure-related readmission was 19% (43 pts) in HBT group and 32% (73 pts) in UC group. After adjusting for clinical and demographic characteristics, the HBT group had a significantly lower risk of readmission compared with the UC group. This study suggests that one-year HBT programme reduce hospital readmissions and costs in CHF patients [22].

#### 4.2.6 A new telemonitoring system intended for chronic heart failure patients using mobile telephone technology — Feasibility study

The main purpose of the study was to propose of a new wireless telemonitoring system via a mobile network for patients in chronic heart failure. System may help to detect early signs of cardiac decompensation, allowing optimization of and adherence to treatments in chronic heart failure. With other studies the telemedical support was online only in office hours in which were limit efficacy. On the certain study was setup a dedicated telemedical centre that was provide service 24 h a day 7 days a week.

Patients that were selected have to fill in some criteria's. They have to be greater than 18, they were in New York Heart Association call II or class III with a left ventricular ejection fraction  $\leq 35\%$ . Besides that, they have to have at least one episode of decompensation in the previous 24 months with hospitalization.

The system that was used was installed on a personal digital assistant (PDA) using wireless Bluetooth system. In order for the system to function it required mobile phone network connection. Additional to that three devices are used in order to collect the electrocardiogram measurements, the blood pressure and the weight. All those three devices support Bluetooth in order to send the data to the PDA. After a collection of the information's the data where transmit through the mobile phone network where the measurements are organized and sent to the local servers of the respective telemedical centres.

Support centres where two telemedical centres that provide medical support 24/7 for the entire period. A structure telephone contact between the telemedical sentre and the patient was made once a month to discuss disease status, assess symptoms of depression, to instruct the patient about dealing with emergency situations and to solve any technical problems. Beside that each patient except from the PDA system was equipped with a landline-based personal response system for a fast and direct connection between the patient and the corresponding medical centre.

A clinical event committee blinded to treatment allocation assessed cause of death and reason for hospitalization. The primary endpoint was total mortality. The first secondary endpoint was a composite of cardiovascular mortality or hospitalization due to heart

failure. Other secondary endpoints included cardiovascular mortality, all-cause and cause-specific hospitalizations as well as days lost due to heart failure hospitalization or cardiovascular death, and changes in quality of life and NYHA class. Overall, 710 CHF patients were recruited. The mean follow-up was  $21.5 \pm 7.2$  months, with a minimum of 12 months.

#### 4.2.7 LifeLink

National Telehealth Initiative will try to provide to Philippine a telehealth system for remote consultations. This will done due to that Philippines has problems on medical care that are the low doctor to patient ration, the concentration of medical specialist in urban areas and the services of high expertise centres such as poisoning and trauma are difficult to be replicated in underserved regions due, that are resource intensive and expensive to maintain.

The benefits of, after the completion of the project will be affecting positive the medical benefits, economic benefits and technological benefits. In more details:

- Medical benefits:
  - toxin or trauma patients in rural test sites maximized by network coverage of K-Agrinet and MCT service communities
  - patients who can benefit from remote access to expert specialists in PGH
  - doctors involved in diagnosis because of their access to advanced bioinstrumentation
- Economic benefits:
  - government and university via eventual OFW use and Medical Tourism via patients
  - start-up entrepreneurs and biomedical companies (benefiting from domestic capabilities on ground-up design and construction of biomedical instrumentation)
- Technological benefits:
  - Philippine academic institutions, academic degrees for research students from NIP, DEEE and PGH;
  - Interdisciplinary research fields ranging from diagnostics to pathology

The project objectives are to develop an application the RxBox that collects health data from the patients and to establish an emergency care and coordinate service system at the UP Manila National Telehealth centre.

The RxBox will be used from health centres in which they will collect real-time remote monitoring data from experts on the centres. The steps on the online diagnostic questions will be helping the medical staff in the diagnose of the patient. The RxBox will collect the ECG, Blood Pressure and Pulse-Ox that will be send using internet or GPRS and will be sending to the medical centres in order to be integrated on the system. The data will be displayed in real-time and analysed for the toxicology/trauma specialist. The specialist can be located either on the TeleCenter or remotely and connected from a Smartphone or a laptop. Visual inspection inspection could be established from the RxBox camera. Audio will be used for streamed the voice or sound of heart, lungs or any other abdominal sounds for more analysis.

Remote health facilities will use an electronic health record system to manage their patients information's and this will be connected to the central operation centre when there is a need to refer a patient to a higher level facility.

#### RxBox Objectives

1. To develop the necessary communications protocols for the Rx Box to transmit data. The test beds shall be situated in rural and urban poor communities from which health signals (sensor readings, video streaming, consultation and heart/lung sounds) shall be transmitted via internet, SMS, MMS and GPRS to remote medical specialists for evaluation.
2. To combine hardware and software protocols to enable multimedia streaming throught internet for remote video consultation and emergency intervention for the following servicers.
  - Remote real-time monitoring of health and biological signals
  - Audio-video remote medical consultation and diagnosis
  - Electronic health-information collection, analysis and reporting
  - Research and electronic statistical health analysis
  - Interoperability and mobility of systems and operations
  - Wireless telemicroscopy for microdiagnostics of TB and Dengue

### **4.3 Compare existing systems with proposed system**



The main goal of all the previous systems is to improve the lifestyle of the patient that suffers from heart problems. All the system that was described previous they invent applications in order to monitor from distance the patient. They try using technology devices to reduce admissions times to hospitals. They provide technology to the patient such as Smartphone, personal computers, sensors, PDA and on doctor site web-services and systems that analyse cardiac rhythms. According to chapter 4.2.5 using technology for distance monitor of the patient reduce the cost from both part of patient and hospitals but more important reduce the readmission of patient to hospitals. Beside that on chapter 4.2.6 remote patient management using PDA and external devices for collecting the information's can help to detect signs of cardiac decompensation, allowing optimization of and adherence to treatments in chronic heart failure (CHF). They have suggest that telemedicine in CHF can reduce mortality by 30–35%. The aim of the TIM-HF study was to investigate the impact of telemedical management on mortality in ambulatory CHF patients.

My goal is to implement an application that will be suitable for remote medical monitor, which have a cardiac surgery. The system that will be implementing will be upon the existing system that is discussed on chapter 4.2.4., that was based on system that is discuss on chapter 4.2.3. The system is using two different devices for monitor distance the patients. User will be using the PatMon that need a personal computer device and doctor will be using the DocMon that you need Windows Mobile Smartphone Device. Our goal is to merge those two systems in one device with the same OS of the device. The OS that the new system will be implementing is Android. This must be done due to that Windows Mobiles are being replaced from Android OS which is open source OS. The system that we have implement is already using advance technologies such as Smartphone's, web-services, ECG devices etc. The difference with others is that does not provide support 24/7 due to that, the patient will collect all the vitals information's that are required and using advance technologies the data will be send to a dedicated server and from there the appropriate medical personnel using the same application will be able to view the results. Another advantage that some of the previous systems that do not implemented are the leads that can support. Some of them could only support only until 3 leads, with the patient weight and the heart rate, but in our system we can support up to 12 leads, patient weight, heart rate, blood pressure, oxygen saturation and plethysmogram.

## 4.4 Development of the existing System

My project is upon the current functionality of an existing system in order to develop it in for a different OS. The project Post-Cardio surgery Home Monitoring System was developed in phase 1 from Panagiota Ximonidou, and on phase 2 from Giorgos Matheou. On this chapter it will be explain what has be done until now and what I will implement.

### 4.4.1 Overview of existing system

The system will be consisting from the follow systems, the application server, the Patient Portal the ECG Analysis server and the ECG archive server. The Application server is web service that is responsible for save all the data on the database of the server or for retrieve any data. The Patient Portal is web site responsible for the representative of patients ECG analysis, patient weight, oxygen saturation, blood pressure, plethysmogram and heart rate. More over it can provide information's according the patient, such as medical information's, or personal details, etc. Also can register new patients or doctors on the system, completion of questionnaire from the patient, etc.

Beside that the PatMon it provides the ability to the patient to record the ECG rhythms. The application is a windows based application for personal computers. Patient can connect to the different external devices that are required to, in order to collect the ECG, heart rate, oxygen saturation, blood pressure, weight, and plethysmogram. According to the selected recorded time the application will start record the data and by the end of that period will upload the data to the database of the Archive Server. PatMon can record up to 12 leads, function that other application's cannot support it.

Furthermore the DocMon application is the corresponding application for doctors and medical personnel. DocMon is windows mobile application that does not support any other OS. The medical personnel will be able using the web-service to download the vital information's of the patient for a certain date and time and preview them on the device. The ECG will be plot on the graph in order for the doctor to make the analysis and provide to the patient the appropriate feedback.

#### 4.4.2 New System

From the existing system nothing will be change, but upon the existing system the new one will be create for different platform. The new system must cooperate with the existing system such as the Application Server and Database Server. Will use the web-services from the Application in order to add functionalities for saving data and retrieve data from the Database Server. Furthermore, from the existing system the CardiacPortal will be use in order to validate that data are upload in the database correct and that, the display of the data are correct concerning the new application draw and CardiacPortal display. The new system will have the functionalities of DocMon and PatMon.

PatMon was gathering all the vital information's of the patient, patients ECG, weight, oxygen saturation, blood pressure, plethysmogram and heart rate. In order to collect the ECG will connect with Bluetooth to a dedicated device and retrieve the information's. Our application has the ability to collect up to 12 leads. Beside that it supports the reconstruction of plethysmogram. Also due to that the connection between two Bluetooth devices is configure and set properly will be easy for the future to add other dedicated devices in order to capture other vital information's. Moreover when all the vitals information's are collected the on the main screen the graph will start display the data on the plot. At the end of the process the data will be upload on the Database Server using the functions of the web-service.

DocMon was the Doctor portal side. Was able to download and review the vital information's that were sending from the patient to the database server. Doctor just has to select the desire information's that need and retrieve them from the server. Upon this idea on our application the doctor portal will be working. DocMon could only provide the graph for one ECG each time. In our application we manage to pass this problem. According the leads that has select previous from the settings and the other selection can display simultaneous the same time on the graph 3 leads, 5, or 12 leads, or it can display the heart rate, the weight , oxygen saturation, or plethysmogram. Additional, doctor would be able to resume the same graph without needed to download again the data from the server. Also it can pause the graph and move back or forward on the plot and with the resume button to start again from the step that was moved.

Besides that, PatMon and DocMon were working on Windows personal computer and Windows Mobile Device respectively. The new system will be working on Android OS. This is being done due to that Android is a very promising OS with a dramatic increase of devices that Android is installed. The application will be function on Android devices such as Smartphone, tablet, notebooks. Despite that Android is an open source which allows a lot of programmers to play around and create their own applications, in which iOS and Microsoft does not provide such functionalities.

# Chapter 5 Analysis and System Specifications

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- 5.1 Introduction
  - 5.2 System Analysis
  - 5.3 Processes Flow Diagram
  - 5.4 Database Structure
  - 5.5 Design Phase
  - 5.6 Class Diagram
  - 5.7 Use Case Diagram
  - 5.8 Sequence Diagram
  - 5.9 Doctor and Patient Scenarios
- 

## 5.1 Introduction

A system requirements specification is a structured collection of information that embodies the requirements of a system [16]. The document must contain the problem, the system functionality and the rules that must be applied in order for the system to function normal. Upon that information the system will be design and implement.

With the implementation of the system we would like to solve the problem of patient with heart rate problems that need to attend to hospital every day. We will implement a system for distance monitor. The system must support ECG, heart rate, blood pressure, oxygen saturation, weight, and plethysmogram.

## 5.2 System Analysis

### 5.2.1 System Description

The system will be consisting of 4 different subsystems which are:

ECG Application (Android Device)

Application Server (Web Services)

CardiacPortalDB (MS-SQL Database)

Cardiac Portal (Web site)

#### 5.2.1.1 ECG Application (Android Device)

The system is compatible only with Android devices. It can be used both from doctors and patient according the privileges that each user has. The system identification is been used in order to provide to the user the appropriate privileges and redirect them to the appropriate portal mode, patient portal or doctor portal.

##### 5.2.1.1.1 Patient Portal

The main goal of patient site system is to collect the vital information's of the patient from the ECG device. The data that will collect are the ECG (3-12 leads), plethysmogram, blood oxygen, weight, heart rate and oxygen saturation. After the collection of the vital information's those data will be uploading to the CardiacPortalDB Database using the Application Server web-service. Beside that it include a device manager which it has the ability to connect to the devices such as Bluetooth Device or Wi-Fi network device. Moreover during the receiving of the data from the ECG device will have the ability to view the data on a graph in real time. Patient has the opportunity to set up the ECG device according to the instructions of the doctor. It can change the leads, heard rate values, oxygen saturation values, recording time, etc. Beside that patient can select the Stand Alone Mode that provides all the functionalities that the application can provide except that cannot send the information's to the Database Server. This can be selected from the user when the patient does not need to send the information's or is not able to connect to the network or a have a personal medical assistance.

##### 5.2.1.1.2 Doctor Site

On the other hand, due to that user is logged on the Doctor portal and is been authenticated from the system, user will be able to user the appropriate functionalities of the Doctor Portal mode. The main purpose of this function is to display the vital information's of the patient in a graph. Doctor will have to provide to the web-service the patient id number and it will return to the doctor all the date times for the selected patient. Those date times that will return they are depend from the settings that the doctor select, the leads that need to

preview and if patient has record the selected leads and upload them to the server. After doctor has select the date time that is required the vital information's of the patient are start to be download on the doctor device. When download has finish it will start loading the data on the application and on the device screen it starts the plod to be drawn. Doctor has the ability to setup what information's needs to be downloaded. Can select the type of ECG, if heart rate, plethysmogram, or oxygen saturations are needed.

#### 5.2.1.2 Application Server (web-service)

The application server is a web-service that gives the ability to the doctor and patient to retrieve and upload data to the server database respectively. The web-service it provides the authentication of the user (doctor, patient) and then according to the type of the user it provides access to the appropriate function in order to download or upload data.

The web service it provides the GET services in order for the Doctor to retrieve the data from the database that have to do with the patient. Also doctor can use the sendCredintialsToPatient service in order to send the credentials to the patient in order the application can be used from the patient and can login on the system. Beside that has the availability of recoverPassword service for receiving a new password for logged on the application. Doctor Portal mode uses the follow methods:

- getBatchTimeStamps
- getBloodPressure
- getEcgAnalyzed
- getHeartRate
- getOxygenSaturation
- getPatient
- getPlethysmogram
- getWeight
- recoverPassword
- UserLogin
- recoverPassword
- sendCredintialsToPatient

The ADD methods from the web-service are being using from the Patient Portal mode. There functionality is in order to provide them the ability to send the data to the Database of the CardiacPortalDB. Depend from the settings that have been configuring the ECG device the appropriate methods will be called in order to send the data. If patient does not select the Stand Alone Mode then the PatientLogin method will be raided in order to authenticate the patient with the database and allow to continue with the application.

- AddBloodPressure
- AddECGAnalyzed12Lead
- AddECGAnalyzed3Lead
- AddECGAnalyzed5Lead
- AddHeartRate
- AddOxygenSaturation
- AddPlethysmogram
- AddWeight
- PatientLogin

#### 5.2.1.3 CardiacPortalDB

The subsystem is the main database of the system. The database is divided into several tables according to the needs. The storage to ECG values is saved into 3 different tables. It has 1 table for each category of leads 3, 5 and 12 lead. Also there are tables to storage the patient weight, oxygen saturation, blood pressure, plethysmogram and heart rate. All tables are identifying by a unique key and the patient id in which it's connects to the patient table according the patient id. The CardiacPortalDB will be using the same from the previous system without any changes. This is being done due to that all the systems are need to cooperate. They are systems for different users with the same database. The CardiacPortalDB was re-designing on phase 2 from Giorgos Matheou and because it covers our needs nothing will be change.

#### 5.2.1.4 Cardiac Portal

Subsystem Cardiac Portal already exists from previous phase of development of the system. Was initially developed on phase 1 from Panagiota Ximonidou and on phase 2 from Giorgos Matheou. Cardiac Portal is a web site responsible for display patients vital



information's such as ECG leads, weight, blood oxygen, etc. Beside that can display several statistics base on patient vital information's and base on questioners that patient has answer. Furthermore it can provide the functionality to register new patients or doctors on the system. Also can displays several personal information's of the patient such as telephone, address, etc. The system in our project is been using in order to compare the results according the graph plot if is correct or not according the data that are upload on the Server Database.

## 5.2.2 Application Interface

### 5.2.2.1 Users Screens

- Screen 1: Initial Screen

This screen is display when the application is been started for both users. On this screen must select the appropriate user type, patient or doctor in order to forward them to the appropriate screen for login.

- Patient Portal Mode

- Screen 1.1: Initial Screen

In this phase user can select if would like to login on the system and continue as authenticated patient and be able to use all the functionalities of the system or if prefer to select the Stand Alone Mode without be able use full functionalities such as the upload function.

- Screen 1.2: Main Screen

On this screen patient will be able to view the vital information's on the graph, setup the ECG device, and use the devices.

- Screen 1.3: Setup ECG Device

Patient can setup the ECG device according to the needs or how is been ask from the appropriate medical personnel.

- Screen 1.4: Devices

Patient can connect from this screen to a Wi-Fi network or can connect with a Bluetooth to the ECG device and create a pair of connection.

➤ Screen 1.5: Send Data

When user is using the full functionality mode, after that vital information's are preview on the screen a menu appeared asking the user if prefer to send the data to the application server or not.

○ Doctor Portal Mode

➤ Screen 1.1: Initial Screen

In this phase user must add its personal credentials in order to login on the system and continue as authenticated doctor to be able to use the system otherwise will not be able to continue

➤ Screen 1.2: Recovery Password

In case that user has forgotten the password with this function can add the username on the fields. Then a random new password will be sending on the user email address.

➤ Screen 1.3: Main Screen

On this screen doctor will be able to view the vital information's on the graph, setup the settings for download, and use the devices.

➤ Screen 1.4: Settings

Doctor in this screen can select what data needs to be downloading in the device. According the selection the application will call the appropriate methods from the web-service.

➤ Screen 1.5: Send Credentials to Patient

Using this screen, doctor fill in the fields with the corresponding data and after a validation the credentials of the patient are send to the corresponding email that user add.

#### 5.2.2.2 Hardware Needs

For the needs of the project in order for the application to be functional we need the following device:

- We need an Android OS phone with Android 2.3 (Gingerbread). The phone uses a 1 GHz ARMv7 "Snapdragon" processor, WLAN Wi-Fi 802.11 b/g, Bluetooth v2.1 with A2DP. Display screen type AMOLED or SLCD, 16M colours Size 480 x 800 pixels, 3.7 inches with touch screen

#### 5.2.2.3 Communication Needs

For the needs concerning the communications are:

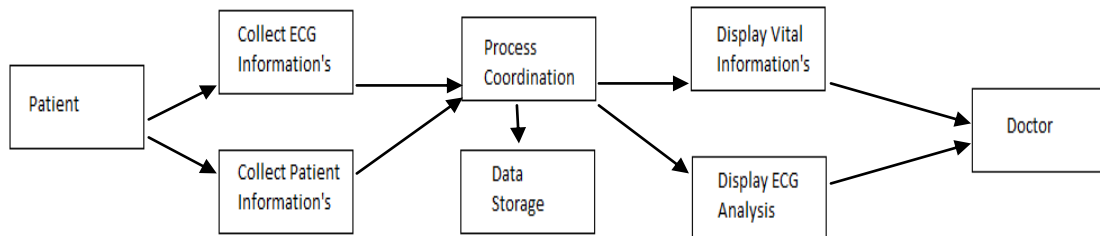
- Wi-Fi network
- Bluetooth

#### 5.2.3 System Limitations

- Memory  
According the memory on the android device, there must be at least 256 MB SD card. This is necessary due that both patient and doctor are using files that are saved on the memory disk.
- System  
The system needs the entire screen in order to be able for the user to view the data. Upon this the user will not be able to use any other application of the device.

### **5.3 Process Flow Diagram (PFD)**

A process flow diagram is a diagram commonly used to indicate the general flow of plant processes and equipment. The PFD displays the relationship between major equipment of a plant facility and does not show minor details such as piping details and designations ref. Fig 5.3.1.



Reference 5.3.1

### 5.3.2 Collect ECG Information's

ECG Information's are collected using the web-service. The web-service is accessible from the web, patient portal and doctor portal. Collections of data are sending and retrieve from the central unit. ECG information's are the ECG 3-12 leads, patient weight, blood pressure, oxygen saturation, plethysmogram and heart rate.

### 5.3.3 Collect Patient Information's

It gathers and uploads the patient details that are need in first entry on the system. The application is accessible from the web site.

### 5.3.4 Process Coordination

The main goal of the process is to collects all the information's from the patient and according to the type of each data to storage the data to the appropriate place calling the appropriate function to make the execution. It collects the ECG, blood pressure, heart rate, oxygen saturation, plethysmogram and weight.

### 5.3.5 Display ECG Analysis

After a request from the doctor do the Display ECG Analysis process according to the filter conditions it retrieve the appropriate data from the database the display them in the graph.

### 5.3.6 Display Vital Information's

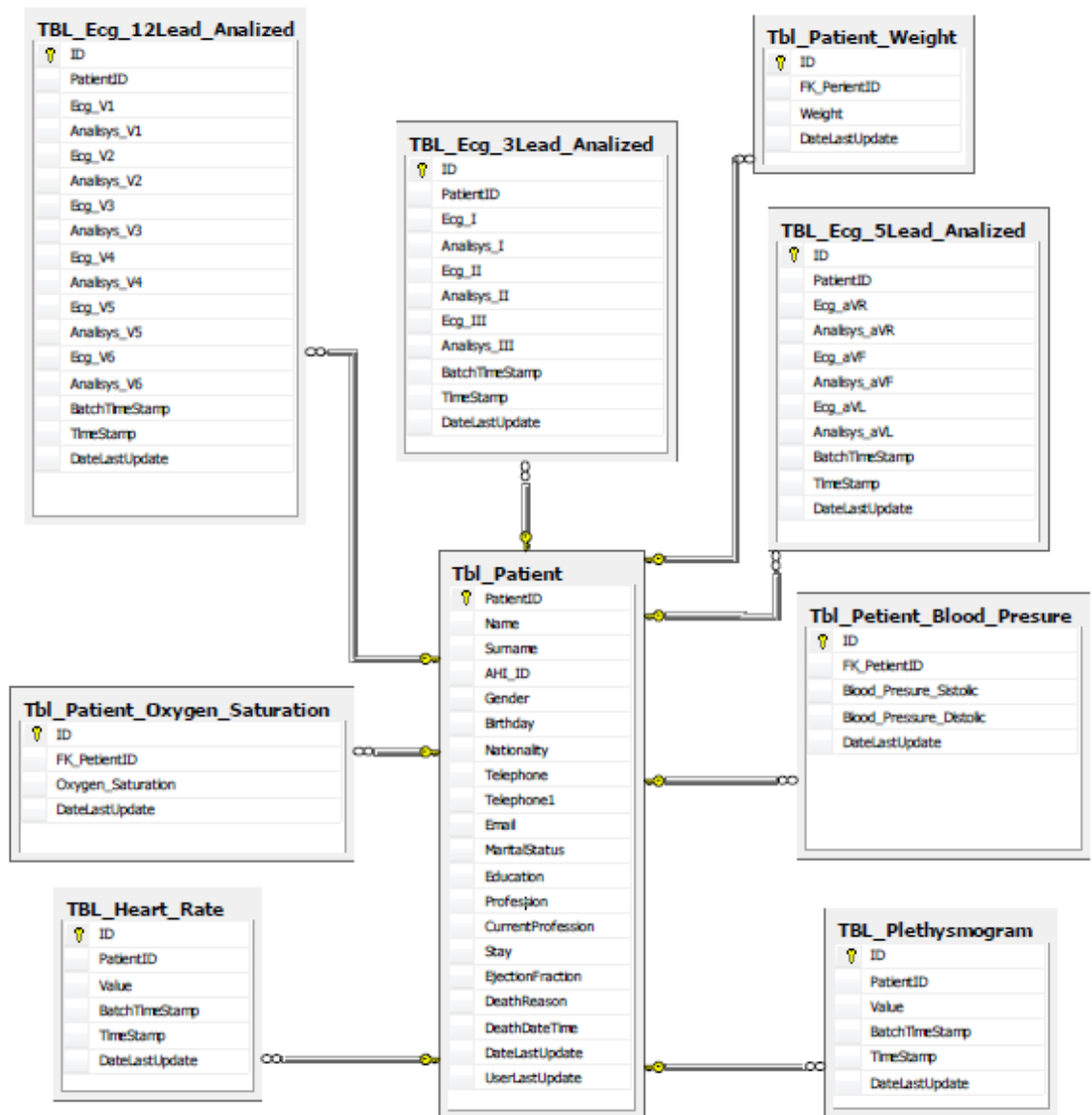
When the doctor needs to see the patient vital information's it call the Display Vital Information's process with the appropriate filters that are define from the doctor and get the patient weight, blood pressure, oxygen saturation, plethysmogram and heart rate.

### 5.3.7 Data Storage

The data that are collected from the different process or the request calls that are made from the process are passed to the Process Coordination in which the process it decide accordingly what process to raise in order to add, modify or delete from the data storage database.

## **5.4 Database Structure**

The database structure ref.fig 5.4.1 represents a part of the database. It represents only the vital tables needed for the ECG of the patient. The database will be used as is build on until know from the previous phase of the system.



Reference 5.4.1: Database Structure [21]

#### 5.4.2 Table Patient

This table contains the entire patient personal details. According to the unique primary key PatientID, it is connected to the other tables.

#### 5.4.3 Table Plethysmogram

The table stores the plethysmogram information of the patient according to the unique ID and the patient ID. For measuring changes in volume within an organ or whole body, usually resulting from fluctuations in the amount of blood or air it contains.

#### 5.4.4 Table ECG 3, 5, 12 Leads

Those tables save the ECG cardiac of the patient in the appropriate table.

##### 5.4.4.1 Table ECG 3 Leads

The leads that save in the table are for 3 leads. The ECG values for 3 leads are I, II, III.

##### 5.4.4.2 Table ECG 5 Leads

The leads that save in the table are for 5 leads. The ECG values for 5 leads are aVL, aVR and aVF.

##### 5.4.4.3 Table ECG 12 Leads

The leads that save in the table are for 12 leads. The ECG values for 12 leads are V1, V2I, V3, V4, V5 and V6.

#### 5.4.5 Table Oxygen Saturation

Oxygen saturation is a relative measure of the amount of oxygen that is dissolved or carried in a given medium. The Oxygen is saved on the table using the primary key ID with the Patient ID.

##### 5.4.5.6 Table Blood Pressure

During each heartbeat, BP varies between a maximum systolic and a minimum diastolic pressure. The two values are saves in the table using the primary key ID with the Patient ID.

#### 5.4.7 Table Weight

The patient weight value is saved in the table using the primary key ID with the Patient ID.

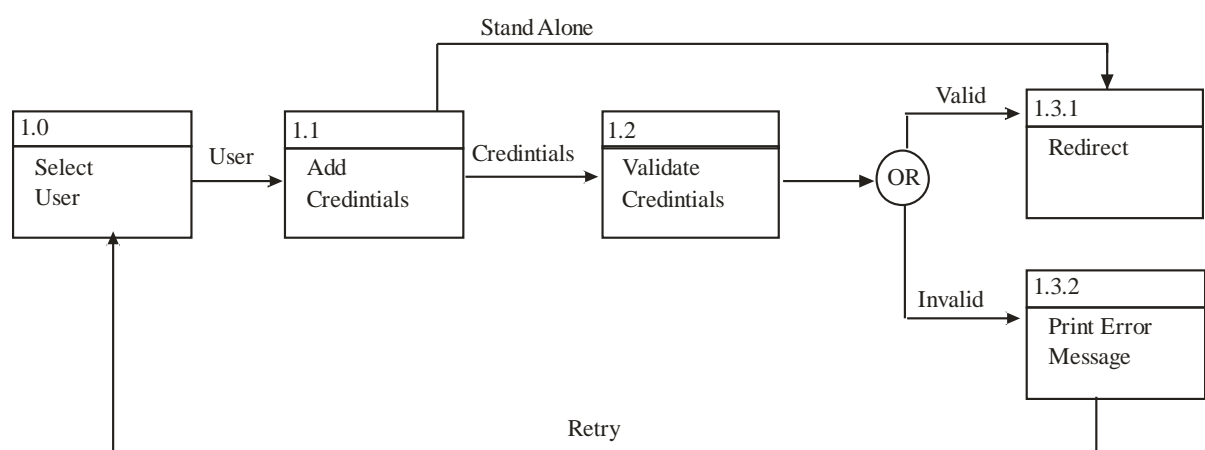
## 5.5 Design Phase

The purpose of this phase is to create a technical solution that will match the functional requirements of the system. The design functions and operations are described in detail, screen layout, process diagrams, rules, and documentation. Using this function will provide the new system as a collection of modules.

On the design phase we take in mind the inputs, the user requirements in order to define the system specifications. Upon the system requirements the new system will be design.

### 5.5.1 Login Control

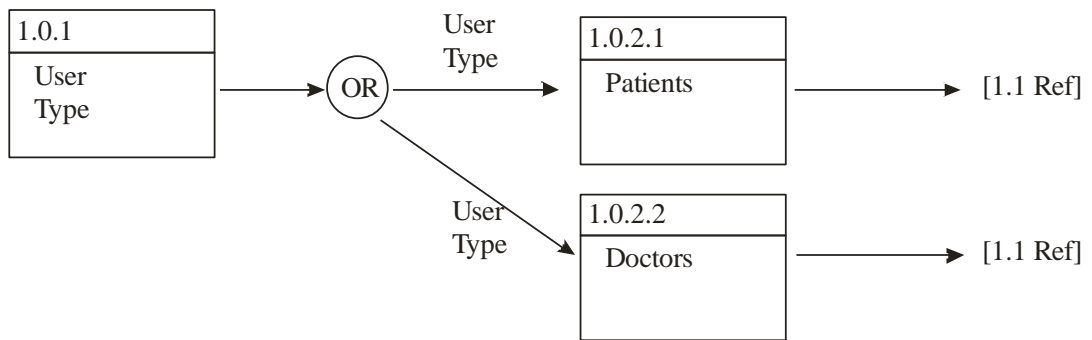
This function provides the authentication of the user with the database, and redirects the user to the appropriate portal mode. In detailed user select the portal mode that prefers, Doctor Portal or Patient Portal. After the user add its credentials on the login window and if the user is the patient, has the ability to select the Stand Alone Mode. After the user is ads the credentials they are validate with the database server in order to confirm that are correct and authenticate the user to use the system. If is authenticated the user then the application forward the user to the corresponding portal depend the credentials of the user. On the other way if the credentials are not correct then an error message is send on the user and inform to try again ref. Fig 5.5.1.1.



Reference 5.5.1.1: Login

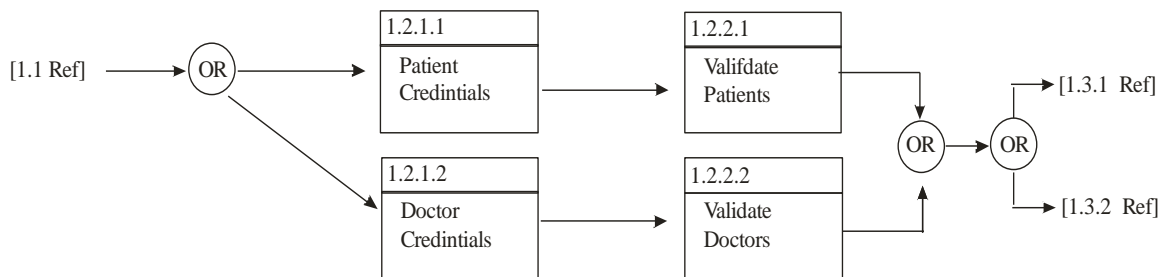
User has to select the type of user that is. On the screen will be display two users, the Patient and the Doctor. Selecting one of them will be forward in the appropriate login form to fill in the credentials ref. Fig 5.5.1.2.





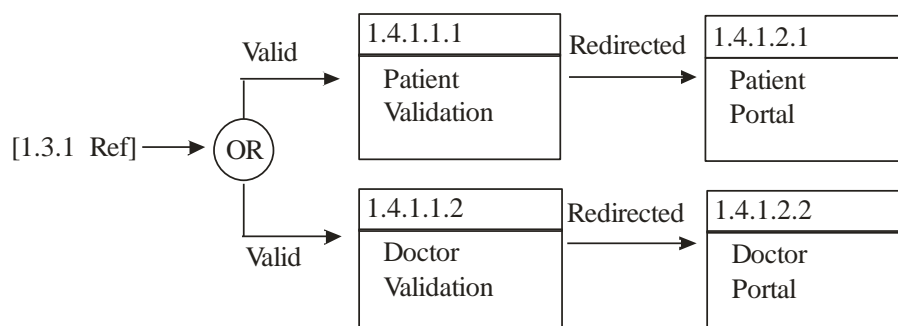
Reference 5.5.1.2: Second Level User Type

According to what the previous user has selected will be forwarded on the corresponding form to fill in the credentials. When the user fills in the fields and submits the form, a validation will be implemented according to the type of user. Due to that the Patient form has more fields to fill in, the application makes different validations for both users. Doctor is validated with username and password, and on the other hand, the patient is validated with Patient ID, Patient SID, and Patient Name ref. Fig 5.5.1.3.



Reference 5.5.1.3: Second Level Validate Credentials

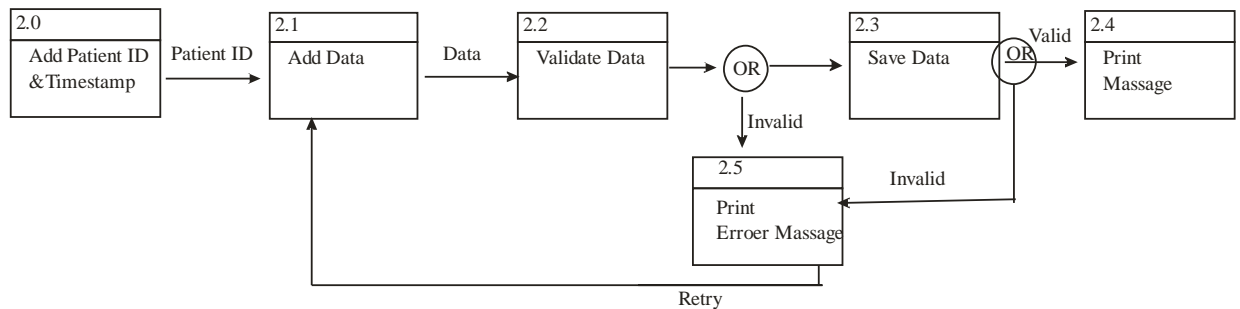
After the user is authenticated with the corresponding role, they are forwarded to the appropriate portal site. If the user is logged as a doctor, they will be forwarded to the Doctor Portal site, and if they are logged as a patient, they will be forwarded to the Patient Portal site ref. fig. 5.5.1.4.



#### Reference 5.5.1.4: Second Level Redirect to Portal

#### 5.5.2 Upload Vital Information's to Database Server

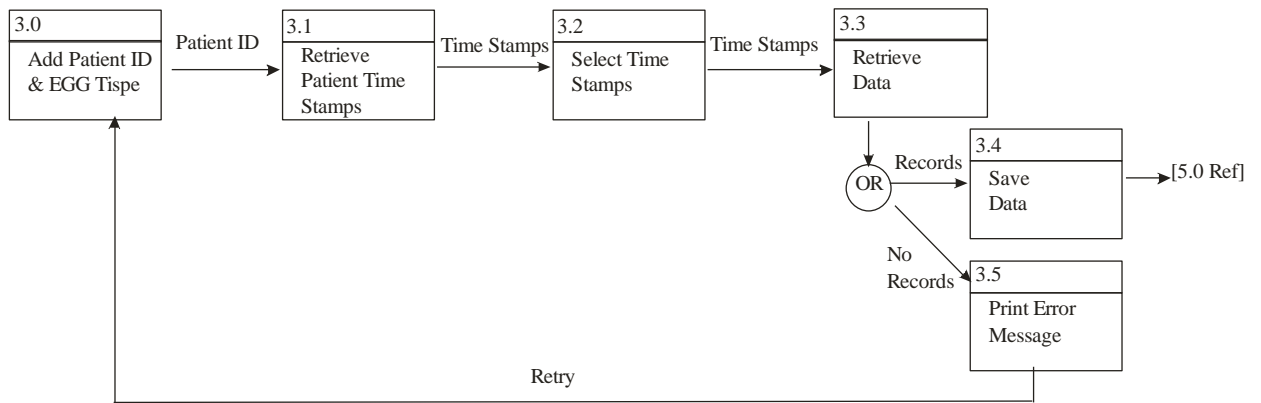
When the ECG recording is finish patient will upload the vital information's on the server. For that we are using as a unique the patient id combine with the date time stamp. Using this as unique key the application tries to upload the data to the server. The server it validates the data to be correct. If the data have any anomaly it report to the user with an error message otherwise it save the data to the database. On the process for saving the data it's been found any problem then again it report to the patient with an error message otherwise it save the information's and report to the patient a successful message and gives the possibility to retry sending the data ref fig 5.5.2.1.



Reference 5.5.2.1: Save Data to Database

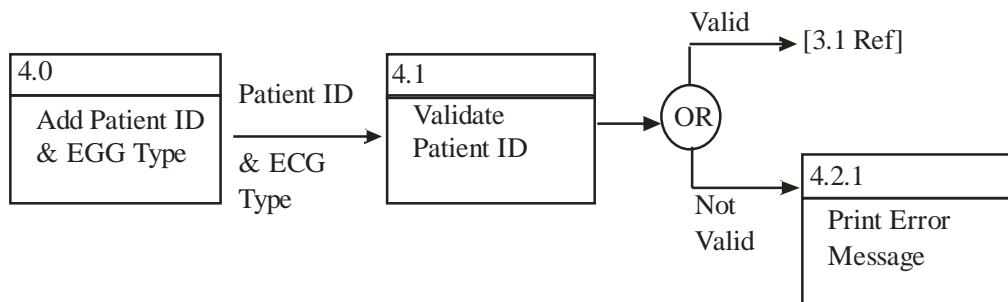
#### 5.5.3 Retrieve Data from Database Server

Doctor needs to download the vital information's of the patient in order to preview them. In order for this doctor has to provide the patient id number and the ECG type that requires. The system validate if the certain patient id number exists or not. If validated and correct then it return all the data time stamps that exist on the database and display them to the doctor. Then the doctor have to decide the certain date time that need and select it in order for the application to capture the selection and pass it to the server. Upon that selection with the combination of the patient id and the ECG type the application starts to download the data into the memory card of the device. If for the certain date time there are no records in the database then it returns an error message on the Doctor Ref fig 5.5.3.1.



Reference 5.5.3.1: Retrieve Data

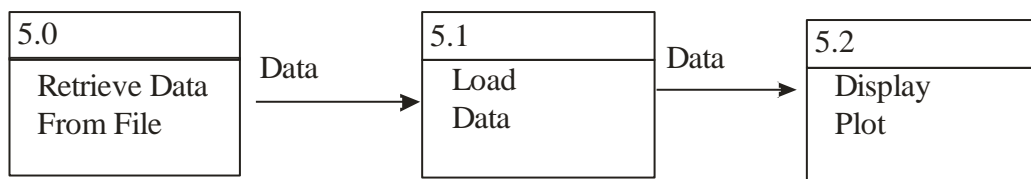
For the application to continue and start download the vital information's of the patient it has to verify that the certain patient id exist and its own to someone. It validate with the database server that the patient id exist and forward the patient to the next step otherwise it return with an error message to the user ref fig 5.5.3.2.



Reference 5.5.3.2: Validate Patient

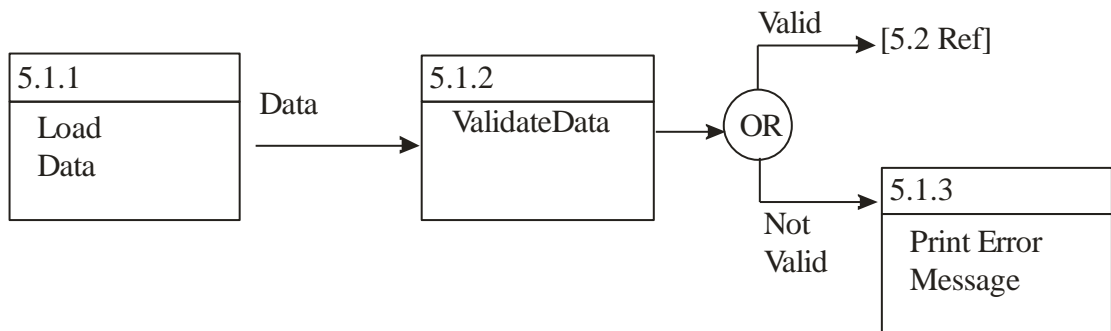
#### 5.5.4 Display Doctor Graph

After the process for retrieve the data from the database server and save them on a file in the memory card the application will try to read them and load them on the application and start the graph to be display with real values that where send from the patient on the server ref fig 5.5.4.1.



Reference 5.5.4.1: Display Doctor Graph

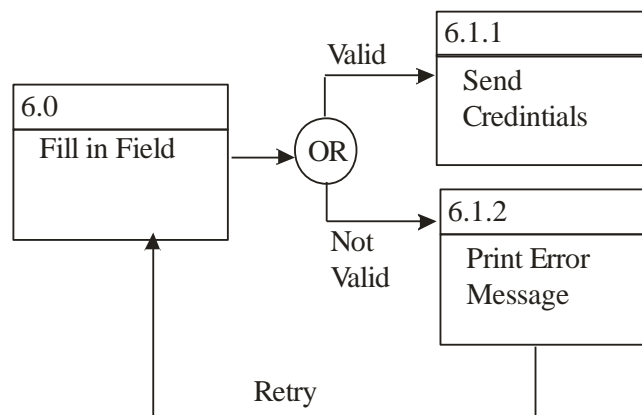
The time that are reading the data and are load on the application, the application makes a validation of the context of the files. It validates them if they are not empty and if the values are separated with the “;” sign. After, if the validation is correct it forward the user to the next step, otherwise it displays an error message on the user ref fig 5.5.4.2.



Reference 5.5.4.2: Second level Validate Load Data

#### 5.5.5 Send Credentials to Patient

Doctor as an administrator can send the credentials to the user. From the appropriate screen user selects and fill in the field with the appropriate values, the application makes a validation with a cooperation with the database and if is correct then it send the credentials to the user otherwise it return with the appropriate error message ref fig 5.5.5.1.



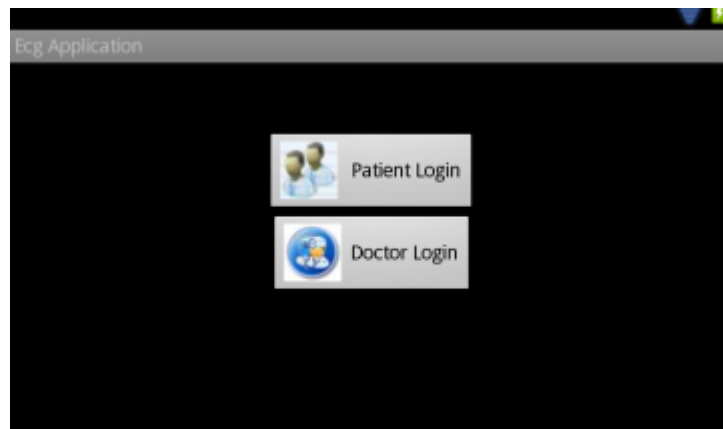
Reference 5.5.5.1: Send Credentials to Patient

## 5.6 Class Diagram

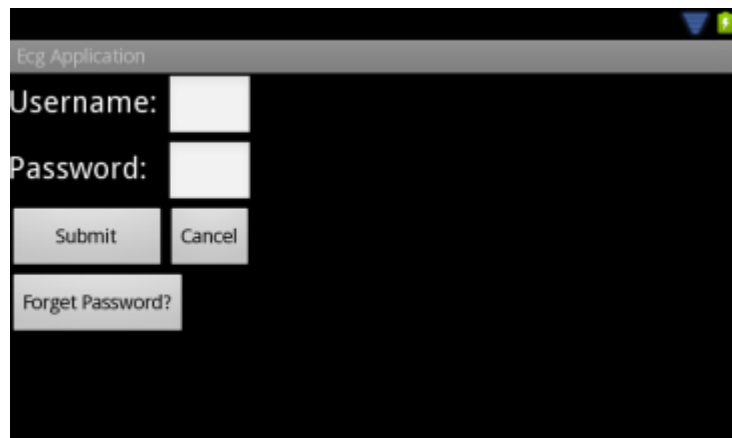
## 5.6.1 UserLogin

```
▲ UserLogin
  ▶ ProgressTask
  ▲ LoginDoctor() : void
  ▲ LoginUser() : void
  ▲ onActivityResult(int, int, Intent) : void
  ▲ onCreate(Bundle) : void
  ▲ onDestroy() : void
  ▲ onStop() : void
```

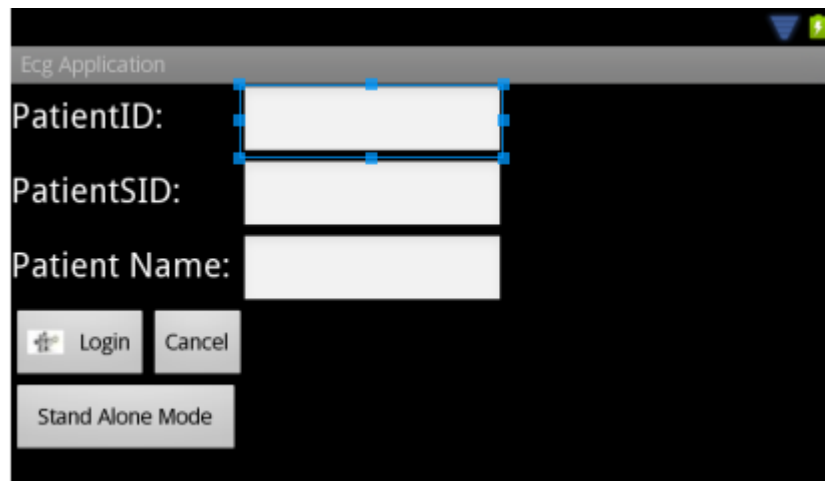
Reference 5.6.1.1: Login Class



Reference 5.6.1.2: Login Screen



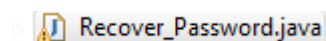
Reference 5.6.1.3: Doctor Login



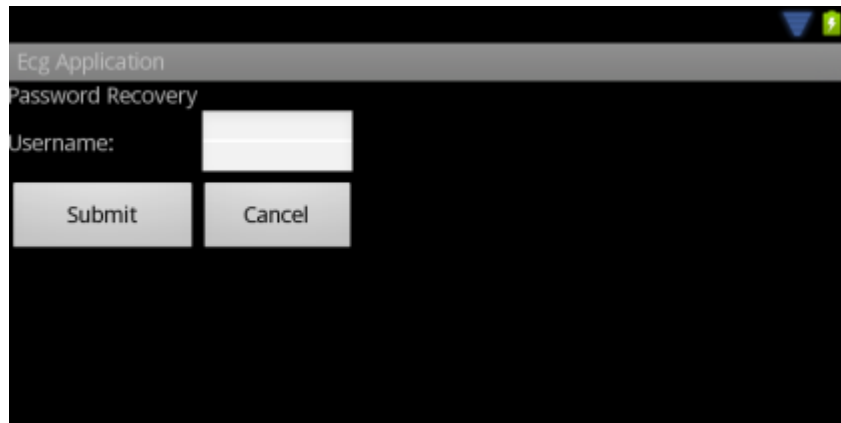
Reference 5.6.1.4: Patient Login

This class is the first class that is been created when the application start. According to the selection of the user from Login Screen ref. Fig. 5.6.1.2, it will raise either the LoginUser function or the LoginDoctor function. When we call those two functions they forward the user to the appropriate login form according the button that you press ref fig 5.6.1.3, ref fig 5.6.1.4 and calling the web-service to log the user to the system. Furthermore it contains the function onDestroy and onStop, when you exit from the system it define some variable in order to logoff the user from the system and exit them. The function onActivityResult it waits for a result from the Wi-Fi class. Before forward the user to the appropriate screen to fill in the credentials it checks for Wi-Fi network and if result is true then it continue to forward the user to the login screens.

Beside that on the Doctor Login page there is a Forget Password button. Pressing the button it raised the Recover\_Password ref. Fig. 5.6.1.5, ref fig 5.6.1.6 in which it will connect to the web-service that will reset the password of the user and a new one will be send back to the user. The user has to add the username and the system will generate a new random password that will be sending on user email address.

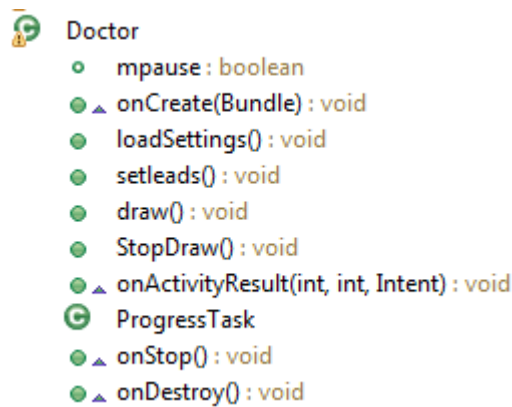


Reference 5.6.1.5: Recover Password

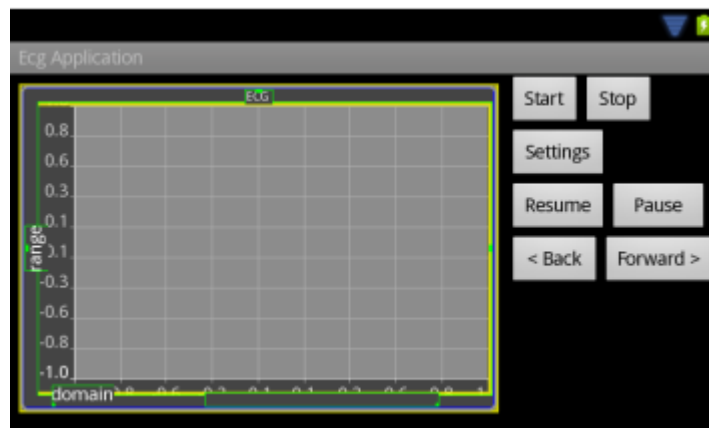


Reference 5.6.1.6 Recover Password Screen

### 5.6.2 Doctor Portal Class



Reference 5.6.2.1: Doctor Portal Class



Reference 5.6.2.2: Doctor Portal Screen

While the user selects the Doctor Button from ref fig. 5.6.1.2 the system authenticates the user as a doctor and log in the user. On the doctor portal the draw function that is been raised when the user select the Start button ref fig 5.6.2.2. Doctor selects the patient id and

batch time in order to start downloads the data from the server data base and draws the data on the graph. onStop and onDestroy they work the same way as on 5.6.1 section.

ProgressTask function it pop up a progress dialog that display the step that the download progress is the current moment and at the same time it raised the appropriate class in order to start and download the information's.

Additional after the ProgressTask the vital data that were downloaded to the device they will be read from the application and will start to draw on the graph. According the setting that Doctor chooses the plot will start to be draw with the appropriate values. If doctor decide to display ECG 5 leads with Heart Rate and Oxygen Saturation then on the Doctor Screen will display on the graph the V1, V2 and V3 values and also will display the heart rate value and the oxygen saturation.

Furthermore with pause button ref fig. 5.6.2.2 you can “pause” the draw of the graph without losing the data. With back and forward button you can move insight the data in order to view again some data and with the resume button you can set the plot to start draw again from the step you want. If draw reach at the end with the resume button you can start draw again the same data from the start point.



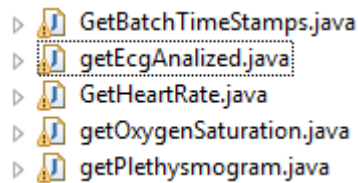
Reference 5.6.2.3

Last, the setting button ref fig. 5.6.2.3 gives to the doctor the ability to select what type of data wants to download from the server database, can choose one from the leads, 3, 5 or 12 leads. Can choose if prefer to download the heart rate, oxygen saturations or Plethysmogram of the patient.



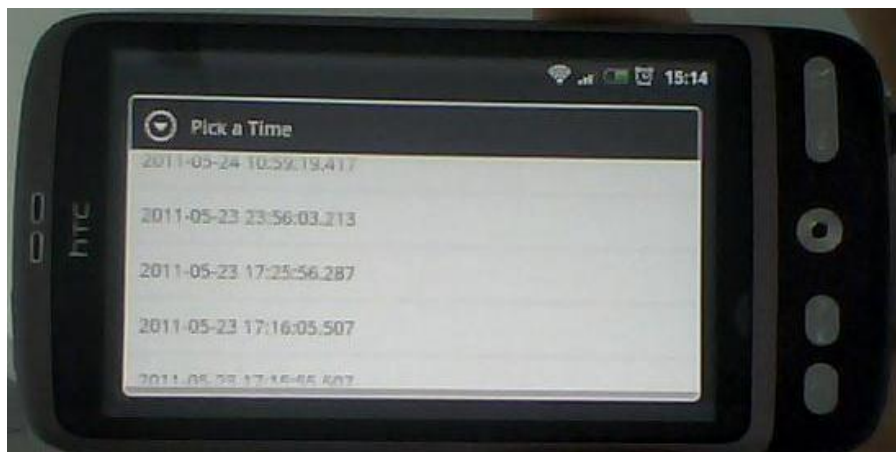
loadSetting functions it work by loading on the application the selections of the doctor from the Settings Dialog. It loads the values in order to know what type of data will ask from the web service to download.

### 5.6.3 Get functions



#### Reference 5.6.3.1

The GetBatchTimeStamps class waits for the doctor to add patient id number and then the class raised the getBatchTimeStamps web service passing the patient id number and the ECG type (3, 5, 12 leads) parameters. The web service return to the application the data according to the request call and the application load the data into a dialog list, in order the user to be able to make one selection from the list ref fig 5.6.3.2.



Reference 5.6.3.2: Date Time List

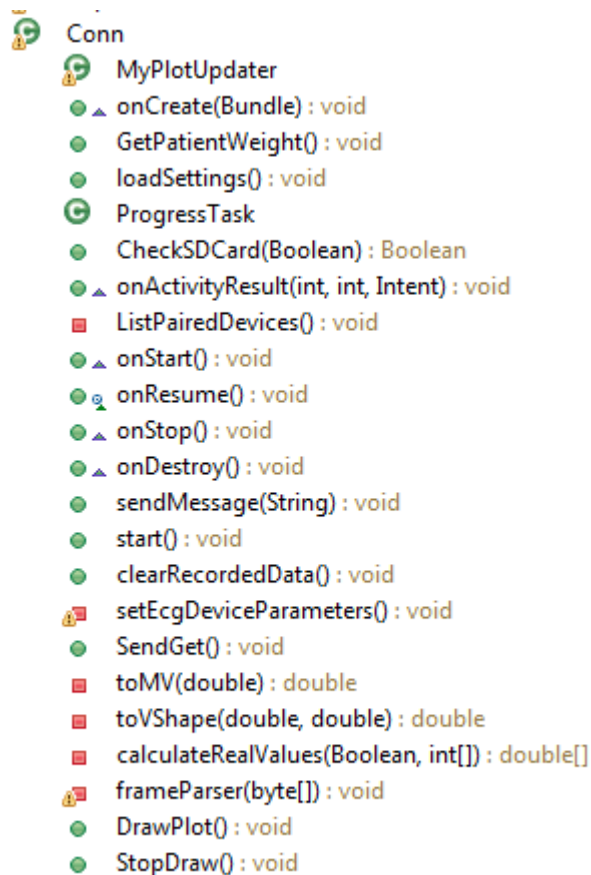
Based on the Date time that the doctor will choose it will start download several data from the server database through the web-service.

Additional the getECGAnalysed function will try to get the ECG values. First it have to check from the doctor settings the type of ECG that will like to search (3, 5, 12 leads) ref. fig. 5.6.2.3. After that according to the selected Date Time stamp and the patient id will

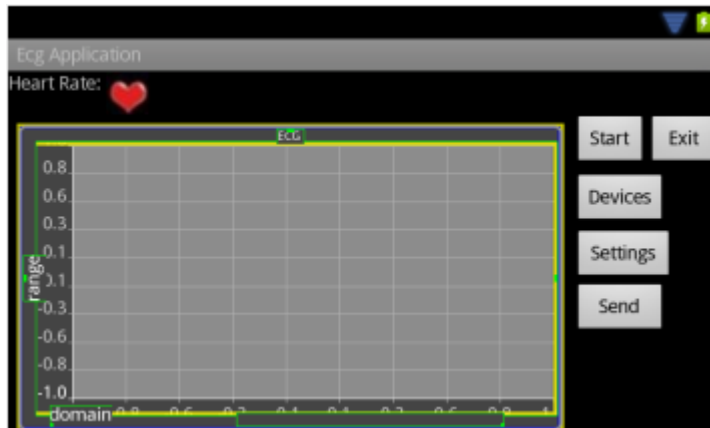
forward those values in order to raise the web-service `getEcgAnalyzed` to search the database and start download the data to the doctor.

Furthermore the `getPlethysmogram`, `getHeartRate`, `getOxygenSaturation` works with the same way. All the classes raised the appropriate web-service passing the parameter of patient id, date time stamp in which it communicate with the database and return the corresponding data to the doctor.

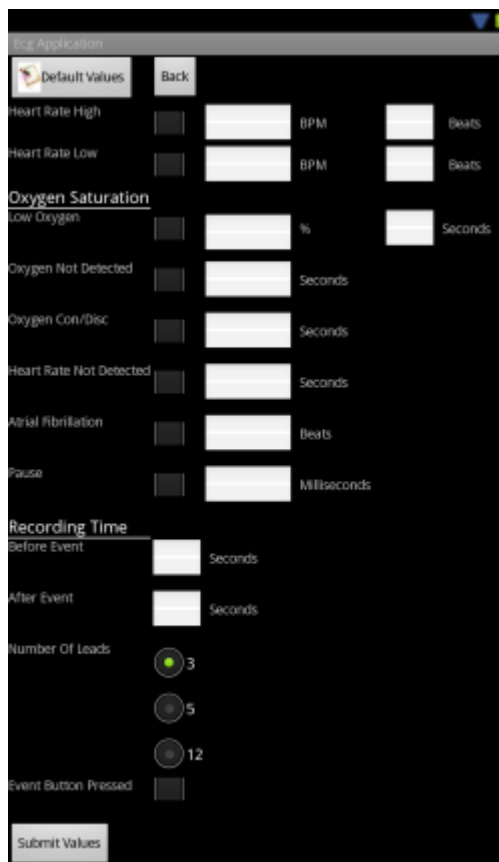
#### 5.6.4 Patient Portal Class



Reference 5.6.4.1: Patient Portal Class



Reference 5.6.4.2: Patient Portal Screen



Reference 5.6.4.3: Patient Settings

Patient has the functionality not to connect on the application through the database server in order to use the application. From the login screen ref. Fig. 5.6.1.4 can select the Stand Alone Mode. Using this functionality patient is able to use the application but cannot send data to the database server.

On the other side on the patient portal they are several functions that are being using. Settings button ref fig. 5.6.4.2 it load the settings screen. Patient can configure the ECG Device according to the instructions of the Doctor. Can select the heart rate values, the oxygen saturation, the recording time, the leads, etc or just can select to set the defaults values that are proposed from the Doctor. After setting the device the settings are loaded on the application and raised the `setEcgDeviceParameters` and send to the ECG device the settings that were selected.

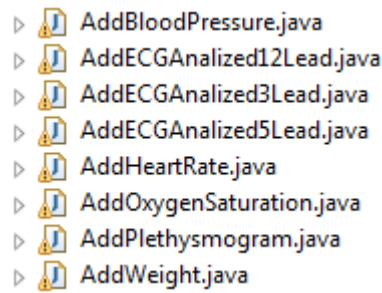
Selecting the Devices button the user can setup the Bluetooth device and the Wi-Fi network device. Patient can select the Wi-Fi network to connect to it in order to have access on the internet and also can select the Bluetooth device to connect to. In order to connect to the ECG Bluetooth device you have to select the appropriate device from the Bluetooth device list.

With the Send button raised the `sendMessage` function. With the certain function the application send data, information's to the Bluetooth device, such as the GET command in order to start sending to the Android device the cardiac values.

Selecting the start button on Patient portal screen it will start draw a plot according the vital information's that it receive from the ECG device. The graph is set up to start draw the cardiac plot. The patient has the ability to view the graph for 3 leads values. It will be a real plot graph as the doctor will be viewing it.

Another function that patient has is the Upload button. Selecting the button the `ProgressTask` function is raised. This function is using some classes that call the corresponding functions from the web-service in order to upload the information's of the patient to the database of the server ref 5.6.5 section.

#### 5.6.5 Add Functions



Reference 5.6.5.1: Add Functions

The upload function will be raised after the data are display on the user screen and has finish. It will display a menu that will ask the user if prefer to upload the data or not. The application through the classes communicates with the web-service in order to upload the selected data to the server database. For all the function it has to pass the patient id number and the date time stamp and then according to the settings will upload the values that were collecting from the ECG device. The settings will define what ECG analysis type will upload and if the other functions are selected from the setting will be uploading too.

## 5.7 Use Case diagram

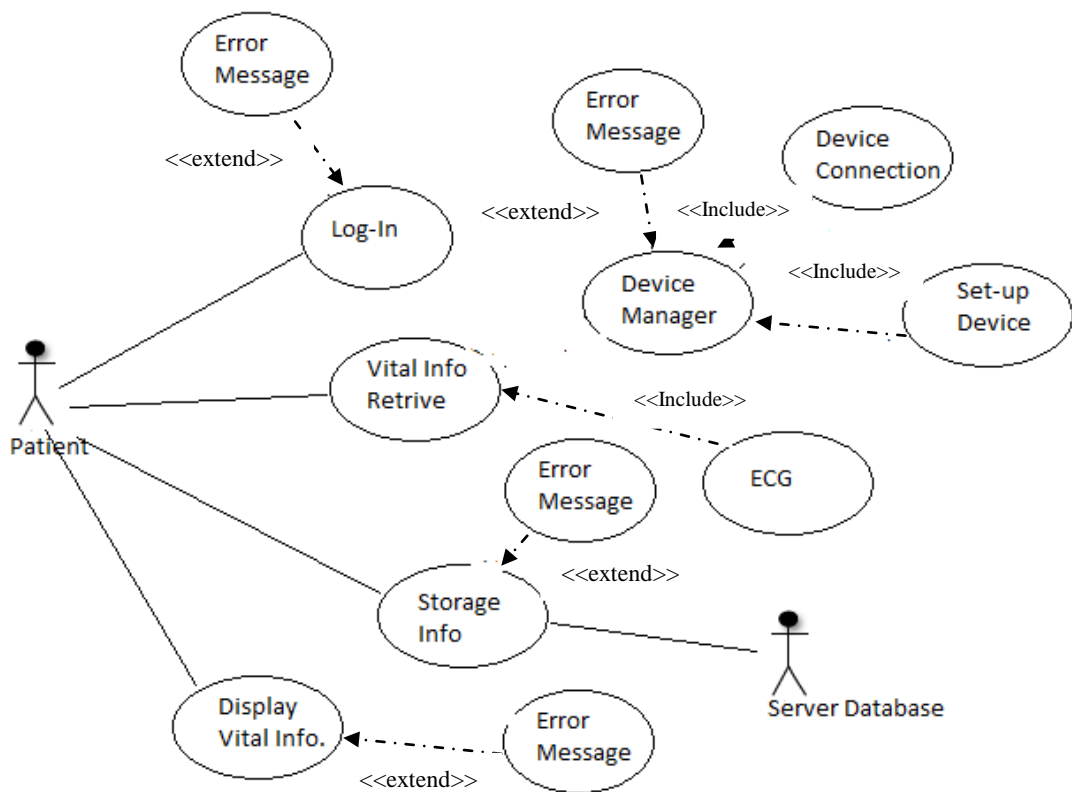
Use case is a list of steps, typically defining interactions between a role and a system, to achieve a goal. Is a graphical representation of the interaction between the user and the system. A use case diagram it present the different types of users of the system and the various ways that they interact with the system [23].

### 5.7.1 Diagram building blocks

- Actor: the actor is describe by the term of “user”, but this mean that does not have to be a human but also can be other external systems. They present outside the rectangular box that represent the system. Actors will interact with the use case by means of arrows.
- Use Case: Are all the functionality of the system that is contained within a system boundary. It might be a sequence of actions, including and the subcategories of them that a system might interact with the actors of the system.
- Use Case Relationship:

- Extend: is the relationship between two use cases in which the functionality, the main concept may be the same but there are some additions depending the scenario. Is determined with the label <<extend>> between the two use case.
- Include: is a relation between two use case where there is a chunk of functionality that are included in several use case and can be abstract into a separate model in other use cases. Is determined with the label <<include>> between the two use case.
- Generalize: is where two use cases have the same functionality but on specific implementation they have some differences. Is describing with an arrow and a generalization label [23].

### 5.7.2 Patient Portal Class Diagram



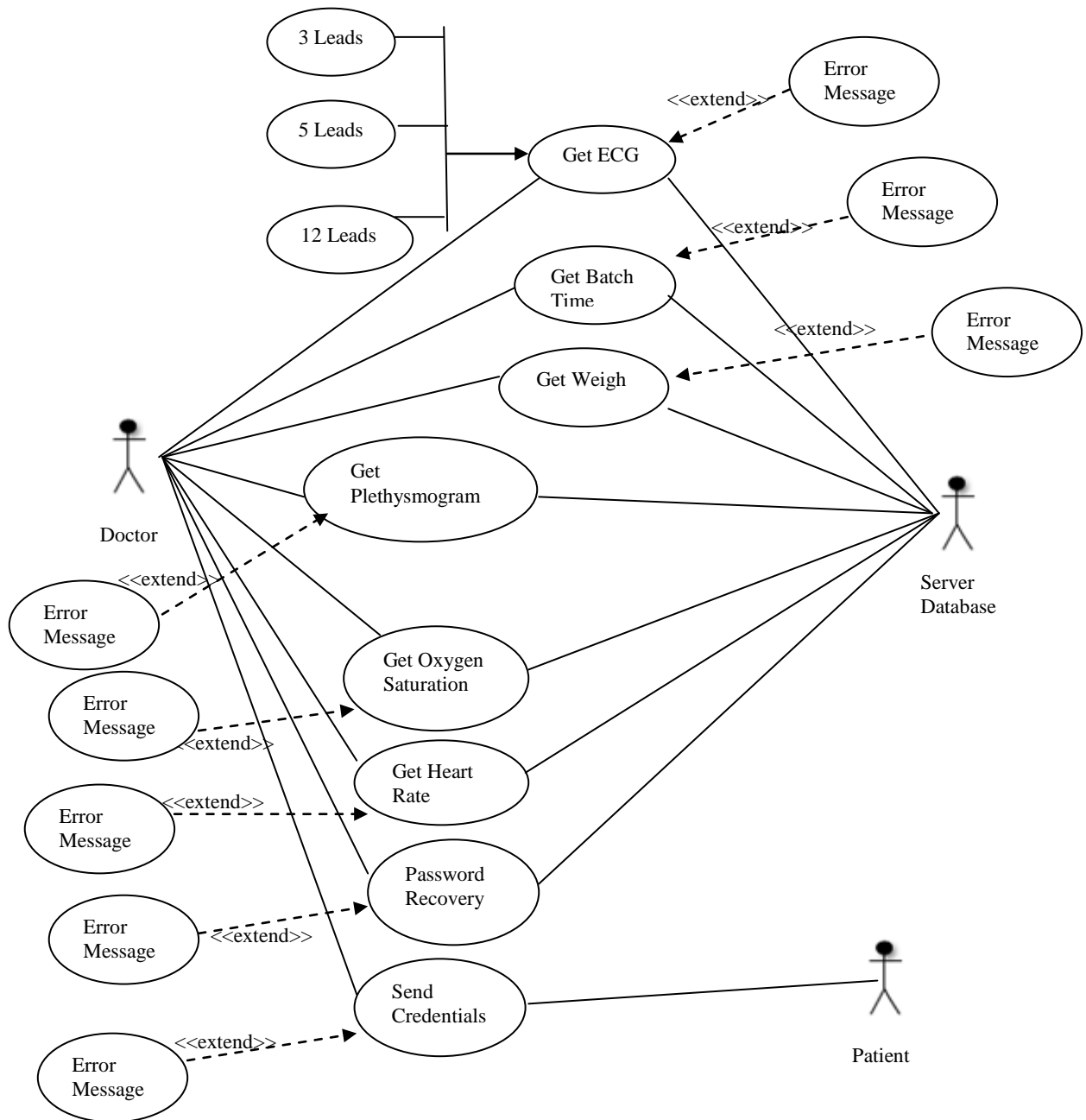
Reference 5.7.2.1: Patient Portal Class diagram

Patient before to be able to use the application have to login on the system otherwise will not be able to continue to the procedure. Then it will have to connect with the Bluetooth ECG device. After that will have to set-up the device according to doctor instructions. It will receive the vital information's and application will start to draw on the graph. When it finishes receiving data from the ECG Device it will upload the data to the server database.

#### 5.7.5.2.2 Vital information's that will be upload

- Heart rate
- ECG 3, 5, 12 leads
- Oxygen Saturation
- Plethysmogram
- Blood Pressure
- Weight

### 5.7.3 Application Server – Retrieve Information's

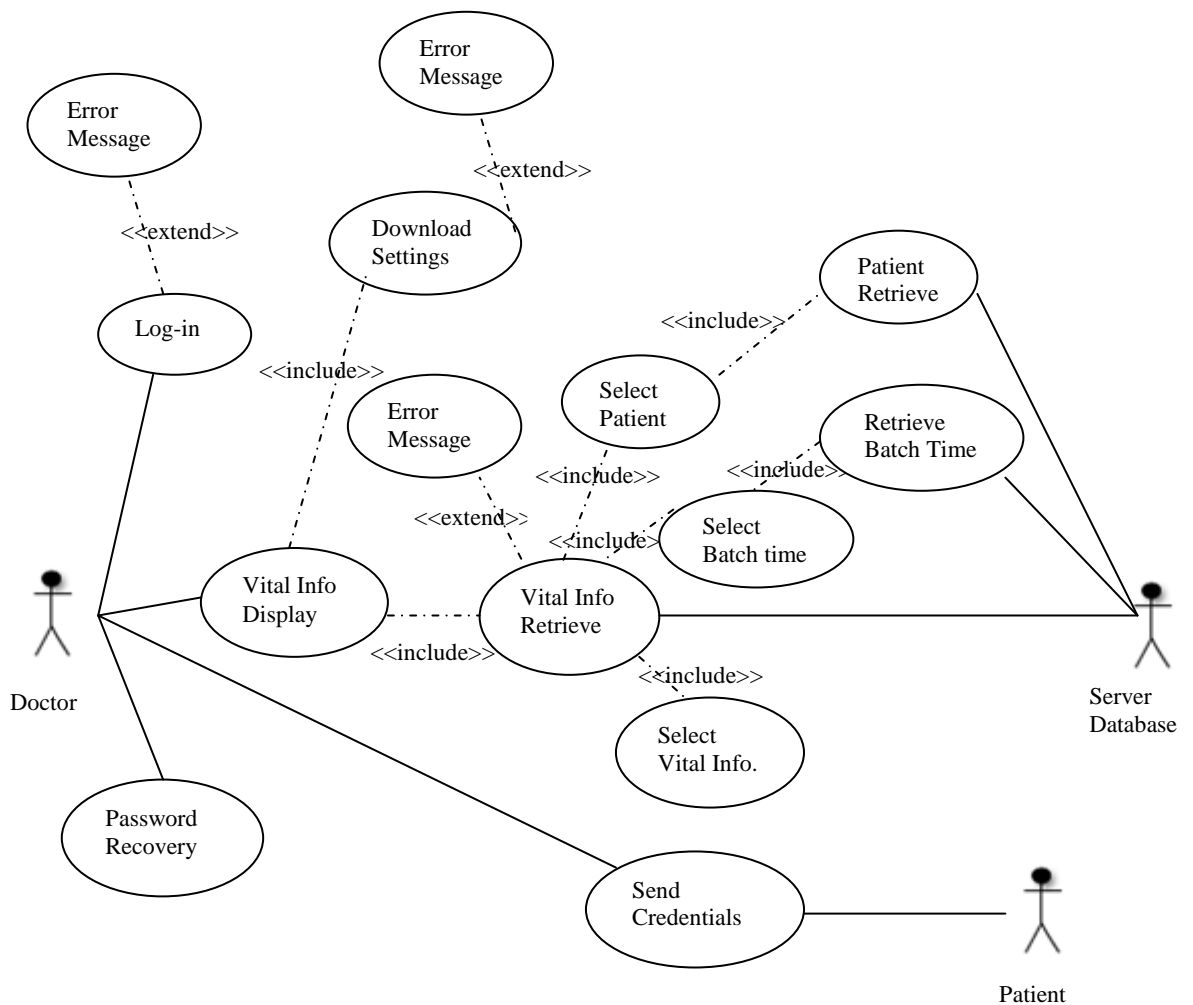


Reference 5.7.3.1: Application Server Class Diagram

After a request from the Doctor user the application will start the appropriate methods that requested from Doctor in order to retrieve the corresponding information's from the database in order to send them to the doctor and download them on the device.

### 5.7.4 Doctor Portal Class Diagram





Reference 5.7.4.1

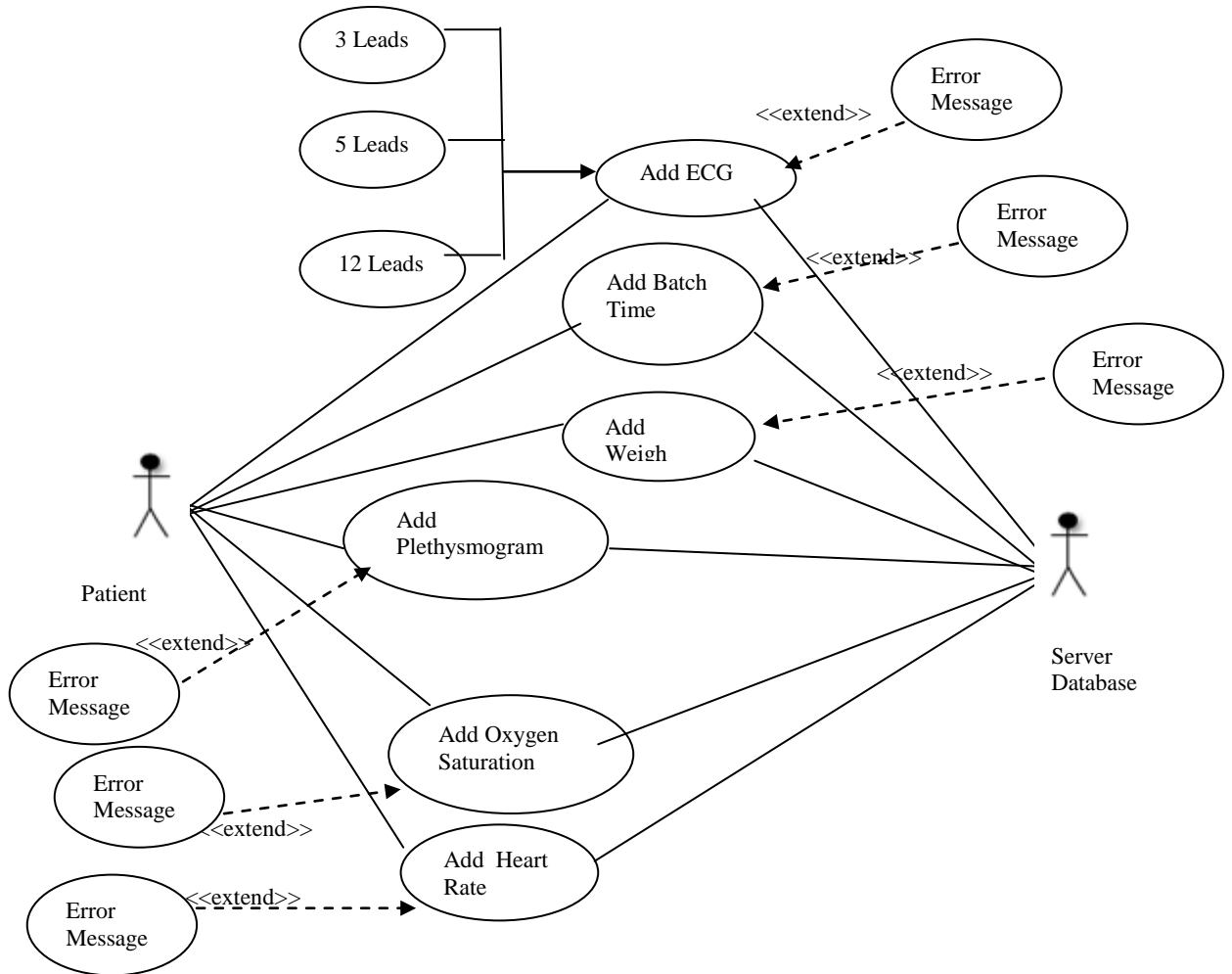
Doctor requests for a certain patient the vital information's. Add the patient id and return to doctor the batch times that are saved on the database. Then the doctor select one batch time from the list and the application starts to download on the doctor device the certain patient information's. The Vital information's that will be downloading are according to the set-up of settings that doctor will figure.

Vital Information's:

- ECG Type
  - 3 Leads
  - 5 Leads
  - 12 Leads
- Weight
- Blood Pressure
- Oxygen Saturation

- Plethysmogram
- Heart Rate

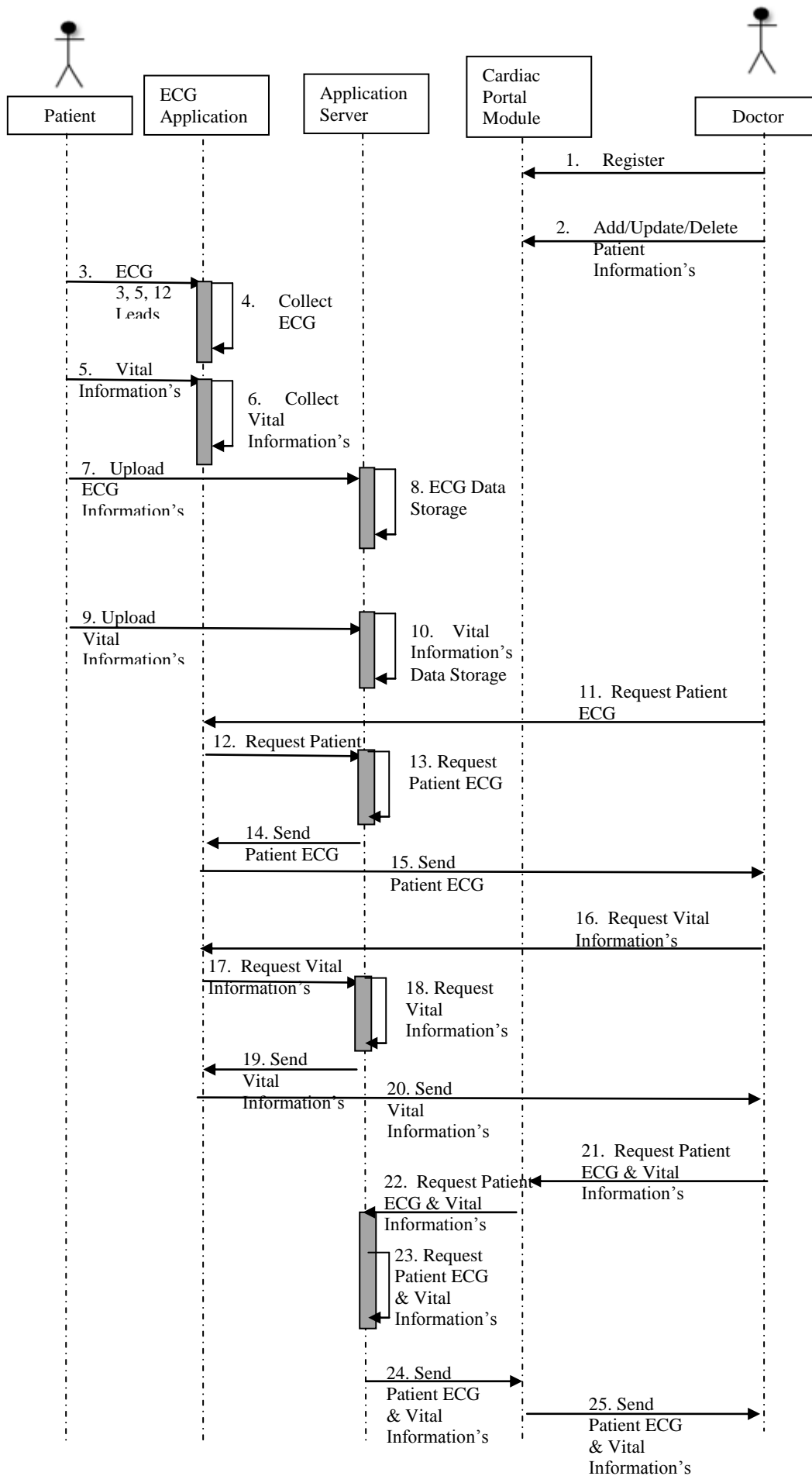
### 5.7.5 Application Server – Save Information's



Reference 5.7.5.1: Application Server – Save Information's

The application server on this scenario after a request from the patient will save the vital information's on the database. The information's will be send from the user to the Application server and then with its turn will raise the appropriate methods in order to start saving the information's

## 5.8 Sequence Diagram



### 5.8.1 Sequence diagram Flow

Doctors are register in the system in order to have access on the Cardiac Portal and on the ECG Application. Then as authorize personnel they can add, modify or delete patients. After that Patient can receive the ECG leads and the vital information's from the ECG Device through the ECG Application. Then can be uploaded and saved to the Server Database. When data are uploaded on the server, the doctor can download the certain data. From the ECG Application can search on the Server database for the certain patient, request the ECG leads data and the vital information's data. The Application server will search on the Database for the certain data and return them on the ECG application and the data will start to be display on the Doctor Portal.

Beside that doctor have the ability to view the data from the Cardiac Portal web site. Will request the data according to the interested patient and the data will be retrieve on the doctor screen.

## 5.9 Doctor and Patient Scenarios

### 5.9.1 Patient Send ECG and Vital Information's

#### 5.9.1.1 Send ECG and Vital Information's – Successful

1. User Start the Application
2. User Select Patient Login Button ref. Fig 5.9.1.1.1
3. User Fill in the form with Patient credentials ref. Fig 5.9.1.1.2
4. Application automatically connect device to a Wi-Fi access point
5. User is been forward to Patient Portal Screen ref. Fig 5.9.1.1.3
6. User select Devices Button
7. Appeared the screen with Bluetooth and Wi-Fi buttons
8. User select Bluetooth Button
9. Appeared the list with all Bluetooth devices in range
10. Select the appropriate Bluetooth device
11. Android device connect with the selected Bluetooth device
12. Select the start button
13. Device start to record and send to the application the ECG and vital information's

14. When it finishes receiving data it start to display the information's on the application screen.
15. After it finish the user is prompt with a menu to upload the data
16. User selects to upload the data and the application sends all the information's to the Application Server Database.
17. Receive a successful message

#### 5.9.1.2 Send ECG and Vital Information's – Successful

1. User Start the Application
2. User Select Patient Login Button ref. Fig 5.9.1.1.1
3. User Select the Stand Alone Mode ref. Fig 5.9.1.1.2
4. Application automatically connect device to a Wi-Fi access point
5. User is been forward to Patient Portal Screen ref. Fig 5.9.1.1.3
6. User select Devices Button
7. Appeared the screen with Bluetooth and Wi-Fi buttons
8. User select Bluetooth Button
9. Appeared the list with all Bluetooth devices in range
10. Select the appropriate Bluetooth device
11. Android device connect with the selected Bluetooth device
12. Select the start button
13. Device start to record and send to the application the ECG and vital information's
14. When it finishes receiving data it start to display the information's on the application screen.

#### 5.9.1.3 Send ECG and Vital Information's – Failure

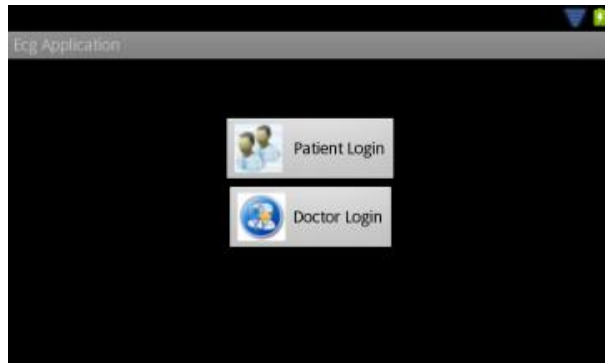
1. User Start the Application
2. User Select Patient Login Button ref. Fig 5.9.1.1.1
3. User Fill in the form with Patient credentials ref. Fig 5.9.1.1.2
4. Application could not connect automatically to a Wi-Fi access point
5. Application forward user to the device Wi-Fi network settings
6. Connect to Wi-Fi network
7. User successful login to the application
8. User is been forward to Patient Portal Screen ref. Fig 5.9.1.1.3

9. User select Devices Button
10. Appeared the screen with Bluetooth and Wi-Fi buttons
11. User select Bluetooth Button
12. Appeared the list with all Bluetooth devices in range
13. Select the appropriate Bluetooth device
14. Android device connect with the selected Bluetooth device
15. Select the start button
16. Device start to record and send to the application the ECG and vital information's
17. When it finishes receiving data in start to display the information's on the application screen.
18. After it finish the user selects the upload button to send all the information's to the Application Server Database.
19. Receive a successful message

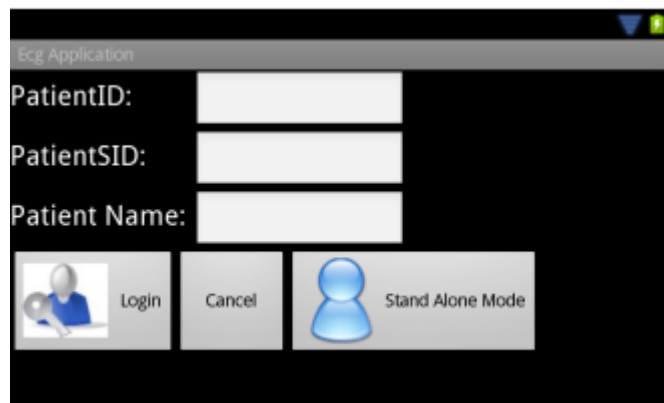
#### 5.9.1.4 Send ECG and Vital Information's – Failure

1. User Start the Application
2. User Select Patient Login Button ref. Fig 5.9.1.1.1
3. User Fill in the form with Patient credentials ref. Fig 5.9.1.1.2
4. Application automatically connect device to a Wi-Fi access point
5. User is been forward to Patient Portal Screen ref. Fig 5.9.1.1.3
6. User select Devices Button
7. Appeared the screen with Bluetooth and Wi-Fi buttons
8. User select Bluetooth Button
9. Appeared the list with all Bluetooth devices in range
10. Select the appropriate Bluetooth device
11. Android device connect with the selected Bluetooth device
12. Select the start button
13. Device start to record and send to the application the ECG and vital information's
14. Device loses Bluetooth connection with ECG device.
15. Message appeared to user
16. User try to reconnect to ECG Device Bluetooth from Devices button
17. When it finishes receiving data in start to display the information's on the application screen.

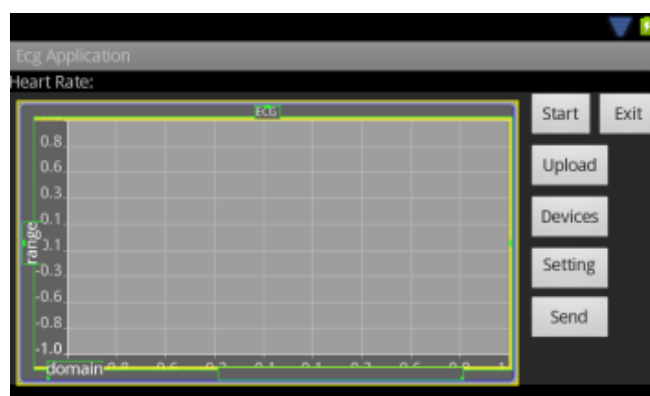
18. After it finish the user selects the upload button to send all the information's to the Application Server Database.
19. Receive a successful message



Reference 5.9.1.1.1: Login Screen



Reference 5.9.1.1.2: User credentials Form



Reference 5.9.1.1.3: Patient Portal

## 5.9.2 Doctor Receive ECG and Vital Information's

### 5.9.2.1 Doctor Receive ECG and Vital Information's – Successful

1. User Start the Application
2. User Select Doctor Login Button ref. Fig 5.9.1.1.1
3. User Fill in the form with Doctor credentials ref. Fig 5.9.2.1.1
4. Application automatically connect device to a Wi-Fi access point
5. User is been forward to Doctor Portal Screen ref. Fig. 5.9.2.1.2
6. From settings button user select the type of ECG and the vital information's that are needed.
7. Select start and a pop-up menu appeared
8. User insert the patient id number ref. fig. 5.9.2.1.3
9. Application connect to the Application Server Database
10. Application retrieve Date Times of specific patient
11. Doctor select from the drop down list the appropriate date time ref fig 5.9.2.1.4
12. Application start t download ECG and vital information's
13. When download completed it start to draw the data on the graph
14. User can pause the application
15. Can move backward with the backward button
16. Can move forward with the forward button
17. Can resume the plot from the step that was pause or move forward or backward
18. Finish draw plot
19. Message appeared that finish draw plot
20. User can resume the same graph from the begin with the resume button

#### 5.9.2.2 Doctor Receive ECG and Vital Information's – Failure

1. User Start the Application
2. User Select Doctor Login Button ref. Fig 5.9.1.1.1
3. User Fill in the form with Doctor credentials ref. Fig 5.9.2.1.1
4. Application could not connect automatically to a Wi-Fi access point
5. Application forward user to the device Wi-Fi network settings
6. Connect to Wi-Fi network
7. User is been forward to Doctor Portal Screen ref. Fig. 5.9.2.1.2
8. From settings button user select the type of ECG and the vital information's that are needed.
9. Select start and a pop-up menu appeared

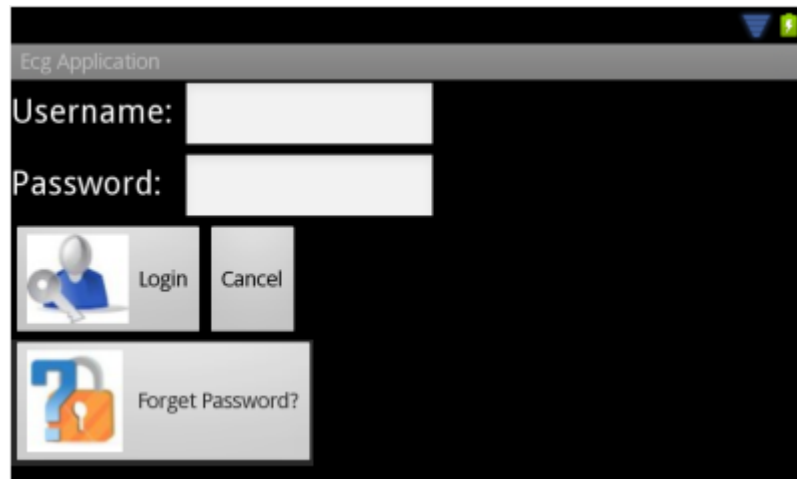


10. User insert the patient id number ref. fig. 5.9.2.1.3
11. Application connect to the Application Server Database
12. Application retrieve Date Times of specific patient
13. Doctor select from the drop down list the appropriate date time ref fig 5.9.2.1.4
14. Application start t download ECG and vital information's
15. When download completed it start to draw the data on the graph
16. User can pause the application
17. Can move backward with the backward button
18. Can move forward with the forward button
19. Can resume the plot from the step that was pause or move forward or backward
20. Finish draw plot
21. Message appeared that finish draw plot
22. User can resume the same graph from the begin with the resume button

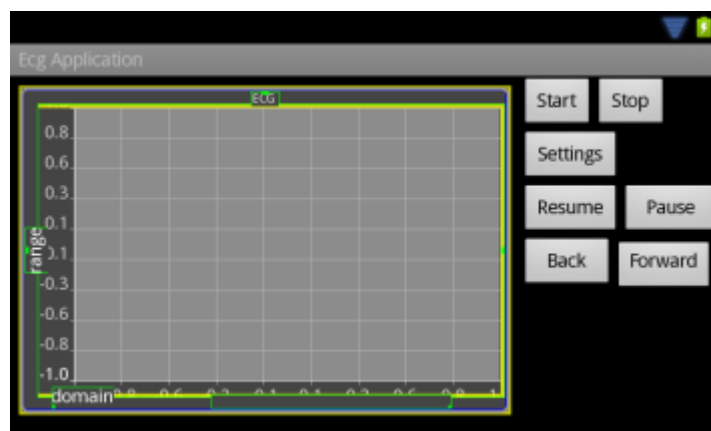
#### 5.9.2.3 Doctor Receive ECG and Vital Information's – Failure

1. User Start the Application
2. User Select Doctor Login Button ref. Fig 5.9.1.1.1
3. User Fill in the form with Doctor credentials ref. Fig 5.9.2.1.1
4. Application could not connect automatically to a Wi-Fi access point
5. Application forward user to the device Wi-Fi network settings
6. Connect to Wi-Fi network
7. User is been forward to Doctor Portal Screen ref. Fig. 5.9.2.1.2
8. From settings button user select the type of ECG and the vital information's that are needed.
9. Select start and a pop-up menu appeared
10. User insert the patient id number ref. fig. 5.9.2.1.3
11. Application connect to the Application Server Database
12. Application retrieve Date Times of specific patient
13. Doctor select from the drop down list the appropriate date time ref fig 5.9.2.1.4
14. Application start t download ECG and vital information's
15. Application lose connection with the Wi-Fi access point
16. Application Stop to download
17. User select Devices button
18. Application forward user to the device settings form

19. Select Wi-Fi button
20. Application try to connect to Wi-Fi access point
21. Connect successful to Wi-Fi network
22. When download completed it start to draw the data on the graph
23. User can pause the application
24. Can move backward with the backward button
25. Can move forward with the forward button
26. Can resume the plot from the step that was pause or move forward or backward
27. Finish draw plot
28. Message appeared that finish draw plot
29. User can resume the same graph from the begin with the resume button



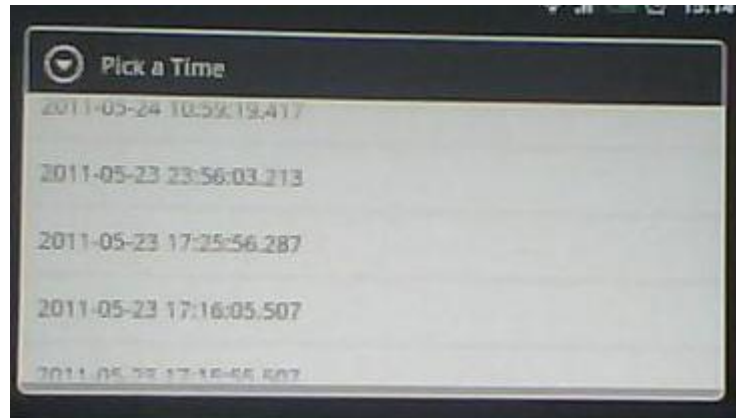
Reference 5.9.2.1.1



Reference 5.9.2.1.2



Reference 5.9.2.1.3



Reference 5.9.2.1.4

# Chapter 6 Implementation Phase

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6.1 Introduction

6.2 Programming Language and Platform

6.3 User Interface

6.4 Steps for Implementing the Application

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## 6.1 Introduction

The implementation phase includes the preparation of the system into a productive environment. In this phase the system is implemented with the tools that are selected. In this chapter we will describe how the application was implemented and what are the steps that were follow.

## 6.2 Programming Language and Platform

For implementing programming and design the application for both Patient Portal and Doctor Portal is going to be used eclipse. Eclipse is an open source platform that gives you the possibility to include Android Development Tools Plug-in. You can create and design the application to your needs. The programming will be in java that can work with eclipse and for implementing Android applications its using C++ libraries. The platform will be Android 2.3.3 with API Level 10 [30].

For the Cardiac Graph is using the Android Plot library which is Java API for creating dynamic and statics graphs. The certain library is an open source library that we have extended the code in order to fulfil our needs. [8]

## 6.3 User Interface

The user interface will be user-friendly in order that people with low knowledge of technology will be able to use the application after a small training. The displays are design

in such a way that will be understandable, using buttons with useful names. Drop down list, radio buttons or static buttons are being using in order to provide better understating from the user. Appendix I

## **6.4 Steps for implementing the application**

Step 1: Learn and understand how tools and the technologies that are going to be use how they work.

Step2: The system is going to be build upon an already and working system, we must understand how is working the system, the database server, the web-services and the Cardiac Portal web site. The system is going to be implementing using the same functionalities as the previous system but in a new OS platform.

Step3: Implement the application using eclipse toll with java API. They were used the android libraries that the most of them are in C++.

Step4: Implement the graph plot of the application using the Android Plot library that is an open source library in which we change it to fit to our needs.

Step 5: Connect the Patient Portal side with the Application Server and save the data to the Database server.

Step 6: Connect the Doctor Portal side with the Application Server in order to retrieve data from the Database server.

# Chapter 7 System Evaluation Phase

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7.1 Introduction

7.2 Testing Specification and planning

7.3 Test Scenarios and results

7.4 Modularity

7.5 Conclusion

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## **7.1 Introduction**

Several tests will be performing the ability of the system to react in real life values. We will test the connection with the different devices, the values that will be read from the ECG device, the correctness of upload and download of that information's, and time that need to fill in a process etc.

## **7.2 Testing specification and planning**

### 7.2.1 Connection Testing

On this section will be tried to test the connections of both portals of the system. On Patient Portal will check the connection with the ECG Device using the Bluetooth connection with an RFCOMM connection. After that have to check that internet services are provided. For both portals will check the Wi-Fi connection if is establish correct without losing the connection.

### 7.2.2 Security Testing

Due to the significant and the privacy of the data we must confirm that no data will be spyware. We must secure that no unauthorized user will have access on the vital information's of the patients.

### 7.2.3 Acceptance Testing

The application will be test with real-life data in a real-life environment. The application will be test by users that will test it. Users will use the application some of the as patients and others as doctors. This will test the application if it can work under some stress of users that are familiar with technology or not.

#### 7.2.4 Upload - Download Testing

The system will be examined in real time checking if is working efficiently. For the Patient Portal we will examine if is sending correct the data on the Database of the Application Server and the time that needs to send them, depend the length of the data. For the Doctor Portal we will examine the time that needs to be download from the Application server depends the length of the data.

#### 7.2.7 Graph Test

We must examine both on Patient and Doctor Portals if the data that are display on the graph are correct without losing any information's. This will be done using in parallel with the Cardiac Portal web site that is already working on the Server.

### **7.3 Test Scenarios and results**

#### 7.3.1 Connection result

Patient Portal site was connected through a Bluetooth with the device successful. The connection was establish successful because we were able to send and receive data, with an important fact that no data where lost or defects on the data because on totals of bytes were the same and on the graph were no changes. Moreover, on the Wi-Fi testing we manage to send and receive data using the internet with the Patient Portal and Doctor Portal. Data were send and received respectively without any lost and display on the graphs correct.

#### 7.3.2 Security results

To accomplice the security, users have to login using username and password on both Patient Portal and Doctor Portal in order to be able to use the application. Transferring the

data to server and back we are using a web-service that it provide Secure Socket Layer in which is a safe encryption protocol in order to send the data with safety. Beside that when a new user is register on the system on the database the password of the patient is encrypted for security.

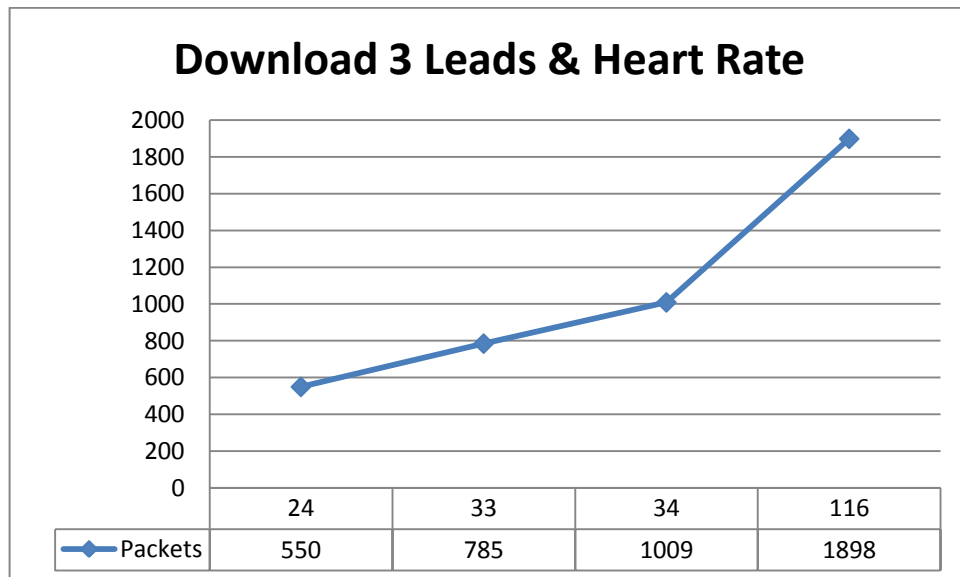
### 7.3.3 ECG 3 Leads Download

On this phase the system will be test on upload data on the database and retrieve the data from the database. The data will be sending from the Android device using the web-service.

On the two scenarios below we can see the difference when download the data for 3 leads and also retrieving the heart rate. We can notice, as the packages are increasing it needs more time in order to retrieve the data from the server.

Packets	Time
550	24
785	33
1009	34
1898	116

Table: 7.3.3.1: ECG Analysis matrices



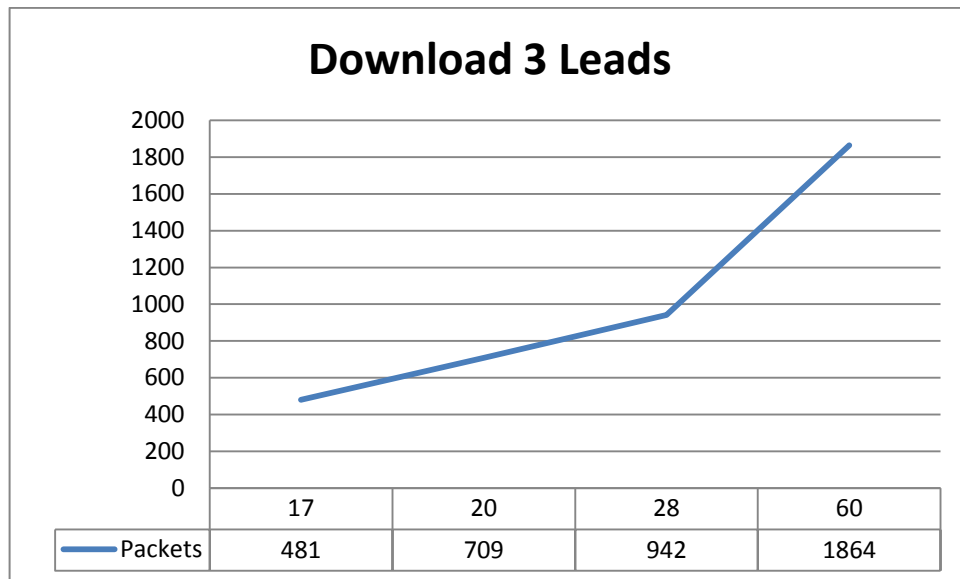
Reference 7.3.3.2 ECG 3 Leads Download

Packets	Time
481	17



709	20
942	28
1864	60

Table 7.3.3.3: ECG Analysis matrices



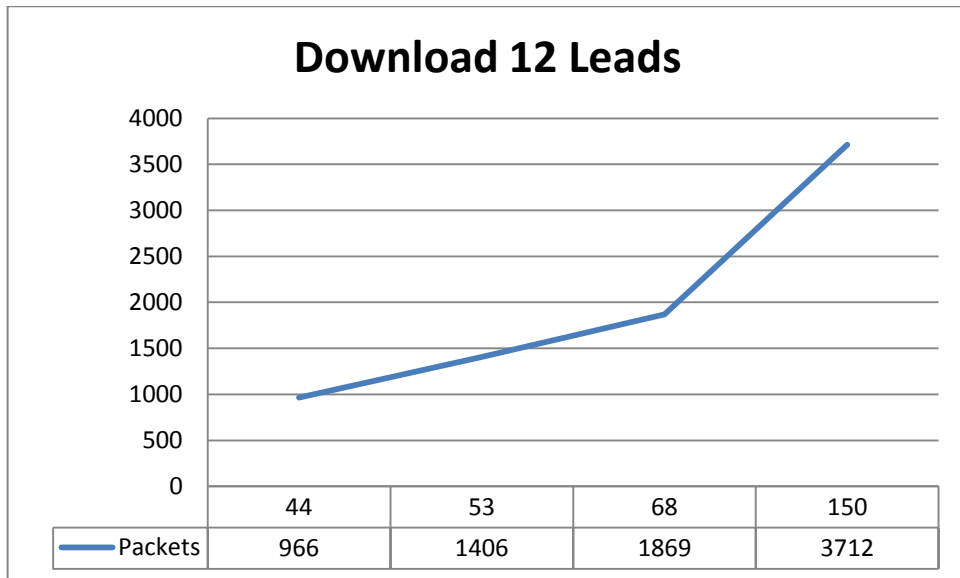
Reference 7.3.3.4: ECG 3 Leads Download

#### 7.3.4 ECG 12 Leads Download

On this scenario we manage to retrieve the data for 12 leads ECG and also a combination with the heart rate data. On this analysis we can notice that even if the data, packets that we retrieve from the database server the times that needs to download them is enough good. We have downloaded the 12 leads ECG in two scenarios, the first scenario was download them without downloading the heart rate and the second one with the heart rate.

Packets	Time
966	44
1406	53
1869	68
3712	150

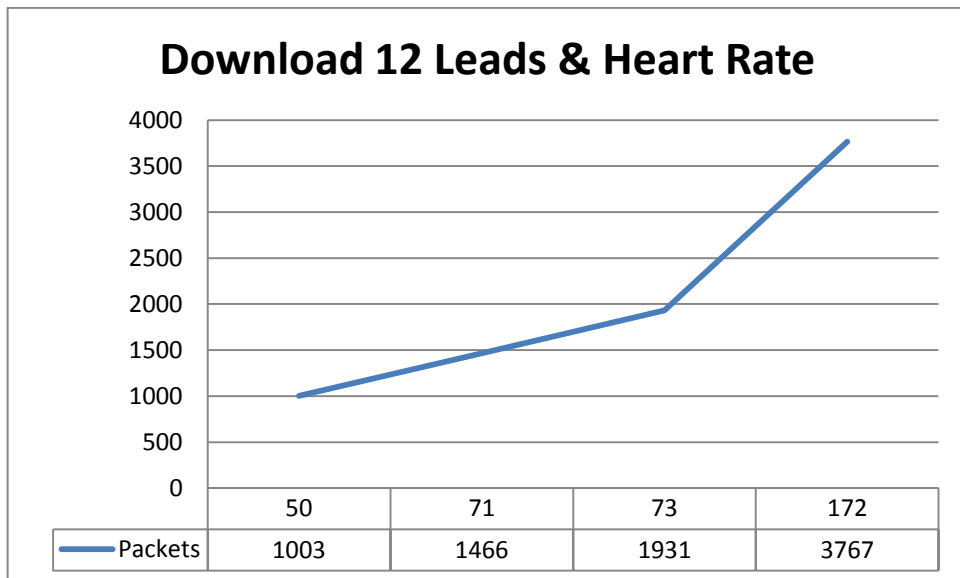
Table 7.3.4.1 ECG Upload matrices



7.3.4.2: ECG Download 12 Leads

Packets	Time
1003	50
1466	71
1931	73
3767	172

Table 7.3.4.3: ECG Upload matrices



Reference 7.3.4.4: ECG Download 12 Leads

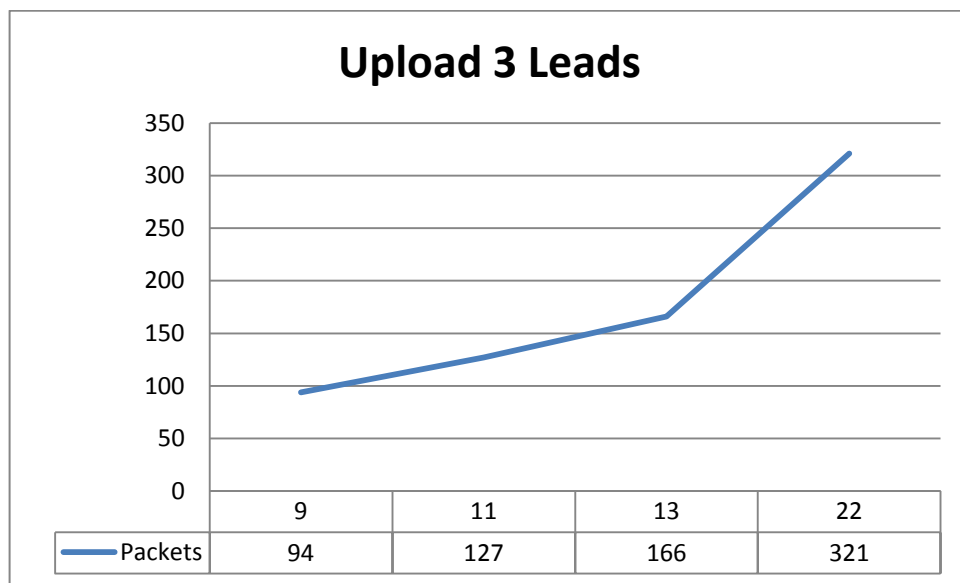
## 7.3.5 ECG and Vital Information's Upload

On this step we will make a combination of information's. We will try to send as many data as we can in order to check the availability of the application and the server and the time that needs in order to send and receive the data.

We use two scenarios in order to check the ability of the application to upload data on the server. The first one was to upload the ECG 3 leads with the heart rate and the second one was the upload of ECG 12 leads with heart rate. Both of them where test with difference sizes of files.

Packets	Time
94	9
127	11
166	13
321	22

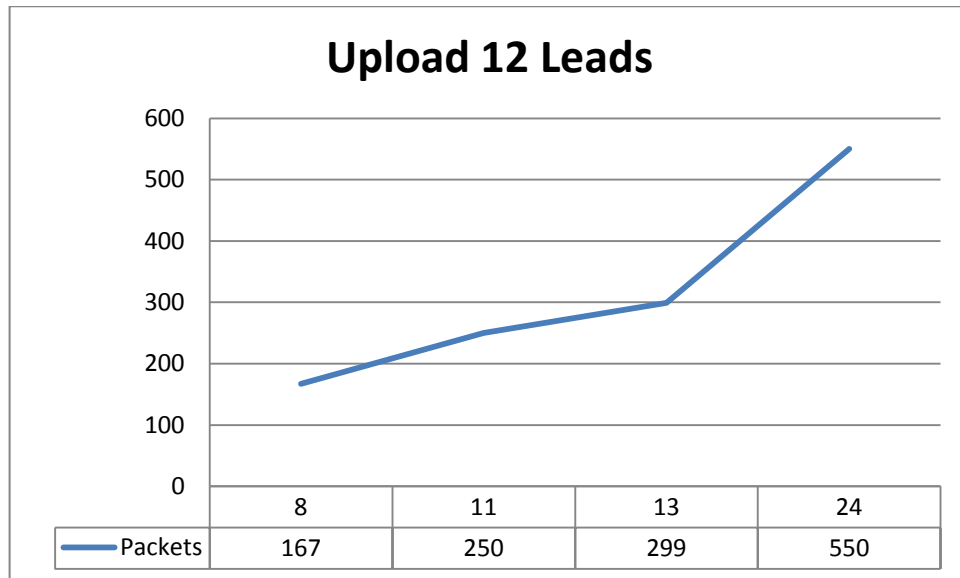
Table 7.3.5.1: ECG Download matrices



Reference 7.3.5.2: ECG 3 Leads Upload

Packets	Time
167	8
250	11
299	13
550	24

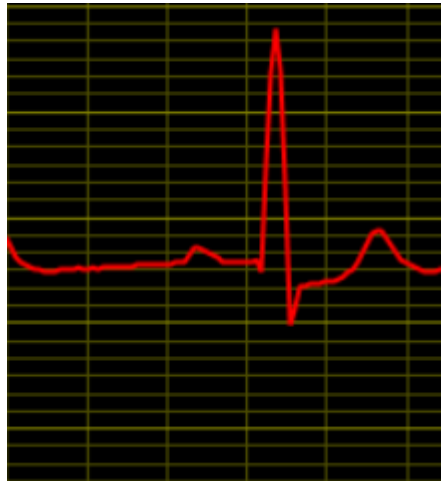
Table 7.3.5.1: ECG Download matrices



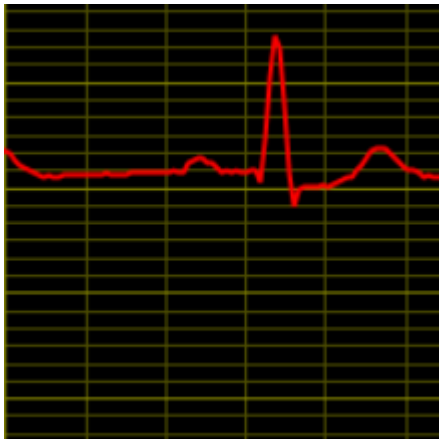
Reference 7.3.5.2: ECG 3 Leads Upload

### 7.3.6 Graph

The plot graph must be validating with the plot graph of the Cardiac Portal web site. When receiving the data from the ECG Device for the Patient Portal must be confirm that when they will be upload to the Database Server of the Application server will be the same graph and also must be the same and with the Doctor Portal graph.



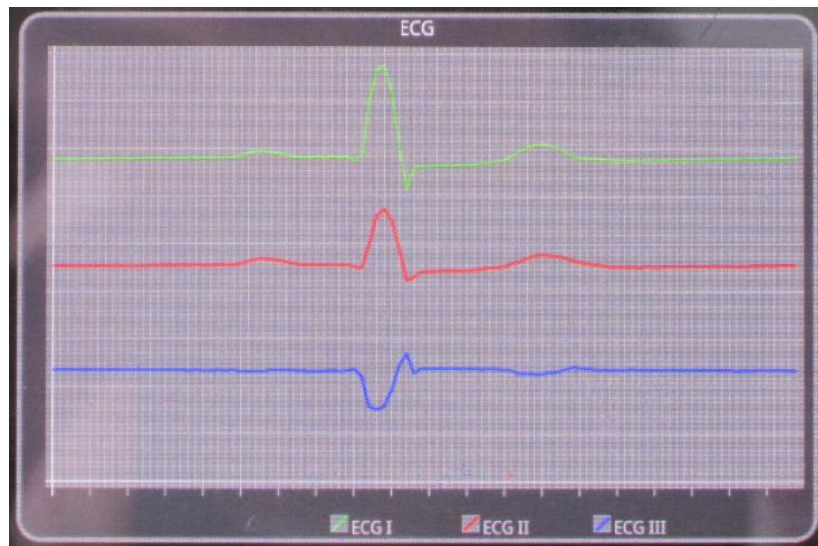
Reference 7.3.6.1: ECG I



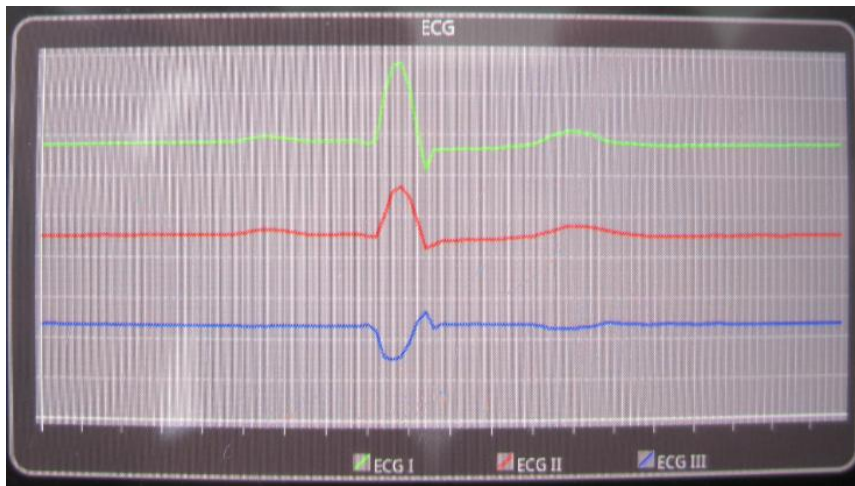
Reference 7.3.6.2: ECG II



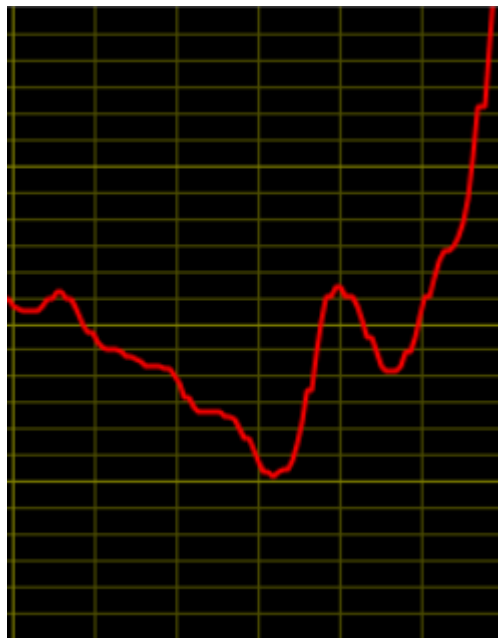
Reference 7.3.6.3: ECG III



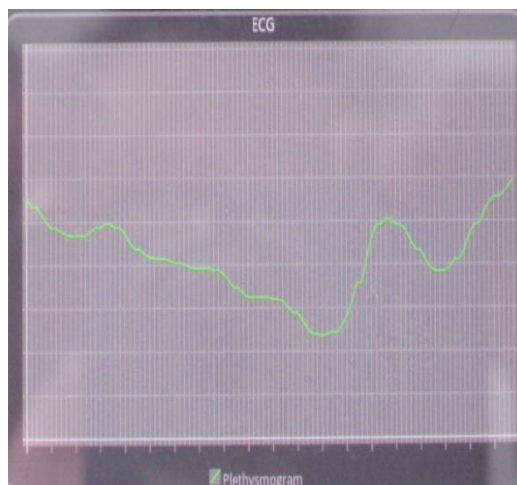
Reference 7.3.6.4: ECG on Doctor Portal



Reference 7.3.6.5: ECG on Patient Portal



Reference 7.3.6.6: Plethysmogram

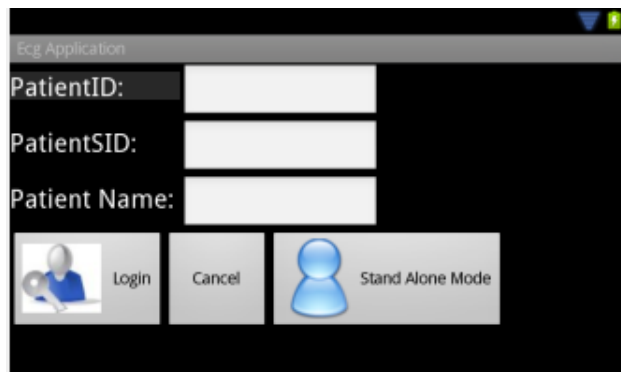


Reference 7.3.6.7: Plethysmogram on Doctor Portal

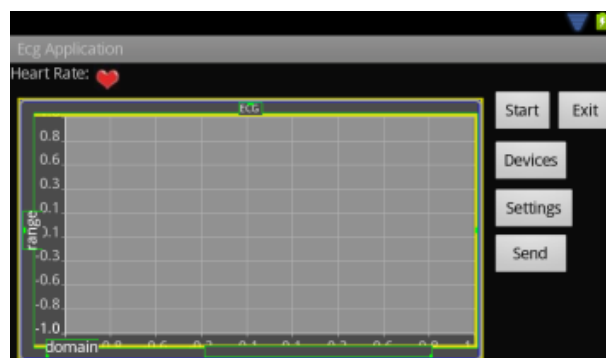
As we can notice on the graph up, the plots are the same. On the Cardiac Portal the range that is been using for the graph is from -3000 to 3000. In our application is in between -5000 to 5000. If we take in mind the ECG I, II, III that we have retrieve from the Cardiac Portal the respectively from our application the fluctuation of the plots are the same. It might be minor difference between them but this is due to the scale that is been using. Beside that we can notice that on the Plethysmogram from the Cardiac Portal and from the Doctor portal, the graph does not have any differences, they are the same.

Using those review we can conclude that the data that are presented on both graphs are correct due to the fact that are exactly the same with the Cardiac Portal in which was tested and is working perfect.

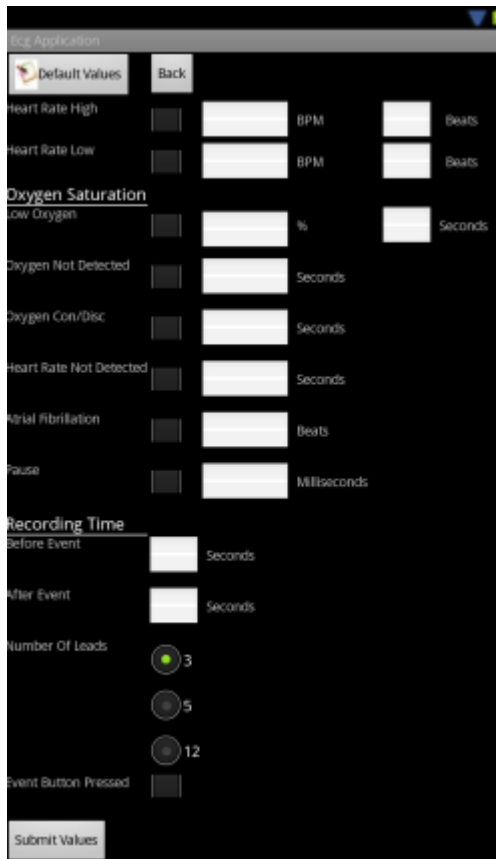
### 7.3.7 Patient Portal Evaluation



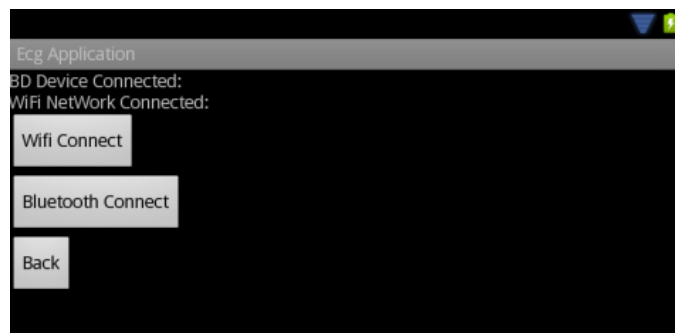
Reference 7.3.7.1: Patient Login Screen



Reference 7.3.7.2: Patient Main Screen



Reference 7.3.7.3: Setup ECG Settings



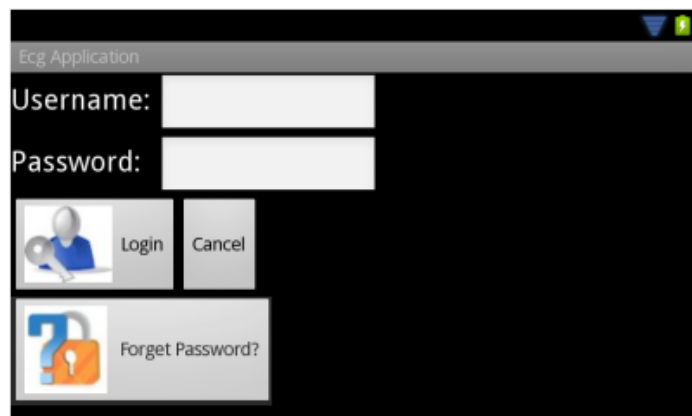
Reference 7.3.7.4: Connect Devices

To the screens up are be display the main screens of the application for the Patient Portal. On screen 7.3.7.1 we can see that is the login screen. In this phase the patient can choose to login on the system by providing it's credentials ids or selecting the stand alone mode in order to continue to the application without full access on the system. In screen 7.3.7.2 is the main screen of the application. The buttons devices and setting will be explained later. On the screen we can view the graph. On the graph will display the different vitals information's of the patient such as ECG I, II, III or V1 etc. The settings button will forward as on the 7.3.7.3 screen. On this screen user will be able to set up the ECG Device according to the proposed directions of the doctor. Furthermore with the start button the

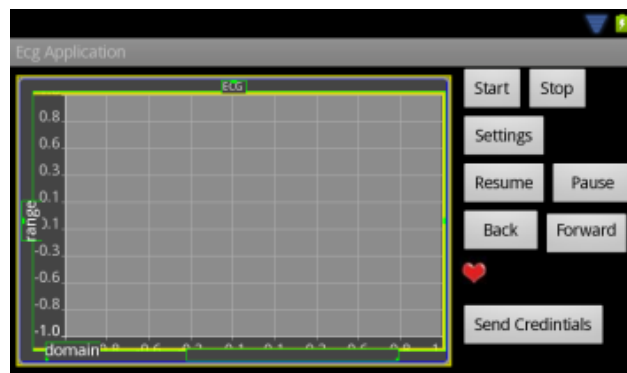


application will start to load from the files the values of the vitals information's and start to display them on the screen. Last with the Devices button will be forward on 7.3.7.4 screen. On this screen user will be able to connect with the Bluetooth ECG device by selecting the corresponding button. It will display a list of all Bluetooth devices and user has to select the correct one. The application is very easy to be used because user can execute the functions that would like without need to navigate to several screens in order to complete it.

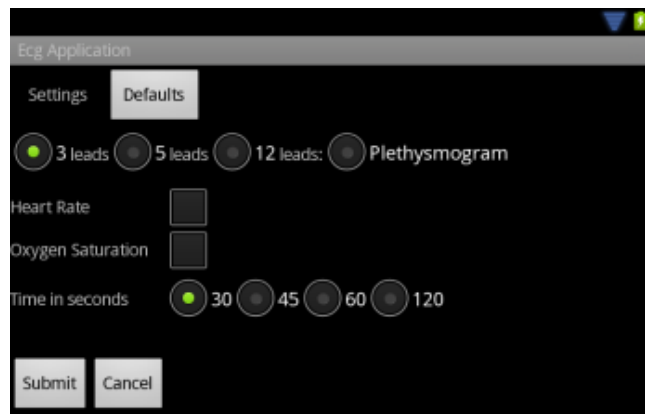
### 7.3.8 Doctor Portal Evaluation



Reference 7.3.8.1: Doctor Login Screen



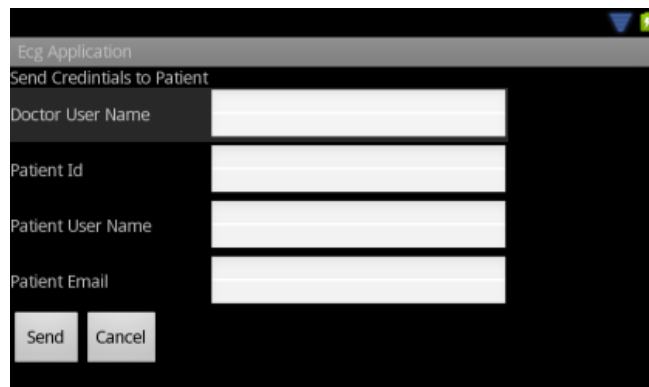
Reference 7.3.8.2: Doctor Main Screen



Reference 7.3.8.3: Settings



Reference 7.3.8.4: Recovery Password



Reference 7.3.8.5: Send Credentials to Patient

To the previous screens are shown the screens of the Doctor Portal site. In screen 7.3.8.1 we can see that in order for the doctor to use the application has to login first by providing its credentials. In screen 7.3.8.2 the main screen of the Doctor Portal. We can notice that they are several buttons and the graph plot. First of all, user has to select the setting buttons in order to setup what information's needs to be download from the server ref fig 7.3.8.3. After user select the settings can press the Start button ref fig 7.3.8.2. The application will start ask from the user some information's corresponding the patient in order to start download the data. When the download is finish will start to display the plot graph. The buttons Resume, Back, Forward and Pause are in order to help the user to move inside the graph. Send Credentials buttons will provide the user to the screen 7.3.8.5 that will fill in the fields in order to send the credentials to the appropriate patient email address. The

screen 7.3.8.4 is been used from the user when has forget its credentials in order to send a new random password that is produce from the application server.

## **7.4 Modularity**

Modularity in programming is defining the style that it breaks down the programs functions into modules. Those modules are in order to accomplishes one function and include all the programming code and the all the needed variables in order to work.

Modularity is a solution from very small programs to huge applications that in that modularity is necessary and compulsory. The program is spit into several functions in which each function is perform some action, can easily debug and determine the errors more easily

Modularity provides the ability to separate jobs and responsibilities between software developers, teams etc. This it help teams to work and cooperate for large projects. Beside that after defining an interface, a module can be change later without affecting users of the module in which this advantage it improves maintainability. Furthermore, is much easier to reuse code. Into a system multiple code segments may use a single module, providing the advance for not re-write the required function in each subsystem but include the existing function. Additional to that modularity helps programmers to be concentrate to their own part. Such as security team can independently create or maintenance a security module, without any interference from the development of the user interface module.

The application provides such modularity. In order to be flexible to any changes and easy readable is been develop upon modularity. Each function of the application is been develop within its own module in which others programmers can easily get the programming code and change whatever is necessary. The application is been develop for two users, the patient and the doctor. For each one of those two users there is one main function in which all the modules are connected and are being using from the mains modules. The main functions they only display the data on the screen, receive and send data between the modules. They are like channels of communication between the other modules.

Modules are named in such a way that can be easily understood from a third person. Such as the Add methods the AddECGAnalyzed12Lead , AddECGAnalyzed3Lead,

AddECGAnalyzed5Lead are the modules that are configured in order to send the data on the Database Server. They are easily understandable what their main purposes are. Besides those all the modules are named in accordance that for better understanding.

Furthermore the programming code of the application of each module is divided into subclasses. Each module consists of several functions inside the module. Each function is designed for one purpose with a readable programming code. Any programmer can read the code and understand what each function is doing and make any changes that are needed.

## **7.5 Conclusion**

During the evaluation of the application it was documented that all ECG and other vital information's are sent on the database correctly with no losses. Upon this which is the main purpose of the system we can conclude that the system is working with success.

Furthermore, during the comparison of the same data between the patients, the doctor and the Cardiac Portal there was no difference between the graphs. Even though a larger scale was used from our application the presentation of the graph was correct and we can notice the fluctuation of the plot.

Moreover on the times that are needed in order to send and retrieve the ECG information's on the server we are very satisfied. Comparing the results, patients will not need at all much time in order to upload the data due to the fact that the transfer was very fast, in which on the other hand the download of the data, the time was not dissuasive for using the application. The matrices that were gathered were made upon the several sizes of files. Actually were made upon the functions that user is able to use in order to select the time of data that needs for downloading the according data from the application server.

# Chapter 8 Conclusion and Future Work

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8.1 Conclusion

8.2 External System to be created

8.3 Internal System to be created

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## 8.1 Conclusion

The rapid technological developments of the 21st century is a powerful tool for improving quality of life of every human and extend the capabilities with purpose to facilitation of his life. The jumps of technology contributed to the development and progress of every type of science.

It is remarkable the fact that the strengthening of multidisciplinary of the information technology and the connection with other sciences like medicine, physics, has led to a high level of knowledge's with purpose to improve the contemporary life of modern human. Situations, ideas that in the past they were imagine as scenarios of science fiction, due to the development of information technology, in our days we can fulfill those ideas with very positive results.

The main purpose of this project was to implement an application in Android device that would contribute to the distance medical support of patients. More specific would help patient that submitted to heart surgery to provide them an environment in order to be more smoothly the period of rehabilitation. This application would help them from unnecessary movements to the hospitals that may sometimes to worsen the situation of the patient. Beside that it will reduce the cost for patient from the movements to and from the hospital and also will reduce the cost for hospitals, due to that the doctor will cherish other patient, the time that medical stuff need for each patient, the beds, etc.

In modern technological society we can find in anywhere Wi-Fi hot spots with high speeds. Cafes, hot spots from Wi-Fi provide, or even in our house we can find a Wi-Fi

network. All the vital information's from the Android application will be send using a Wi-Fi network. It will be no fear of losing any data due to the high quality that all providers support. It was proposed to be used the 3G network for sending and receiving of the data but due to the mass data that would be transfer each time it would be no economic for the user. In Cyprus the 3G network is still expensive. For example 1 GB mobile internet will be cost € 18.30 and each additional MB that is been used, will be cost extra.

I believe that we implement the application in a very stable and helpful stage, that will provide to the user a more easy way to control its cardiac arrhythmias and for the doctor to control the patients that need support. The application is easy to be control from home from the patients of any age and send the information's to the appropriate medical stuff.

## **8.2 External System to be created**

- An ECG device must be buying in order to be provided to the patient. The existing device could not be use due to that Android Devices have some bugs on the Bluetooth settings we could not configure the application to send and receive the data, we have manage to setup a connection. The ECG device that will be got must have in mind to work with Android devices. The device must be able to collect the minimum until 12 leads vital information's and the power autonomy that will has.
- The analyses of the ECG could not be done on the Android device. In order to make analyses of the information's it will cost to the device CPU and time. If the analysis is being done on the upload time it will delay until the information's would uploaded on the server taking too much time to be done. The analyses can be done on the server, the moment that the data are uploaded on the server and saved on a temporary table a service could fire up a task in order to make the analysis and save the data in the main ECG table.
- The system could not be only to be use from people with cardiac arrhythmias but also can be used from home user to check there ECG, blood pressure, etc. For example on ambulance they only check until 5 leads. The application can be setup to display with standard settings with no need to change them. When a tablet device exist it will be easy for the ambulance medical personnel to use it combine with an ECG Device.

- The methods AddBloodPressure, getOxygenSaturation and getBloodPressure from the web-service could not be establish due to that are using pointers and could not find a way to pass that problem in order to download and that values. Even thought on the application the fields and text values are ready and the connection with the web-service for future solution.

### **8.3 Internal System addition work**

- The blood pressure device was not connected on the application due to there was no device that would support the system. It will be easy to be setup on the future the moment that the Bluetooth connection is already working and the transfer of data between two devices are working without losing any data.
- The application was implementing using an Android Smartphone device. The screen of the device is 3.7 inches touch screen in which is a small screen. It could get a tabled with a bigger screen in order to view better the graphs that are display and will be more usable.

#### **Proposed Tablets**

- Tablet SAMSUNG GALAXY TAB P7510

Operating System: Android 3.0 (Honeycomb)

Memory: 16GB

Touch Screen: TFT 10.1" με ανάλυση 1280 x 800 HD

CPU: NVIDIA Tegra 2 1 GHz, Dual Core ARM cortex

Connections: Bluetooth, Wi-Fi 802.11 (a/b/g/n)

- Tablet ARCHOS 101 G9 Turbo 101 G9

Operating System: Android 3.2 Honeycomb

Memory: 16GB

Touch Screen: 10.1" LCD capacitive

CPU: OMAP 4 ARM CORTEX smart multi-core A9 1.2 GHz

Connection: USB, Wi-Fi 802.11 b/g/n, Bluetooth 2.1 + EDR,

The proposed tablets they fulfil the minimum technical characteristics in order for the application to be compatible with the tablets. The Archos has a newer Operating system than the Samsung in which is not a problem because can be updated, beside that the CPU of the Samsung is much better than this of Archos. According the other characteristics are the same so there is no problem which one to chose. The only that characteristic that we should take in mind is the CPU and my opinion is to get the SAMSUNG that has better CPU and update the Operating System from the manufacturer support web site.

- When the doctor downloads the data, it has to download all the data and then it start to display them on the graph. A smart and difficult, but efficient way to be done, it to use buffer. It can start download until a point and then to start display the data but in the same time to continue downloading the rest of the data.
- Could incorporate a function in the application in order when the patient don't fill well or there is a problem with the analysis will send a message to the medical center in order to provides help to the patient.
- Furthermore in order to minimize the time for send and receive the data it could be used a compress method. Before the data would be send or receive to be compress with an algorithm, this can be done in upload the phase that patient is receiving the vital information's, those data to be compress in order not to be needed when it will be upload them in order to reduce the time that is needed to upload them. Also on the doctor when it tries to download them from the Application server to compress them, in order the phase to takes for less time.
- Video-Conference can be developed on the existing application for better communication between the patient, the assistance and the remote medical stuff. Could provide the ability to the doctor to examine the patient remotely, to inspect the patient for any beatings, injuries, rashes on patient body that could affect the current illness of the patient



- Photo-snapshot could be used in order to provide an extra help on the doctor in cases that cannot carry a video conference. Besides that, photo snapshots could be kept for history in the patient file for future use.

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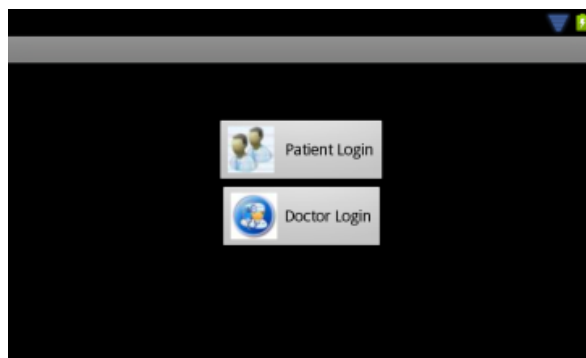
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# Appendix I - User Manual

## 1. Start applications

When the user start the application has to choose between the two types of the users. Must be selected the Patient or Doctor Portal side, in order to be forward to the corresponding Login Site ref fig I-1.

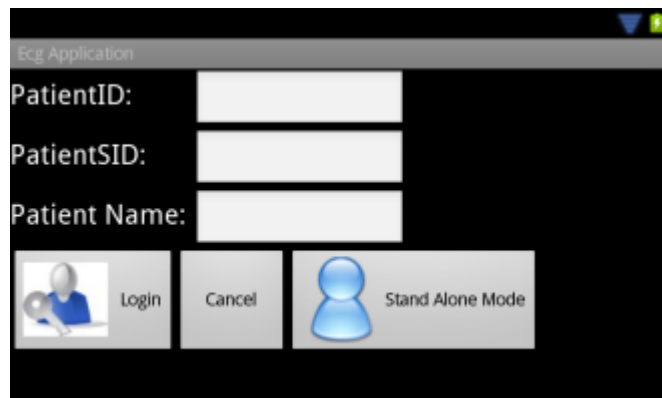


Reference I-1

## 2. Patient Portal Side

### 2.1 Login Site

The user can select between two modes of the Patient Portal site. Can choose either to add the credentials to continue as an authenticated user with full access on the application or can select the Stand Alone Mode ref fig I-2.1.1.



Reference I-2.1.1

## 2.2 Connect ECG Devices

User select from the menu to connect to devices. Select the Bluetooth Connect button and display a list to the user with all paired and not paired Bluetooth devices on the range of the application device. Then selecting the correct ECG devices from the list, the application will try to connect to the corresponding Bluetooth device ref fig I-2.2.1, ref fig I-2.2.2.



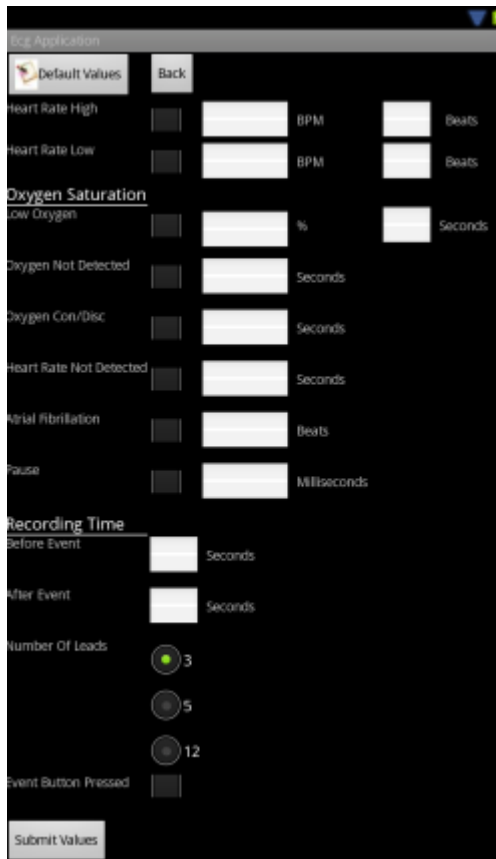
Reference I-2.2.1



Reference I-2.2.2

### 2.3 Setup ECG Device

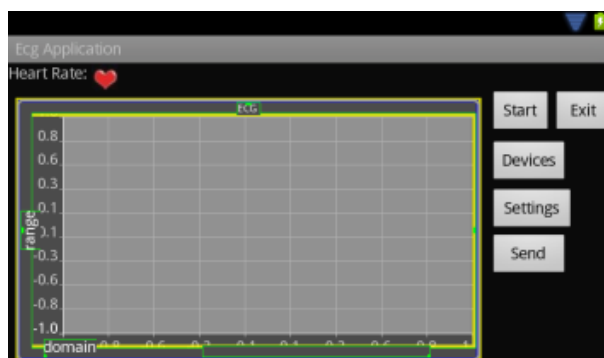
Selecting from the menu the Settings button will display to the user the form in order to set up the ECG Device. From this form can select the leads, the heart rate etc. Or can select the Default Values and save the selections ref fig I-2.3.1.



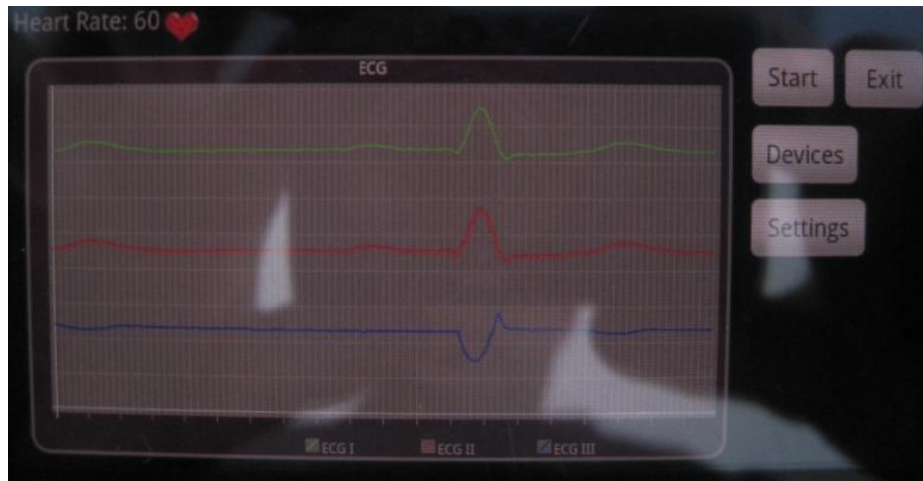
Reference I-2.3.1

## 2.4 Start Recording

When user connects with the ECG Device can select the start button from the main screen. When is pressed will start to reading the data and display them on the screen ref I-2.4.1; ref fig I-2.4.2. When it finishes the preview of the data a pop up question will be appeared in order to confirm with the user, is willing to send the information's on the server.



Reference I-2.4.1

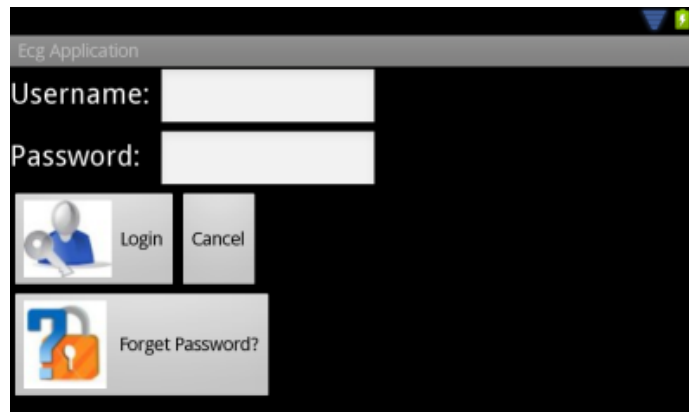


Reference I-2.4.2

### 3. Doctor Portal Site

#### 3.1 Login Site

User has to login on the system, providing its credentials username and password in and will login button will send the credentials to the server in order to confirm them and authenticate the user. If user is authenticated then it forwards them to the main form of the Doctor Portal site ref fig I-3.1.1.



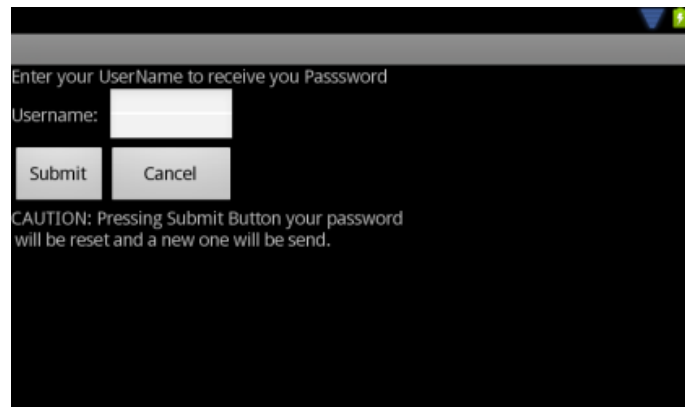
Reference I-3.1.1

#### 3.2 Password Recovery

In case that user forgets its password can choose the Forget Password button in order to forward him in the appropriate form to fill in his username. When user



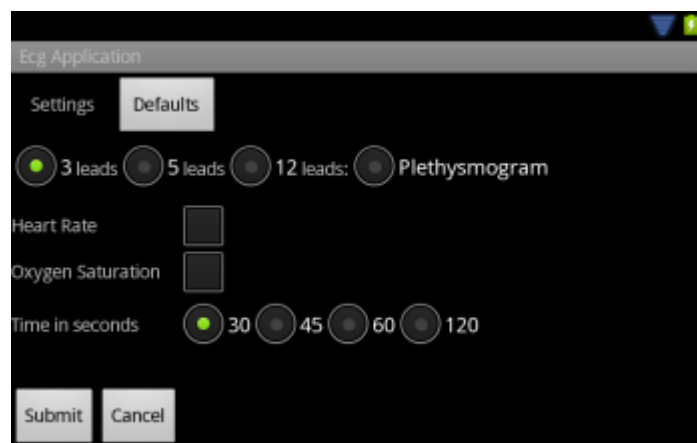
fill in the username, will press the Submit button and the system will send to them the new random password to the user email address ref. Fig I-3.2.1



Reference I-3.2.1

### 3.3 Select Vital Information's

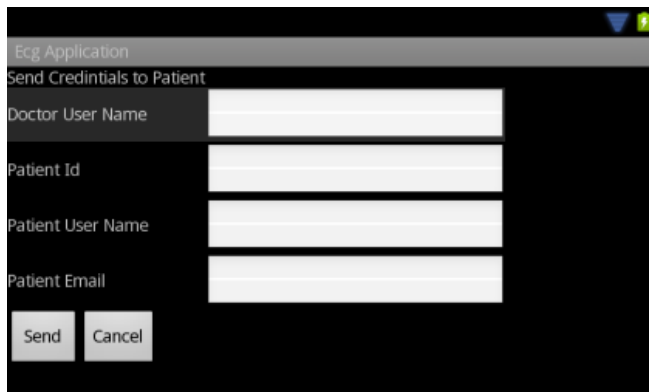
Before start download the data of the specific patient user has to set up and select what data would like to download. Can choose the type of ECG and other vital information's or just select the default button I-3.3.1.



Reference I-3.3.1

### 3.4 Send Credentials

When a user needs to send the credentials of a patient needs to follow the next steps. From the main screen select the button Send Credentials that will take as in the screen I-3.4.1. Next user has to fill in all the fields and then with the send button will be send the credentials to the patient email address.

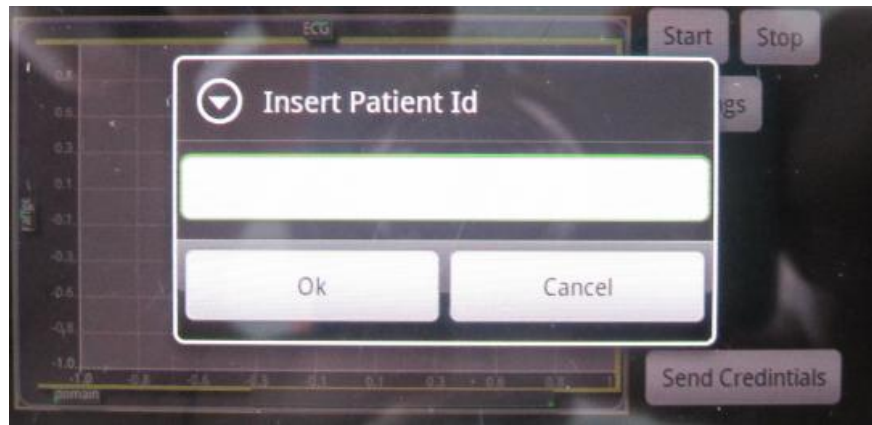


Reference I-3.4.1

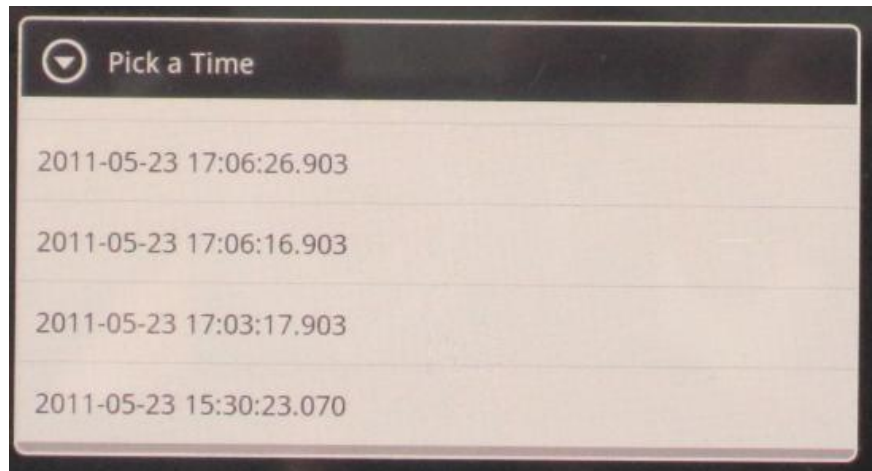
### 3.5 Main Screen

When user has set up the setting can select the Start button. When it selects it a pop up box is appeared ref. Fig. I-3.5.1. User adds the patient id on the box and a pop up drop down list is appeared ref. Fig. I-3.5.2. On the drop down list it appeared all the date time stamps for the certain patient for the certain setting that were chosen before. If other ECG type was chosen then it might be other data time stamps. User select one from the data time stamps and the application call the web-service with the appropriate methods and start download the information's of the patient ref. Fig. I-3.5.3. After it finish downloading it start loading on the graph the data ref. Fig. I-3.5.5.

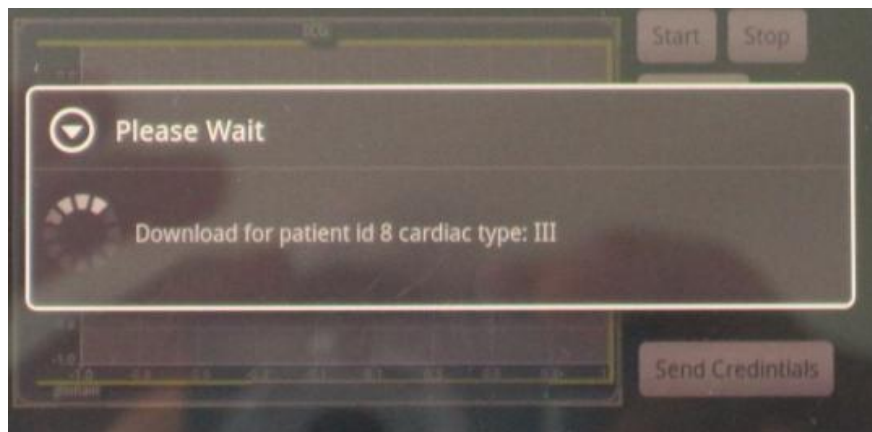
Using the button Pause, Resume, Back, Forward can move inside the data ref. Fig. I-3.5.4. If the Pause button pressed then it can move Back on the data and with the Resume button can start again display the data from the step that it was move. When it finishes display the data with the Resume button can display again the same data without need to download again the information's.



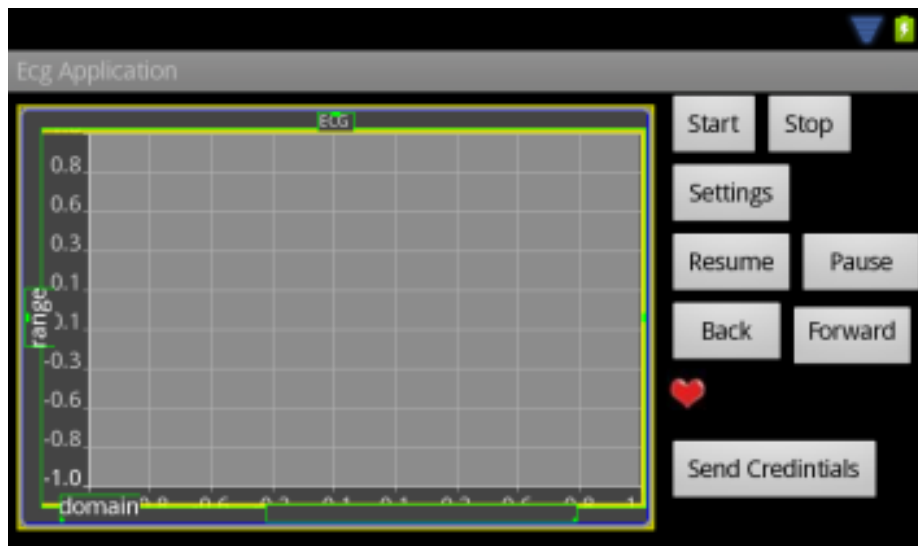
Reference I-3.5.1



Reference I-3.5.2



Reference I-3.5.3



Reference I-3.5.4



Reference I-3.5.5

# Appendix II - Installation Phase

## 1. System Installation Method

The application will be able to be installing on Android Devices. In order this do be done an .apk file is been created. The certain .apk file in order to install it on the device the following method must be follow.

1.1 Copy the APK file to the root directory of your memory card.

1.2 Download an application called **Apps Installer** or any File Manager from the Android Market. Install it and start the application.

1.3 In the Apps Installer application, you will see a list of the APK files stored in the root directory of your memory card.

1.4 Select the APK you want to install and you are done. You can now access the application from the menu.

## 2 Files Installation

The application in order to be working it needs some files. Those files are been created automatically for the first time that the application is been started. Beside that each time that the application start it makes a check on the memory card if the certain folders and files exist. If some of them are deleted then it creates them.