

SUMMARY

One of the major factors limiting but also causing the application of modern technology in medicine is the response time to patients, should they need specialized medical care. In this thesis we propose a solution that can help and improve the patients' life. Patients, after a heart surgery, have to visit the hospital for a small period of time for a routine check which can take only a few minutes. The aim of this project is to give the opportunity to these patients to be monitored at home after their operation and not visit the hospital every day. On the other hand, the doctor can use his time seeing other patients. Furthermore he can view his patient's vital information from his office at any time that he desires.

The vital information that can be measured by the proposed system is the blood pressure, oxygen saturation, weight and last but most important is the patient's ECG at for at least five minutes. The ECG will be analyzed by the system using a specific algorithm that recognizes some predefined types of arrhythmias. This algorithm was implemented during a previous project and it will be incorporated in this project. The ECG can be shown to the doctor when he wishes to see it. Furthermore the system can preview the ECG with the analyzed information in order to help the doctor. In addition statistics and scores can be measured before and after the patient's treatment and can be used to find some important results concerning his/her heart condition. This project can improve the life quality of patient after his/her surgery.

POST-CARDIOSURGERY HOME MONITORING SYSTEM

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Chapter 1

Introduction

-
- 1.1 Overview Narrative
 - 1.2 Project Purpose
 - 1.3 Project Structure
-

1.1 Overview Narrative

The phenomenon of ageing population nowadays constitutes one of the most complex problems of modern societies. The progress in science and the improvement of hygiene, diet and health conditions resulted to an increase of the average duration of life expectancy by 20 years internationally during the last fifty years (1950-2000), while a further increase is expected if current demographic tendencies continue. Cypriot population is also experiencing demographic ageing (Eurostat, 2006). Elderly's percentage in Cyprus was 11.65% in 2001. It is expected to increase up to 28.71% of the whole population until the year of 2025 (Eurostat, 2006). The ageing of population and the increase of the living cost considerably will lead to increasing demands for health and social care, affecting health care systems (Lambrinou, et al., 2009; Drennan, et al., 2004; Treharne, 1990).

To cope with the challenges, effective delivery of health and social care will require multi-disciplinary approach to design appropriate and cost effective solutions (de Bruin, et al., 2009;

Koch, and Hagglund, 2009). Also, the issue of domiciliary living and care is gaining prominence in the research literature (Ryan, et al., 2009).

Cardiovascular diseases and diseases related to arrhythmias are a problem that affects a large percentage of the population, and it is one of the main reasons for death in Europe. The advantage of the rapid technology evolution, regarding the internet, the mobile phones, the wireless communications and vital parameter sensors is that Man has managed to produce revolutionary medical monitoring systems, which noticeably improve the lifestyle of patients.

The system that we are going to deal with has as its main purpose to make it easy for doctors to see and review the patient's progress, after a cardio surgery when they are released to go home.

Like every web-based application, in order to achieve a respectable level of status, the system must offer substantial services. Some typical facilities that our system includes are: doctor registration, doctors must have the ability to help each other with some patients, patient's ECG must be provided to the system in order to be displayed to the doctor, the ECG, in the case that it is not analyzed, it must be analyzed with the aim of giving the doctors helpful information.

Another objective of this system is to help patients. With the use of this system they don't have to visit the hospital almost every day just for some minutes. With the help of specialized sensors and other equipment, vital information like ECG, weight, blood pressure and oxygen saturation will be collected by the patient and sent automatically to the doctor. After that, the doctor can process that information and decide what action he/she must take. The solution that will be taken at the patient's home is not going to be implemented at this stage of the project.

The current project will build upon and further past research, incorporating multiple, disparate technologies in one cohesive system focussing on the reasoning and inferencing components of the system via the application of innovative machine learning techniques and transferring this into a viable home automation-based product that can handle this complex domain and meet the needs of elders. Additionally, will focus on the development of an automated monitoring and care provision system based on a set of dedicated software applications running on top of a platform designed to allow mobile context-aware applications to focus on the real-world activity domain sensing, activity recognition and medical monitoring of elderly people. The whole system will be based on novel sensor network technologies, signal processing techniques as well as several telemedicine technologies in order to achieve monitoring functions.

1.2 Project purpose

Cardiovascular diseases are a problem that affects a big percentage of the population, with many subjects needing. When a patient has to undergo a surgery he/she has to visit the hospital every day, at least the first 15 days in order to get his/her vital information. That information is the ECG, the weight, blood pressure and finally the oxygen saturation. This action consumes a lot of the doctor's time and effort; furthermore the patient has to visit the hospital every day, and this is not the best solution for the patient because not everybody lives near the hospital.

With the help of technology we can provide a system that will control and help both parties, the patients and the doctors. Technology nowadays provides several tools that can be used to manage this. Several sensors are going to be used in order to get the patient's ECG and send it to the system. The patient has to measure his/her weight, his/her blood pressure and with the help of a sensor he/she will calculate his/her oxygen saturation. That information will be recorded by the system and will be displayed to the doctor.

With this system it is not necessary for the patient to visit the hospital every day. The doctor is able to view the vital information that he needs from the system without the need of the patient to be there.

The phenomenon of the aging population is one of the biggest challenges in the Western society, including Cyprus, as it addresses the needs of 50% of the active population in 2050 in an economically sustainable and effective way. In view of the complexity of older peoples' needs, it is clear that older people need an important degree of resource with their daily activities, both from formal and family carers, including the scientific, the economic and the community resources. Without this input it is difficult to envisage them remaining in the community. The ultimate aim of health informatics is to create a safe environment in the community and their home, improving the quality of care and the quality of life (living in their place, outside a hospital or a nursery) in a cost-efficient way.

The scientific objectives of this project will focus on a multidisciplinary approach, combining the novel application of innovative software with advanced capabilities, health monitoring devices, as well as low-cost wireless sensor networks, and home automation technology and systems in order to transform elderly homes into affordable Secure Intelligent Assisted Living environments, where our growing numbers of the elderly can live safely and independently.

More specifically the objectives are:

1. Trigger clinicians to the early signs and symptoms of decompensation by telemonitoring the electrocardiogram (ECG), non invasive blood pressure (BP), heart rate (HR) and oxygen saturation (SpO₂).
2. Reduce the risk of house hazards (eg fire hazards, falls, accidents) by monitoring safety and
3. Promote health associated quality of life by monitoring routine tasks and activities (eg whether an elderly is eating regularly, takes his medication in regular time answering the phone etc)

1.3 Project Structure

This thesis has the following chapter structure:

- **Chapter 2 – Theoretical Background:** The second chapter contains the necessary information about Electrocardiography (ECG), e-health systems and necessary information concerning previous work.
- **Chapter 3 – System Requirements:** In this chapter we are going to examine the system that we are going to implement and on the other hand we are going to see the functional specifications of the system.
- **Chapter 4 – System Specifications:** In this chapter we are going to examine all the input and output information that we collect from the users.
- **Chapter 5 – System Design:** Chapter five analyzes all the information for the design the system.
- **Chapter 6 – Implementation Phase:** In this chapter we describe in detail how the system will be designed and implemented. We are going to see what tools are going to be needed.

- **Chapter 7 – Installation Phase:** In this chapter we are going to list the necessary information needed for the project installation.
- **Chapter 8 – System Evaluation Phase:** In this chapter we are going to provide information concerning the system testing and evaluation.
- **Chapter 9 – Conclusions and Future Work:** In this chapter we are going to see the conclusions and future work.

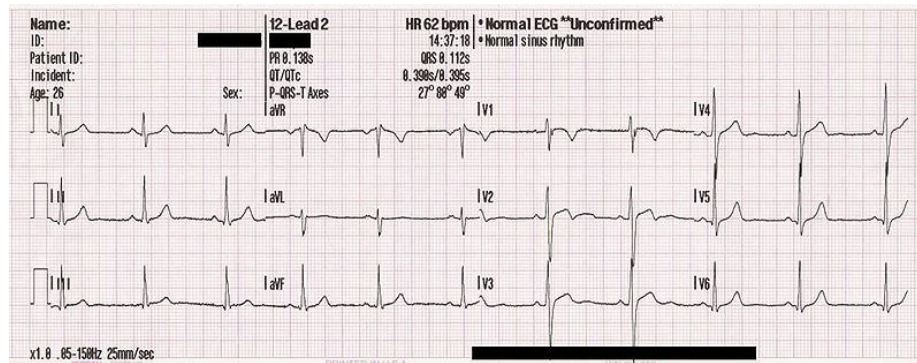
Chapter 2

Theoretical Background

-
- 2.1 Electrocardiography (ECG)
 - 2.2 Characteristics of Normal-ECG
 - 2.3 ECG Rhythms
 - 2.4 Web Applications and health systems
-

2.1 Electrocardiography (ECG)

“**Electrocardiography (ECG or EKG)** is a transthoracic interpretation of the electrical activity of the heart over time captured and externally recorded by skin electrodes. It is a noninvasive recording produced by an electrocardiographic device. The etymology of the word is derived from electro, because it is related to electrical activity, cardio, and graph” [1], refer to fig. 2.1.1.



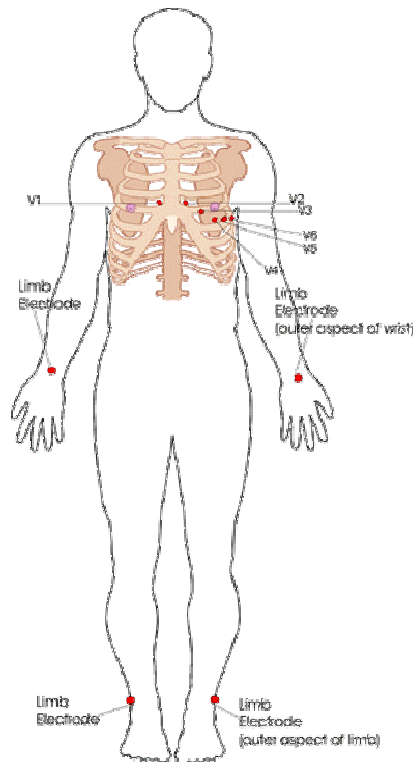
Reference 2.1.1: ECG of a 26 year old male

Electrical impulses in the heart originate in the sinoatrial node and travel through the intrinsic conducting system to the heart muscle. The impulses stimulate the myocardial muscle fibers to contract and thus induce systole. The electrical waves can be measured at electrodes placed at specific points on the skin. Electrodes on different sides of the heart measure the activity of different parts of the heart muscle. An ECG displays the voltage between pairs of these electrodes, and the muscle activity that they measure, from different directions, can also be understood as vectors. This display indicates the overall rhythm of the heart and weaknesses in different parts of the heart muscle. It 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. In a myocardial infarction (MI), the ECG can identify if the heart muscle has been damaged in specific areas, though not all areas of the heart are covered. The ECG cannot reliably measure the pumping ability of the heart, for which ultrasound-based (echocardiography) or nuclear medicine tests are used [1].

2.1.1 Placement of electrodes

Ten electrodes are used for a 12-lead ECG. They are labeled and placed on the patient's body as follows [1]:

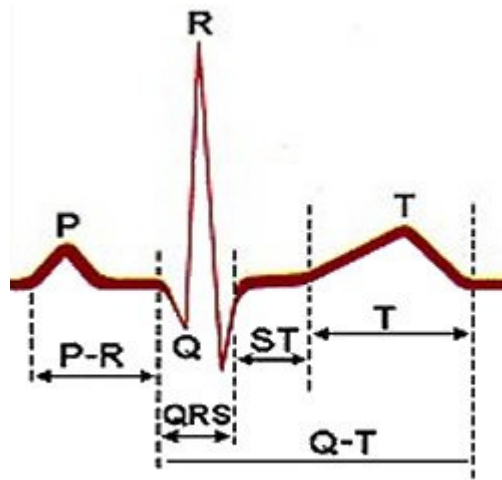
- **RA** - On the right arm.
- **LA** - In the same location that RA was placed, but on the left arm this time.
- **RL** - On the right leg.
- **LL** - In the same location that RL was placed, but on the left leg this time.
- **V1** - In the *fourth* intercostal space (between ribs 4 & 5) just to the *right* of the sternum (breastbone).
- **V2** - In the fourth intercostal space (between ribs 4 & 5) just to the left of the sternum.
- **V3** - Between leads V2 and V4.
- **V4** - In the fifth intercostal space (between ribs 5 & 6) in the mid-clavicular line.
- **V5** - Horizontally even with V4, but in the anterior axillary line.
- **V6** - Horizontally even with V4 and V5 in the midaxillary line.



Reference 2.1.2: ECG Leads - Views of the Heart [4]

2.2 Characteristics of Normal ECG

The normal EKG (ECG) is composed of a **P** wave, a **QRS** complex and a **T** wave. The **P** wave represents atrial depolarization and the **QRS** represents ventricular depolarization. The **T** wave reflects the phase of rapid repolarization of the ventricles [2]. **P wave** represents atrial depolarization, it is the time necessary for an electrical impulse from the sinoatrial (SA) node to spread through the atria musculature. The **QRS** complex represents the Ventricular contractions. And finally T wave is the electrical activity produced when the ventricles are recharging for the next contraction (repolarizing). The electrical activity results in P, QRS, and T waves that are of different sizes and shapes. When viewed from different leads, these waves can show a wide range of abnormalities of both the electrical conduction system and the muscle tissue of the heart's 4 pumping chambers [4].



Reference 2.2: Schematic representation of a normal ECG [2]

The **P-Wave** starts before the QRS complex. It should not exceed 2.5mm in height. Its duration must be between 0.06 and 0.11 seconds.

The **P-R Interval** represents the time it takes for an impulse to travel from the atria through the AV node, bundle of His, and bundle branches to the Purkinje fibres [4]. It extends from the beginning of the P wave to the beginning of the QRS complex. It lasts from 0.12 to 0.20 seconds.

The **QRS Complex** represents ventricular depolarisation. It consists of three waves: the Q wave, the R wave, and the S wave. The Q wave is placed at the beginning of the QRS complex. Q may not be present. On the other hand the R wave is always the first positive deflection. Furthermore the S wave, the negative deflection, follows the R wave. The QRS follows the P-R interval. QRS normal values vary with age and sex. Its duration must be no longer than 0.10 seconds.

The **Q-T Interval** represents the time necessary for ventricular depolarization and repolarization [4]. It extends from the beginning of the QRS complex to the end of the T wave (it includes the QRS complex, S-T segment, and the T wave). Its duration varies according to age, sex, and heart rate.

The **T Wave** represents the repolarization of the ventricles. On rare occasions, a U wave can be seen following the T wave. The U wave reflects the repolarization of the His-Purkinje fibres [4]. It follows the S wave and the S-T segment
Amplitude: 5mm or less in standard leads I, II, and III; 10mm or less in precordial leads V1-V6. Its duration is not usually measured.

The **S-T Segment** represents the end of the ventricular depolarization and the beginning of ventricular repolarization [4]. It extends from the end of the S wave to the beginning of the T wave. Its duration is not usually measured.

2.3 ECG Rhythms

2.3.1 Normal Sinus Rhythm

The ECG Rhythm is regular, the Rate is between 60 and 100 bpm. The QRS duration is normal. The P Wave is visible before each QRS complex. On the other hand P-R Interval is Normal is <5 small Squares. Anything above this would be 1st degree block [4]. This indicates that the electrical signal is generated by the sinus node and travelling in a normal fashion in the heart [4].



Reference 2.3.1: Normal Sinus Rhythm [4]

2.3.2 Sinus Bradycardia

The heart rate in this case is less than 60 beats per minute (BPM). In the case of an athletic person this is may be “normal”, but other causes may be due to increased vagal tone from

drug abuse, hypoglycemia and brain injury with increased intracranial pressure (ICP). We can see from the ECG example that the rhythm is regular, but the rate is less than 60 beats per minute. On the other hand the QRS duration is normal. In this case the P wave is visible before each QRS complex. Furthermore the PR interval is normal.



Reference 2.3.2: Sinus Bradycardia [4]

2.3.3 Sinus Tachycardia

In this case we can observe an excessive heart rate above 100 beats per minute (BPM) which originates from the SA node. It can be caused by stress, fright, illness and exercise. Not usually a surprise if it is triggered in response to regulatory changes e.g. shock. But if there is no apparent trigger then medications may be required to suppress the rhythm [4].

We view that rhythm is regular. The heart rate is more than 100 beats per minute. On the other hand QRS Duration is normal. P Wave is visible before each QRS complex. But P-R interval is Normal. The impulses generating the heart beats are normal, but they are occurring at a faster pace than normal. Seen during exercise [4].



Reference 2.3.3: Sinus Tachycardia [4]

2.3.4 Supraventricular Tachycardia Abnormal

A narrow complex tachycardia or atrial tachycardia which originates in the 'atria' but is not under direct control from the SA node. SVT can occur in all age groups[4]. The rhythm is regular. In this case the heart Rate is between 140 and 220 beats per minute. The QRS duration is usually normal. The P wave is often masked in the preceding T wave. P-R interval depends on the site of the supraventricular pacemaker [4]. Impulses stimulating the heart are not being generated by the sinus node, but instead are coming from a collection of tissue around and involving the atrioventricular (AV) node [4].



Reference 2.3.4: Supraventricular Tachycardia (SVT) Abnormal [4]

2.3.5 Atrial Fibrillation

Many sites within the atria are generating their own electrical impulses, leading to irregular conduction of impulses to the ventricles that generate the heartbeat. This irregular rhythm can be felt when palpating a pulse [4]. We observe that rhythm is irregularly irregular. Furthermore the Heart Rate is usually between 100 and 160 beats per minute, but in the case of medication it is slower. The QRS duration is usually normal. The P wave is not distinguishable as the atria are firing off all over [4]. PR interval is not measurable. The atria fire electrical impulses in an irregular fashion causing irregular heart rhythm.



Reference 2.3.5: Atrial Fibrillation [4]

2.3.6 Atrial Flutter

In this case the rhythm is regular. The heart rate is around 110 beats per minute. The QRS duration is usually normal. We notice that the P wave is replaced with multiple F (flutter) waves, usually at a ratio of 2:1 (2F - 1QRS) but sometimes 3:1. The p wave rate is 300 beats per minute. Furthermore the PR interval is not measurable. As with SVT the abnormal tissue generating the rapid heart rate is also in the atria, however, the atrioventricular node is not involved in this case.



Reference 2.3.6: Atrial Flutter [4]

2.3.7 1st Degree AV Block

1st Degree AV block is caused by a conduction delay through the AV node but all electrical signals reach the ventricles. This rarely causes any problems by itself and often trained athletes can be seen to have it. The normal PR interval is between 0.12s to 0.20s in length, or 3-5 small squares on the ECG [4].

In this case the rhythm is regular as well as the heart rate, QRS duration and P wave rate are normal. On the other hand P wave duration is 1:1. PR interval is prolonged >5 small squares.



Reference 2.3.7: 1st Degree AV block [4]

2.3.8 2nd Degree AV Block Type 2

When electrical excitation sometimes fails to pass through the A-V node or bundle of His, this intermittent occurrence is said to be called second degree heart block. Electrical conduction usually has a constant P-R interval; in the case of type 2 block atrial contractions are not regularly followed by ventricular contraction [4].

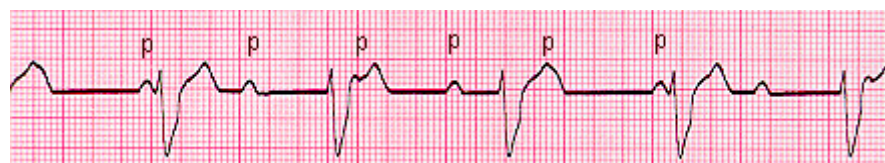
We can notice from the diagram that the Rhythm is Regular. Heart Rate is normal or slow. On the other hand QRS duration is prolonged. P Wave Ratio is 2:1 or 3:1. The P Wave rate is normal but faster than QRS rate. Furthermore the PR Interval is normal or prolonged but constant.



Reference 2.3.8: 2nd Degree AV block type 2 [4]

2.3.9 3rd Degree Block

3rd degree block or complete heart block occurs when atrial contractions are 'normal' but no electrical conduction is conveyed to the ventricles. The ventricles then generate their own signal through an 'escape mechanism' from a focus somewhere within the ventricle. The ventricular escape beats are usually 'slow' [4]. We can observe that the rhythm is regular. But on the other hand the heart rate is slow. QRS duration is prolonged. The P wave is unrelated and the rate is normal but faster than the QRS rate. The PR interval has variations. Complete AV block. No atrial impulses pass through the atrioventricular node and the ventricles generate their own rhythm.



Reference 2.3.9: 3rd Degree block [4]

2.4 Web Applications and health systems

2.4.1 Web Application

In software engineering, a web application is an application that is accessed via a web browser over a network such as the internet or an intranet [1]. The term may also mean a computer software application that is hosted in a browser-controlled environment and reliant on a common web browser to render the application executable [1].

2.4.2 Healthcare Information Systems

Healthcare Information Systems; also they often refer to software solutions for appointment scheduling, patient data management, work schedule management and other administrative tasks surrounding health. Whether these tasks are part of eHealth or not depends on the chosen definition; they do, however, interface with most eHealth implementations due to the complex relationship between administration and healthcare at Health Care Providers [1].

2.4.3 e-Health system

eHealth (also written e-health) is a relatively recent term for healthcare practice which is supported by electronic processes and communication. The term is inconsistently used: some would argue it is interchangeable with health care informatics and a sub set of health informatics, while others use it in the narrower sense of healthcare practice using the Internet. The term can encompass a range of services that are at the edge of medicine/healthcare and information technology [1].

2.4.4 m-Health

Mobile Health, mHealth or m-Health includes the use of mobile devices in collecting aggregate and patient level health data, providing healthcare information to practitioners, researchers, and patients, real-time monitoring of patient vitals, and direct provision of care (via mobile telemedicine) [1].

2.5 Other Mobile ECG Monitoring Systems

Health informatics in older care is an expanding field which aim to improve the quality of living and the quality of care of older people in a cost efficient way (Koch, and Hagglund, 2009). A system of frequent monitoring could trigger clinicians to the early signs and symptoms of decompensation, providing the opportunity of intervention before elderly become severely ill and require hospitalization. Currently available literature does not present a wealth of information about the use of wearable systems for monitoring motion activities older people (eg fall prediction) (de Bruin, et al., 2009).

Traditionally Holter recording has been used during normal patient activity to record the cardiological signal called electrocardiogram (ECG). A Holter is a small, mobile and light device that records, during a period of 24 or 48 hours, ECG signals which are later analyzed in the hospital [6].

In the case that the patient suffers from a serious rhythm irregularity the Holter only records, making it possible to establish a diagnostic later but it does not react to it in real time. In the case of the Holter the patient does not have a normal life. With the technology improvement (PDAs, intelligent mobile, wireless communications and vital parameter sensors) the development of revolutionary medical monitoring systems is allowable. This revolution helps the patient's lifestyle to be improved, offering them security even outside the hospital.

2.5.1 M-Health Monitoring System for Children with Suspected Arrhythmias

This system is based on sensor networks, in order to monitor the patient, the sensors are placed in a predefined area like his/her house. On the other hand a module based on PDAs and wearable ECG recorders was used in order to extend the coverage outside the patient's house.

This m-Health system is monitoring children continuously during their daily life activities. This system is a real-time system; it gathers and transmits ECG signals from the patient and it offers alarms when it detects possible arrhythmias.

The system covers two cases, the first case is the case that the patient is at home and the second case is when the patient is moving (outside the house).

FIRST CASE: IN-HOUSE CASE

During this case, a sensor network is installed in the child's house in order to continuously monitor ECG signals from the patient [7]. Other environmental parameters will be collected, like light, temperature, sound acceleration in order to check the existing conditions.

The ECG signal will be recorded by a sensor carried by the child, and it will be part of a wireless sensor network (WSN) installed in the house [7]. Signal information from the wearable sensor will be sent to a local monitoring station which will also act as a gateway to the rest of the monitoring network [7].

SECOND CASE: MOVING PATIENT CASE

For this case, the child is monitored using the same ECG recording device but the signals are transmitted, through a PDA device, directly to the central monitoring system using of 2.5G and 3G mobile communication networks (GPRS/UMTS).

Vital information will be stored locally on the PDA and basic analysis of the ECG signal is performed. Furthermore, the central station analyses, stores and displays the information. On the other hand notification in the case of an alarm is provided to the relative and to the on-call doctor.

2.5.2 A Web Access to Data in a Mobile ECG Monitoring System

The system that was developed by the University of the Basque Country was designed to capture record and locally analyze the ECG signals in a PDA carried by the patient. This system uses several methods that can detect, with high precision, risk arrhythmias that the user is suffering from [6].

Alarms are sent in time to an alarm center in order to receive the proper medical assistance through GPRS [6]. The system has been designed to optimize limited and expensive resources like PDA memory size and wireless communication costs [6]. This system has an innovate feature; it contains web services that query the data computed in the PDA. This feature gives the opportunity to authorized people to have easy access to that data.

Chapter 3

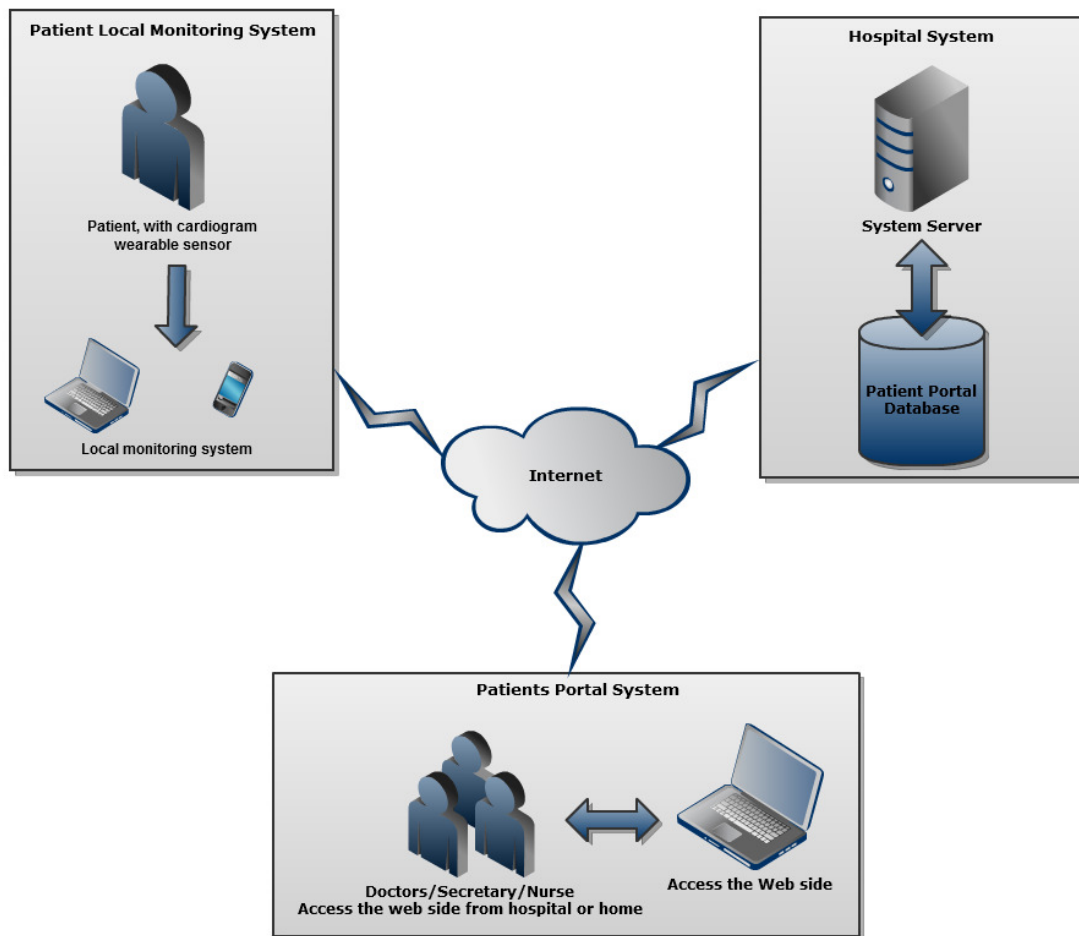
System Requirements

3.1	Introduction
3.2	System Requirements
3.3	Major Processes

3.1 Introduction

3.1.1 System's Purpose and System Function

Our system will gather all the necessary information concerning patients, such as weight, blood pressure, oxygen saturation and ECG (analyzed or not), in the case that the ECG is not analyzed the system must analyze it to facilitate extra and helpful information to the doctor. Each doctor can see his patient's information; on the other hand, he must have the ability to give or remove access to other doctors, to see the patient's information, statistics and other information in order to help each other to get some decisions.



Reference 3.1: System Architecture Diagram.

Web application – The Patient’s Portal provides site functionality as historical information is stored and maintained by the system for the patients. Medical background information, patient hospitalization information, the patient’s symptoms are collected. Furthermore, questionnaires are provided before and after the treatment in order to calculate Physical, Emotional, Global Score and Sum Score, although patient’s calls and follow up information are stored in the system.

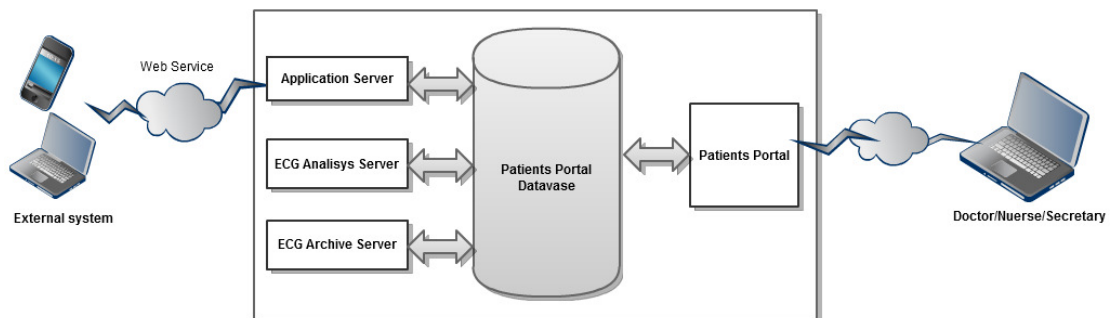
Also the Hospital system is used to store, analyze and archive patients’ information. The system is able to facilitate and provide all the necessary functionality to the doctors and the nurses. Reference 3.1 shows the System architecture diagram.

3.2 System Requirements

3.2.1 System operations and functions

Application server Functionality

The patient must evaluate his vital information every day. That information will be gathered from the system that will be located at the patient's home. With the help of web service technology this information will be sent to the central system: the Application Server. The web services that are provided by the Application Server contain the following methods *AddWeight* that can be used to set the patient's weight, and *AddOxygenSaturation* which can be used to send the patient's oxygen saturation. Moreover, the *AddBloodPressure* method can be used to send the patient's blood pressure. Additionally two more methods are provided *AddECGNotANalyzed* and *AddECGAnalyzed*. Those methods can be used in order to send the patient's ECG to the Application server; further information concerning the Web Service and web service methods and types can be found at Appendix I.



Reference 3.2: Detailed System Architecture Diagram

ECG Analysis Server

Application Server stores ECG, and the ECG Analysis Server which is scheduled to the server, is running in predefined time, and checks if there is new ECG information that it has not been analyzed yet, if it has not been analyzed, then it analyzes it and stores it back to the server. Additionally, log files are provided by the system for auditing purposes. ECG Analysis

Server is calling the ECGAnalysis module which is used to analyze the ECG and finds out that there is an arrhythmia, which this module developed in the previous project.

ECG Archive Server

Another important background process is the ECG Archive Server which is also scheduled at the server to run in a predefined period of time. It is used to archive the patient's ECG which is scheduled to be done by the doctor. The archive process is important to be done to minimize the ECG analysis time and the ECG preview process. By archiving the ECG data which are too many, the size of the ECG table is minimized; with this action we optimize read and write actions to that table.

Patients' Portal – Web Application

After all the background processing, doctors and nurses are able to view and maintain Patients' information using the Patients' Portal Web Application. The portal provides the users the necessary security procedures that are required, as well as auditing information stored in the server. The portal is accessible from the WEB. Patient information maintenance and side functionality concerning the patient history as well as vital information, and statistics are provided for viewing by the permitted users. Reference 3.2 shows the Detailed System Architecture Diagram.

3.2.1.1 Basic System operations and functions

The System will consist of the following operations and functions:

- Doctor registration
- Patient Registration which can be done by the doctor or the nurse
- Doctor must have the ability to give access to another doctor as contributor or just as a viewer.
- Before and after patient's treatment several scores will be measured based on some predefined questionnaire.
- Historical information relating to previous diseases, medical background and symptoms, is handled.
- Patient calls and follow-up information are handled by the system.
- Several statistics and graphs will be provided to the doctor such as
 - ECG
 - Weight
 - Blood pressure
 - Oxygen saturation
 - Score statistics
- The doctor has the ability to schedule an archive process for the patient's ECG.

3.3 Major Processes

3.3.1 Registration Process

This is the process where Doctors and Nurses are enabled to register and provide a username and password which will enable them to access the system in the future. Additionally, in this process the doctors are able to add patients.

3.3.2 Adjustment Process

By this process the user names and passwords and user role are checked for verification purposes. The doctor has the facility to give or remove access to some other doctor to review patient information and help him to take a decision.

3.3.3 Analysis Process

This is the process that will take the patient's ECG and analyze it, in order to give extra information to the doctor such as if the patient has arrhythmia and other information.

3.3.4 Vital Information Preview Process

This is the process that will use the necessary components and information after the analysis procedure, and will display the patient's ECG as well as other collected information to the doctors.

3.3.5 Archive Process

This is the process that will be scheduled on the server, in order to archive the ECG for optimization, (refer to 3.2.1 for additional information).

Chapter 4

System Specifications

-
- 4.1 Introduction
 - 4.2 System Inputs
 - 4.3 Entity Relationship Diagram
 - 4.4 Process Flow Diagram (PFD)
 - 4.5 Database Structure
 - 4.6 Data Files
 - 4.7 Class Diagram
 - 4.8 Sequence Diagram
-

4.1 Introduction

A System Requirements Specification is a structured collection of information that embodies the requirements of the system [1].

The system requirements specification document must contain the problem, the system functionality and the rules that must be applied. This information must be accurate and reliable because, based on that information; the system will be designed and implemented.

4.2 System Inputs

System input information concerning the patient and his vital information are listed below (refer to Appendix I for user input forms):

- Doctor, Secretary and Nurse Registration
- Patient Information
 - Patient personal information
 - Patient hospitalization information
 - Patient medical background
 - Information during hospitalization
 - Information concerning patients release from hospital
 - Follow up information
 - Questionnaire
- Remotely input information
 - ECG Input from another system
 - Weight
 - Oxygen Saturation
 - Blood Pressure

4.3 Entity Relationship Diagram

Entity-relationship model (ERM) is an abstract and conceptual representation of data. Entity-relationship modeling is a database modeling method, used to produce a type of conceptual schema or semantic data model of a system, often a relational database, and its requirements in a top-down fashion. Diagrams created by this process are called entity-relationship diagrams, ER diagrams, or ERDs [1]. Refer to Appendix II for the ERD.

4.4 Process Flow Diagram (PFD)

The process flow diagram PFD displays the relationship between major equipment of a plant facility and does not show minor details such as piping details and designations. Another commonly-used term for a PFD is a flowsheet. Refer to Appendix III for more details.

4.4.1 Collect Vital Information

The vital information which is the patient's weight, blood pressure and oxygen saturation are collected using a web service. This web service is accessible from the web and it is accessible from the patient's station.

4.4.2 Collect ECG Information

The ECG information is collected using a web service. This web service is accessible from the web and it is accessible from the patient's station. A batch of ECG data is sent to the central unit.

4.4.3 User Input

The users of the system, which are Doctor, Nurse and secretary can register to the system; additionally they can maintain the patients. Furthermore doctors have the ability to view and maintain patients' vital information and ECG information.

4.4.4 Process Coordination

This process concerns the central unit of the system. This process collects all the vital information, ECG Information and user input and gets the decision which process to call; additionally it stores the information in order to be accessible any time.

4.4.5 ECG Analysis

When the Process coordinator collects the ECG then if that ECG is not analyzed it calls the ECG Analysis process. This process gets one by one the ECG voltage and analyzes it in order to determine if there is arrhythmia and if there is it defines what arrhythmia is.

4.4.612 Display ECG

When the Doctor wants to see the patient's ECG then it triggers the Display ECG Process. This process, based on doctors' filter conditions, gets the ECG data from the database and displays it graphically.

4.4.7 Display Vital Information

When the Doctor wants to see the patient's vital information then it triggers the Display Vital Information Process. This process, based on doctors' filter conditions, gets the Weight, Blood Pressure and Oxygen Saturation data from the database and displays it graphically.

4.4.8 ECG Archive

After the patient's treatment the Doctor has the opportunity to schedule the archive process. The ECG Archive process gets the ECG data and stores this information to an archive table in order to optimize read and write the process to the original ECG data.

4.4.9 Data Storage

Data are collected from the "Collect Vital Information Process", the "Collect ECG Information Process" and from the user; then based on the instructions that it gets from the "Process Coordination Process" it stores, updates and deletes the data to the database.

4.5 Database structure

The Database structure which represents logically-related records and files (tables) is consolidated into a common pool that provides data for one or more multiple uses. System Database Structure can be found at Appendix IV.

4.6 Data Files

All the files of our system will be indexed and normalized.

4.6.1 Table Patient

This Tbl_Patient table contains the entire patient's personal and demographic information.

The primary key of the table is the PatientID.

Field Name	Field type and length
PatientID	int
Name	nvarchar(150)
Surname	nvarchar(150)
AHI_ID	nvarchar(50)
Gender	int
Birthday	datetime
Nationality	nvarchar(150)
Telephone	nvarchar(50)
Telephone1	nvarchar(50)
Email	nvarchar(250)
MaritalStatus	int
Education	int
Profession	nvarchar(250)
Stay	int
EjectionFraction	int
DeathReason	nvarchar(4000)
DeathDateTime	datetime
DateLastUpdate	datetime
UserLastUpdate	nvarchar(150)

Table 4.1: Table Patient

4.6.2 Table Patient Calls

This Tbl_Patient_Calls table contains patient's calls information. The primary key of the table is the ID and it is related with the TBL_Patient with the field FK_PatientID.

Field Name	Field type and length
ID	int
FK_PatientID	int
Reason	nvarchar(4000)
PersonAnsewer	nvarchar(200)
EmergencyRoomVisit	int
DateTimeCall	datetime
DateLastUpdate	datetime
UserLastUpdate	nvarchar(150)

Table 4.2: Table Patient Calls

4.6.3 Table Patient ECG Analyzed

The tbl_Patient_ECG_Analyzed table contains the patient's analyzed ECG information. The primary key of the table is the ID and it is related with the TBL_Patient with the field FK_PatientID.

Field Name	Field type and length
ID	int
FK_PatientID	int
ECGVoltage	int
Analisis	varchar(50)
TimeStamp	datetime
dateLastUpdate	datetime

Table 4.3: Table Patient ECG Analyzed

4.6.4 Table Patient Archive ECG Analyzed

The Tbl_Patient_ECG_Analyzed_History is the table that contains the patient's historically analyzed ECG information. The primary key of the table is the ID and it is related with the TBL_Patient with the field FK_PatientID.

Field Name	Field type and length
ID	int
FK_PatientID	int
ECGVoltage	int
Analisis	varchar(50)
TimeStamp	datetime
dateLastUpdate	datetime

Table 4.4: Table Patient Archive ECG Analyzed

4.6.5 Table Patient Archive ECG Analyzed

The Tbl_Patient_ECG_NotAnalyzed is the temporary table contains the patient's ECG information before it is analyzed, after the analysis the data are deleted automatically from the table. The primary key of the table is the ID and it is related with the TBL_Patient with the field FK_PatientID.

Field Name	Field type and length
ID	int
FK_PatientID	int
ECGVoltage	int
BatchTimeStamp	datetime
TimeStamp	datetime
dateLastUpdate	datetime

Table 4.5: Table Patient Archive ECG Analyzed

4.6.6 Table Patient ECG to Archive

The Tbl_Patient_ECG_ToArchive table is used to store the patient ID that it has to be archived. The primary key of the table is the ID and it is related with the TBL_Patient with the field FK_PatientID.

Field Name	Field type and length
ID	int
FK_PatientID	int
UserLastUpdate	varchar(150)
DateLastUpdate	datetime

Table 4.6: Table Patient ECG to Archive

4.6.7 Table Patient Follow Up information

The TBL_Patient_FollowUP table is used to store the patient's follow up information. The primary key of the table is the ID and it is related with the TBL_Patient with the field FK_PatientID.

Field Name	Field type and length
ID	int
FK_PatientID	int
RecruitmentDate	datetime
RGroup	int
Doctor	nvarchar(200)
NurseEducator	nvarchar(200)

Table 4.7: Table Patient Follow Up information

4.6.8 Table Patient Hospitalization information

The Tbl_Patient_Hospitalization table is used to store the patient's Hospitalization information. The primary key of the table is the HospitalizationID and it is related with the TBL_Patient with the field FK_PatientID.

Field Name	Field type and length
HospitalizationID	int
FK_PatientID	int
HospitalizationDate	datetime
HowRecruitment	int
Escort	int
Dyspnoea	int
SymptomsOnImport	nvarchar(50)
CoronaryIllness	int
SergioProcedure	nvarchar(2000)
SergionDate	datetime
LeaveHospitalDate	datetime
DateLastUpdate	datetime
UserLastUpdate	nvarchar(150)

Table 4.8: Table Patient Hospitalization information

4.6.9 Table Patient Hospitalization Discharge Symptoms information

The Tbl_Patient_Hospitalization_discharge_Symptoms table is used to store the patient's symptoms after his hospitalization discharge. The primary key of the table is the ID and it is related with the Tbl_Symptoms with the field FK_SymptomID and with the Tbl_Patient_Hospitalization with the field FK_HospitalizationID.

Field Name	Field type and length
ID	int
FK_SymptomID	int
FK_HospitalizationID	int
DateLastUpdate	datetime
UserLastUpdae	nvarchar(150)

Table 4.9: Table Patient Hospitalization Discharge Symptoms information

4.6.10 Table Patient Hospitalization Symptoms information

The Tbl_Patient_Hospitalization_Symptoms table is used to store the patient's symptoms at his hospitalization. The primary key of the table is the FK_SymptomID and FK_HospitalizationID.

Field Name	Field type and length
FK_HospitalizationID	int
FK_SymptomID	int
DateLastUpdate	datetime
UserLastUpdate	nvarchar(150)

Table 4.10: Table Patient Hospitalization Symptoms information

4.6.11 Table Patient Medical Background information

The Tbl_Patient_MedicalBackground table is used to store the patient's medical background information. The primary key of the table is the FK_PatientID and it is related 1:1 with the TBL_Patient with the primary key.

Field Name	Field type and length
FK_PatientID	int
Allergies	nvarchar(500)
PreviousImports	int
PreviousImportsReason	nvarchar(2000)
ChirurgicalIntervetions	nvarchar(2000)
OlderDisease	nvarchar(2000)
ChronicAccompanyingDisease	int
RheumaticDisease	int
Exercising	int
UseSubstances	int
FamilyHeardProblemsBackground	int
FamilyHeardProblemsBackgroundTotal	int
FactorsHypertension	int
FactorsDiabetes	int
FactorsAlcoholAbuse	int
FactorsHyperlipidemia	int
FactorsObesity	int
FactorsCardiotoxicMedicines	int
FactorsSmoking	int
FactorsActiveSmoker	int
AmenableCoronarIllness	int
AmenableArrhythmias	int

AmenableAngiography	int
AmenableAngiographyDate	datetime
AmenableBalloonAngioplasty	int
AmenableBalloonAngioplastyDate	datetime
AmenablePermanentPacemaker	int
AmenablePermanentPacemakerDate	datetime
AmenableAddedValves	int
AmenableAddedValvesDate	datetime
DiseaseCoronary	int
DiseaseValvular	int
DiseaseArrhythmias	int
DiseaseHypertensiveCardiomyoeathy	int
DiseaseCardiomyopathy	int
DiseaseChronicAtrialFibrillation	int
DiseaseOther	nvarchar(1000)
ComorbiditiesRheumaticDisease	int
ComorbiditiesCOPD	int
ComorbiditiesAsthma	int
ComorbiditiesStroke	int
ComorbiditiesFailure	int
ComorbiditiesOther	varchar(1000)
AblationTherapy	int
CardiacArest	int
Sergery	nvarchar(4000)
DateOfSergery	datetime
Surgeon	nvarchar(500)
DateLastUpdate	datetime
UserLastUpdae	nvarchar(150)

Table 4.11: Table Patient Medical Background information

4.6.12 Table Patient Oxygen Saturation information

The Tbl_Patient_Oxygen_Saturation table is used to store the patient's oxygen saturation. The primary key of the table is the ID and it is related with TBL_Patient with FK_PatientID .

Field Name	Field type and length
ID	int
FK_PatientID	int
Oxygen_Saturation	real
DateLastUpdate	datetime

Table 4.12: Table Patient Oxygen Saturation information

4.6.13 Table Patient Weight

The Tbl_Patient_Weight table is used to store the patient's weight. The primary key of the table is the ID and it is related with TBL_Patient with FK_PatientID.

Field Name	Field type and length
ID	int
FK_PerientID	int
Weight	numeric(18, 3)
DateLastUpdate	datetime

Table 4.13: Table Patient Weight

4.6.14 Table Patient Questionnaire

The TBL_PatientQuestion table is used to store the answers of the patient before and after the treatment. The primary key of the table is the ID and it is related with TBL_Patient with FK_PatientID and with the TBL_Scores_Questioner with the FK_QuestionID.

Field Name	Field type and length
ID	int
FK_PatientID	int
FK_QuestionID	int
Answer	int
DateTime	datetime
UserLastUpdate	nvarchar(150)

Table 4.14: Table Patient Questionnaire

4.6.15 Table Patient Blood Pressure

The Tbl_Petient_Blood_Presure table is used to store patient's Blood Pressure. The primary key of the table is the ID and it is related with TBL_Patient with FK_PatientID.

Field Name	Field type and length
ID	int
FK_PetientID	int
Blood_Presure_Sistolic	int
Blood_Presure_Distolic	int
DateLastUpdate	datetime

Table 4.15: Table Patient Blood Pressure

4.6.16 Table Score Questionnaire

The TBL_Scores_Questioner table is used to store the questions that are needed to calculate the scores. The primary key of the table is the ID.

Field Name	Field type and length
ID	int
Question	nvarchar(2000)
Type	char(1)

Table 4.16: Table Score Questionnaire

4.6.17 Table Symptoms

The Tbl_Symptoms table is used to store the symptoms that a patient may have. The primary key of the table is the ID.

Field Name	Field type and length
SymptomID	int
Description	nvarchar(200)
DateLastUpdate	datetime
UserLastUpdate	nvarchar(150)

Table 4.17: Table Symptoms

4.6.18 Table User – Patient

The Tbl_User_Patient table is used to store the doctor's user name that has access to review a patient's ID. The primary key of the table is the ID and it is related with TBL_Patient with FK_PatientID.

Field Name	Field type and length
ID	int
FK_PatientId	int
UserName	varchar(150)
DateLastUpdate	datetime
UserLastUpdate	nvarchar(150)

Table 4.18: Table User – Patient

4.7 Class Diagram

The class diagram in the Unified Modeling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, and the relationships between the classes [1].

4.7.1 Application Server Classes

The Application Server contains the two web services SystemWS and VitalInfoWS which are used from the internal and external systems to mainly send the vital information. Furthermore the Application Server web application contains DAL class and mdlDeclares that help classes for the web services.

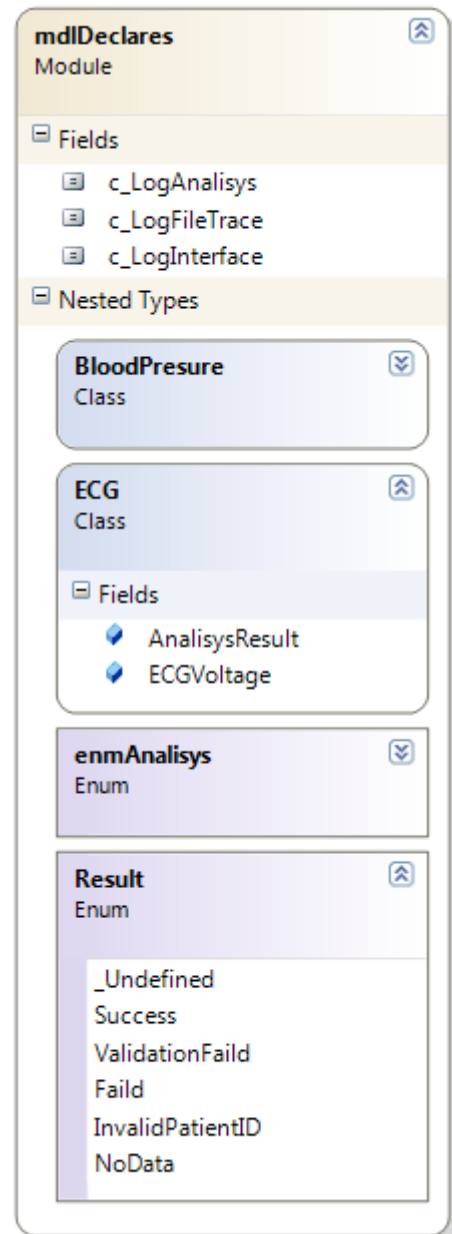
4.7.1.1 Declare Class

The Module Declares contains three constant names for the log files that the system creates; the first log file is the Analysis which contains the information about the analysis like start end time, patient ID and other. The Trace Log file contains the information concerning system crashes.

The Blood Pressure class contains the information about Systolic and Diastolic blood pressure.

The ECG class contains the information for the ECG, the AnalysisResult is of type **enmAnalysis** and it indicates the analysis information like PVC, NTQRS and others.

Finally the enumeration **Result** contains some error codes like success, NoData and others.



4.7.1.2 Utils Class

This class contains help functions and classes that are used from all the projects in the solution.

Fields

It contains several constants that are used in most cases for validation.

Methods

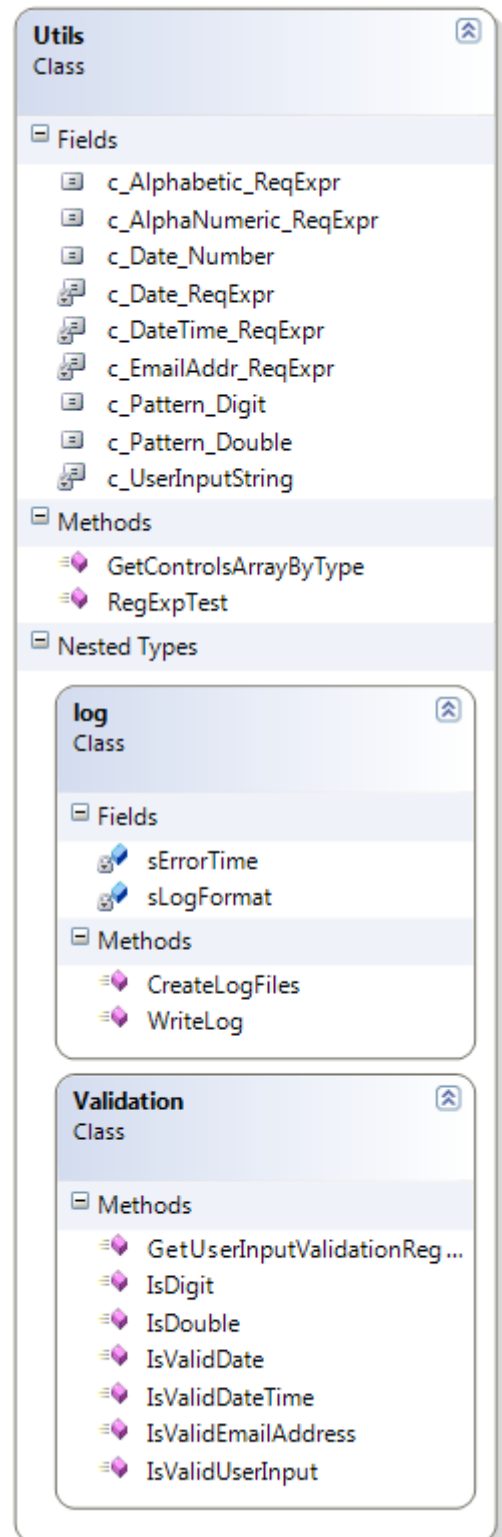
The two methods that are included in the class are used for validation, the method `GetControlsArrayByType` is used to validate the user input that was entered in a specific user control. `RegexTest` is used to evaluate a regular expression over a user input.

Log Sub Class

This sub class is used for logging. It creates a log file that does not exist with the method `CreateLogFile` and with the method `WriteLog` it writes the input information to the created log file.

Validation Sub Class

This sub class has several helpful methods for validation. Those methods are validating digits, double numbers, dates, date and times, E-mail addresses and the method `IsValidUserInput` is used to discard any illegal character.



4.7.1.3 Data Access Layer (DAL) Class

The Data Access Layer is the layer that is allowed to have access to the database. In this layer we are reading and writing in the database. DAL class is used from all the projects in the solution.

Fields

The fields of this class are mainly the constants for the store procedure names and the connection string that is used to access the database.

Properties

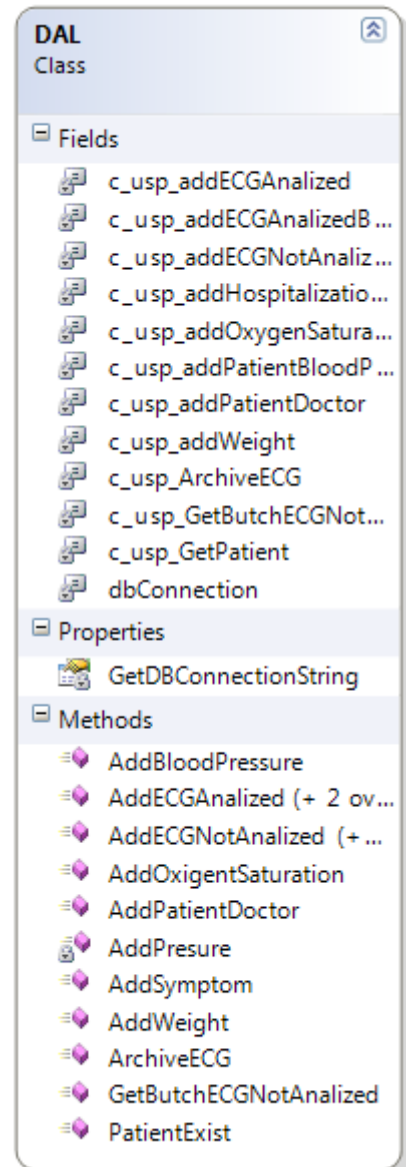
There is one property the `GetDBConnectionString` has that it is used to get the connection string from the configuration file (`app.config` or `web.config`)

Methods

Most methods here are used to store vital information and ECG information in the Database.

The method **ArchiveECG** is used from the project `ECGArchiveServer` and it is used to archive the ECG.

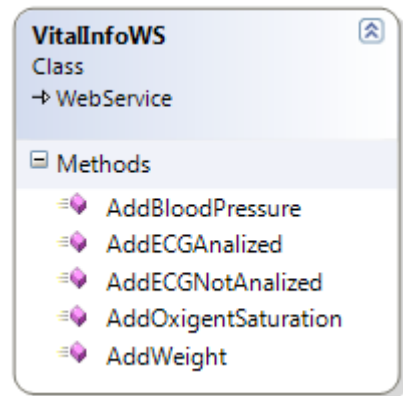
The method **GetButchECGNotAnalyzed** is used from the project `ECGAnalysisServer` and it reads a data set of ECG data that is not analyzed for a patient.



The method **PatientExist** is a help function and it is used almost from all the methods in the DAL class; it validates if the specific patient exists or not and it returns the appropriate result code (InvalidPatientID) (refer to 4.7.1.1 Declare Class for more information).

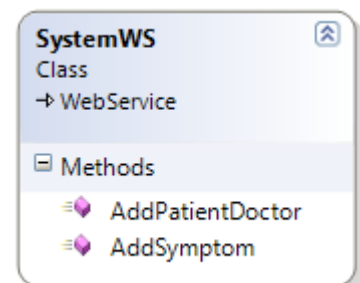
4.7.1.4 Vital Information Web Service (VitalInfoWS)

This web service class contains all the necessary methods that are needed to collect the vital information which are AddBloodPressure, AddECGAnalyzed, AddECGNotAnalyzed, AddOxygenSaturation and AddWeight. For more details about VitalInfoWs refer to Appendix VIII.



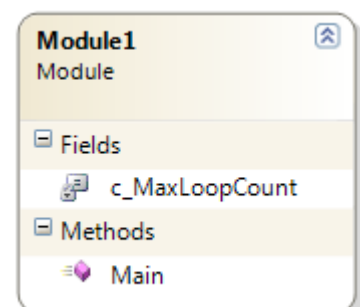
4.7.1.5 System Web Service (SystemWS)

This web service is used from the Patients Portal web application. It contains two methods: the first method is AddPatientDoctor and it is used to associate the Patient with his Doctor. The method AddSymptom is used to add the symptoms that the patient has.



4.7.2 ECG Analysis Server Class

The ECG Analysis Server is going to be a scheduled task in the server to run many times per day to check if there is a new not analyzed ECG. If there is then it will get it from the database and analyze it. This class contains a constant of maximum number of retries. This number is collected from



the configuration files (refer to chapter 7 Installation Phase section 7.3.3.3 ECGAnalysisServer and ECGArchiveServer settings).

4.7.2.1 ECG Analysis Class

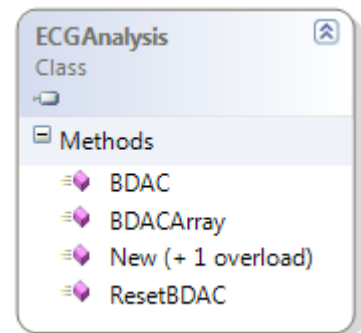
The ECG Analysis is an old C program that was converted to the .Net C# program and it is used from the ECG Analysis Server to Analyze the ECG.

Methods

The **BDAC** method is used to analyze record by record the ECG voltage and returns the Arrhythmia definition for each record.

The **BDACArray** method gets an array of ECG voltage and analyzes it using the BDAC method.

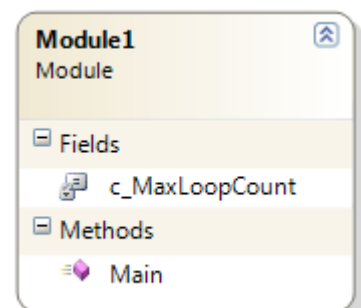
The **ResetBDAC** method clears the variable that is used for the analysis and it must be called every time that the BDAC method is called.



4.7.3 ECG Archive Server Class

The ECG Archive Server is going to be a scheduled task in the server to run many times per day to check if there is a schedule task of the ECG archive. If there is then it will get it from the database and archive it. This class contains a constant of a maximum number of retries. This number is collected from the configuration files (refer to chapter 7

Installation Phase section 7.3.3.3 ECGAnalysisServer and ECGArchiveServer settings).



4.8 Use Case Diagram

4.8.1 Use Case Diagram

A use case diagram in the Unified Modeling Language (UML); it is a type of behavioral diagram defined by and created from a Use-case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases [1].

The main purpose of a use case diagram is to show what system functions are performed for which actor. Roles of the actors in the system can be depicted [1]. Use cases are represented by ovals and the actors are represented by stick References [1].

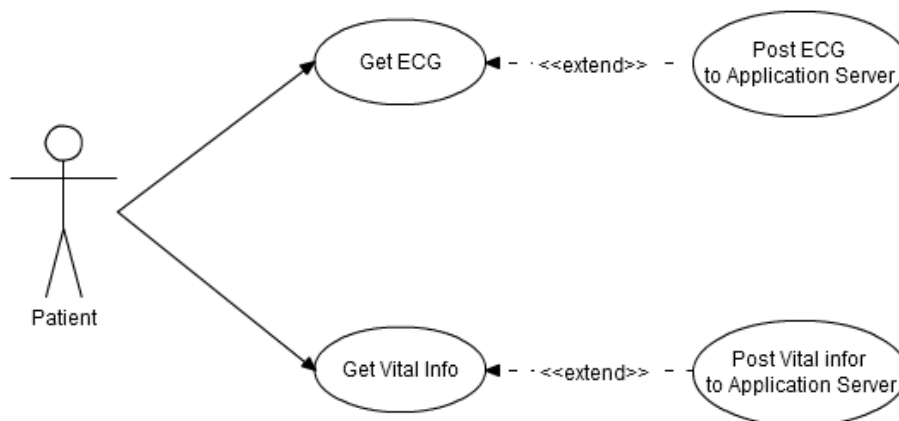
Diagram building blocks

- **Actor:** The most important relationship between the Actors is Generalization/Specialization. This is helpful in determining overlapping roles between actors. The notation is a solid line ending in a hollow triangle drawn from the specialized to the more general actor [1].
- **Use case Relationships:**
 - **Include:** Include is a Directed Relationship between two use cases, implying that the behaviour of the included use case is inserted into the behaviour of the including use case [1]. The notation is a dashed arrow from the including to the included use case, with the label "«include»".
 - **Extend:** This relationship indicates that the behaviour of the extension use case may be inserted in the extended use case under some conditions [1]. The notation is a dashed arrow from the extension to the extended use case, with the label "«extend»".

- **Generalization:** A given use case may have common behaviours, constraints and assumptions to the general use case; describe them once, and deal with it in the same way, except for the details in the specialised cases. The notation is a solid line ending in a hollow triangle drawn from the specialized to the more general use case.

4.8.2 System Use Case Diagrams

4.8.2.1 Scenarios system communication with the Application Server



Reference 4.8.1: Patients' system and Application Server interface Use Case Diagram

The system that is located at the patient's house will communicate with the Application Server to send ECG and Vital information. The two systems will communicate with the Web Service application programming interface, and will be accessed over the Internet network.

The web service will contain the functions that will transfer the data to the server; furthermore all functions will return a status code that will indicate if there was an error in the communication. Those return error codes are the same to all functions.

Error codes will cover the following scenarios:

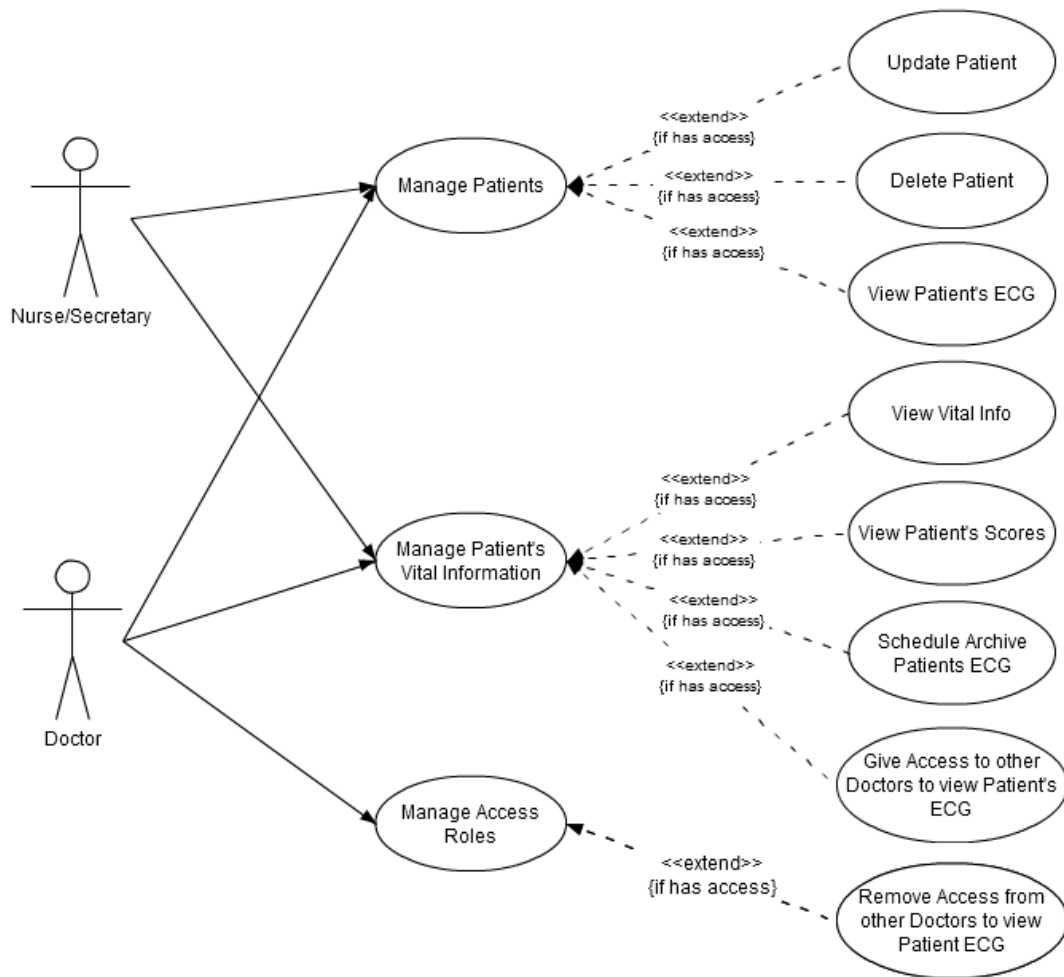
- There was an unhandled error.
- Process completed successfully
- One or more input parameters contain invalid values
- There was an error in the process and it didn't complete successfully.
- The input patient ID is invalid
- There wasn't any data for the search criteria

Methods that must be implemented to handle all the cases are:

- **Vital Information**
 - **Weight:** Send the patient's weight. It must take three parameters: the Patient ID which will indicate the system identity of the patient and it must be numeric, the Weight which takes numeric values and indicates the patient's weight and the Date Time Stamp which indicates the time that the patient measured his/her weight.
 - **Oxygen Saturation:** Which can be used to send the patient's Oxygen Saturation. This method must take three parameters: the Patient ID which indicates the system identity of the patient and must be numeric, the Oxygen Saturation which must be numeric and it will indicate the patient's oxygen saturation and finally the Date Time Stamp which will indicate the time that the patient measured his/her oxygen saturation.
 - **Blood Pressure:** This function will be used to send the patient's blood pressure. This method will contain three parameters as well: the Patient ID which was mentioned above, the Blood Pressure parameter which must be an array and must take two values: the systolic and diastolic blood pressure and the last parameter must be the Date Time Stamp which was mentioned above.

- **ECG Information**

- **ECG Not Analyzed:** Which will be used to collect a batch of ECG measurements for a specific patient. This method must take four parameters. The first parameter is the Patient ID that was mentioned before, the second parameter must be an array of integers which indicates the series of ECG Voltage. The third parameter must be the Sample Rate which is the number of bits that are processed per unit of time. Finally the last parameter must be the Date Time Stamp which was mentioned above.
- **ECG Analyzed:** This is going to be used to collect a batch of analyzed ECG measurement for a specific patient. The first parameter must be the Patient ID that was mentioned before, the second parameter must be an array and it will take 2 values the ECG – Voltage and the analysis result. The third parameter will be the Sample Rate which was mentioned above. Finally the last parameter is the Date Time Stamp which was mentioned above.



Reference 4.8.2: Patients Portal Use Case Diagram

A Patients' Portal must be a web application and must be accessible from the internet. The users must register with the system and define their role. Furthermore registered users must be able to update their information and their password.

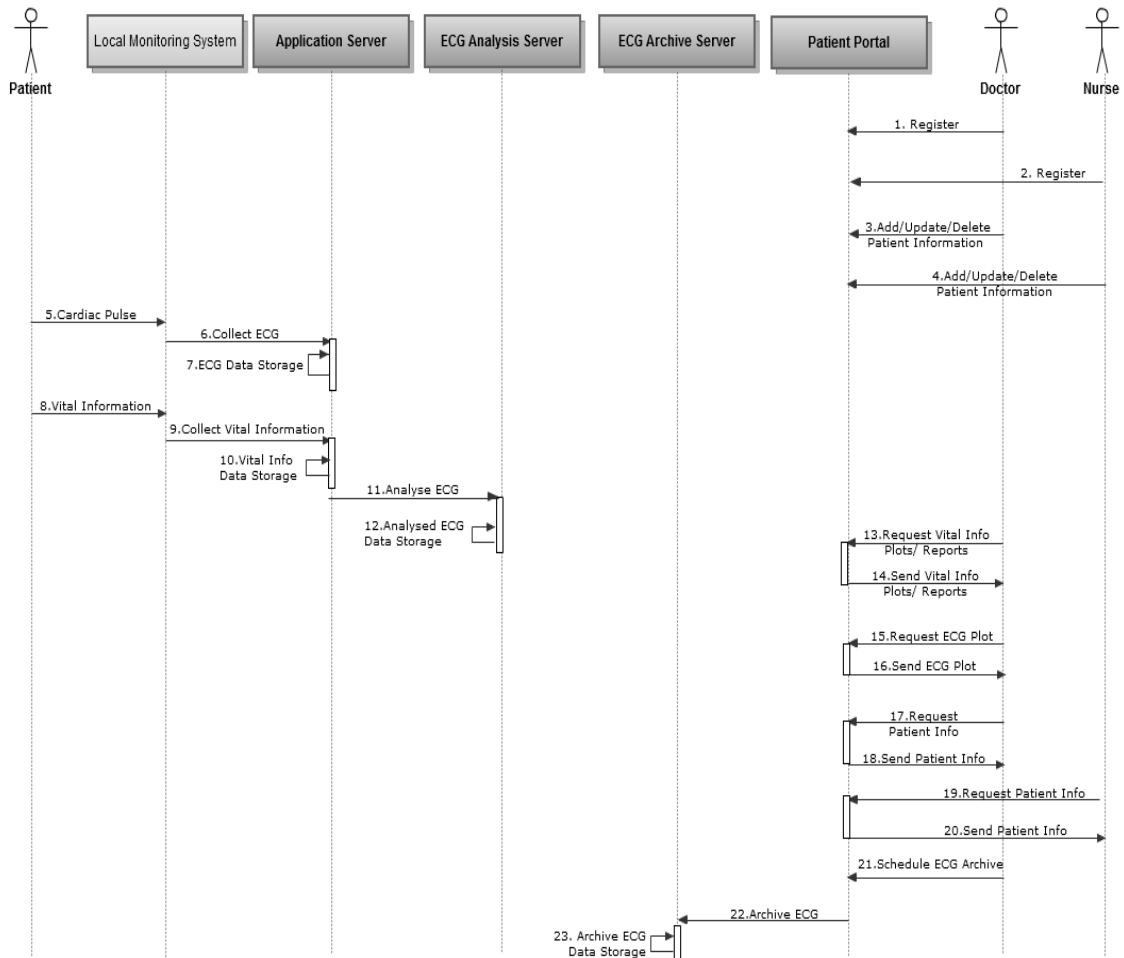
The users must be able to add, update and delete Patients. Users must see, update and delete Patients' Medical Background information, hospitalization information, Patients' symptoms, and information relevant to patient hospital calls and follow up information. A questionnaire concerning the physical and psychological state of the patient will be offered. Based on that questionnaire, important scores will be calculated.

Vital information concerning the patient must be provided to the doctors. This information is the patient's weight, blood pressure and oxygen saturation. The last and most important information that will be provided to the doctor is the patient's ECG. Several search criteria will be provided to the doctor, in order to find and view the ECG that he wants.

At the end of the patient's treatment, the doctor must schedule an archive procedure for the patient's ECG. This process will archive ECG information to minimize the table size; by doing that we optimize, read, and write time to the ECG table.

Additionally patients must be attached to a doctor. That doctor can name another doctor or doctors, who will be his collaborators – helpers. Only doctors that are attached to the patient together with their appointed collaborators–helpers can have access to view, edit and maintain patients' information.

4.9 Sequence Diagram



Reference 4.8.3: Sequence Diagram

First of all the Doctors and the Nurses must register to the Patients Portal system in order to have access to the system. After that they are going to be able to add, update and delete patients' information. Cardiac Pulse and Vital Information are collected from the Local Monitoring System and it is sent to the Application Server system for further processing and storage to the Database. After the ECG is collected to the Application Server, then the ECG is analyzed and then it is stored back to the Database. When the above information is collected, then the Doctor requests to see the Vital Information, ECG Plot and the Patient's information from the Patient's Portal. The nurse is able to see and request the Patient's information. When the treatment is completed then the doctor is able to schedule the ECG Archive procedure; after that ECG Analysis Server takes action and archives the Patient's ECG.

Chapter 5

System Design

5.1	Introduction
5.2	System Communication and Interface
5.3	Security and Control

5.1 Introduction

The System Analysis is a detailed study of various operations performed by a system and their relationships within and outside the system. During analysis, data are collected on the available files, decision points and transactions are handled by the present system. Interviews, on-site observation and questionnaires are the tools used for the system analysis [9].

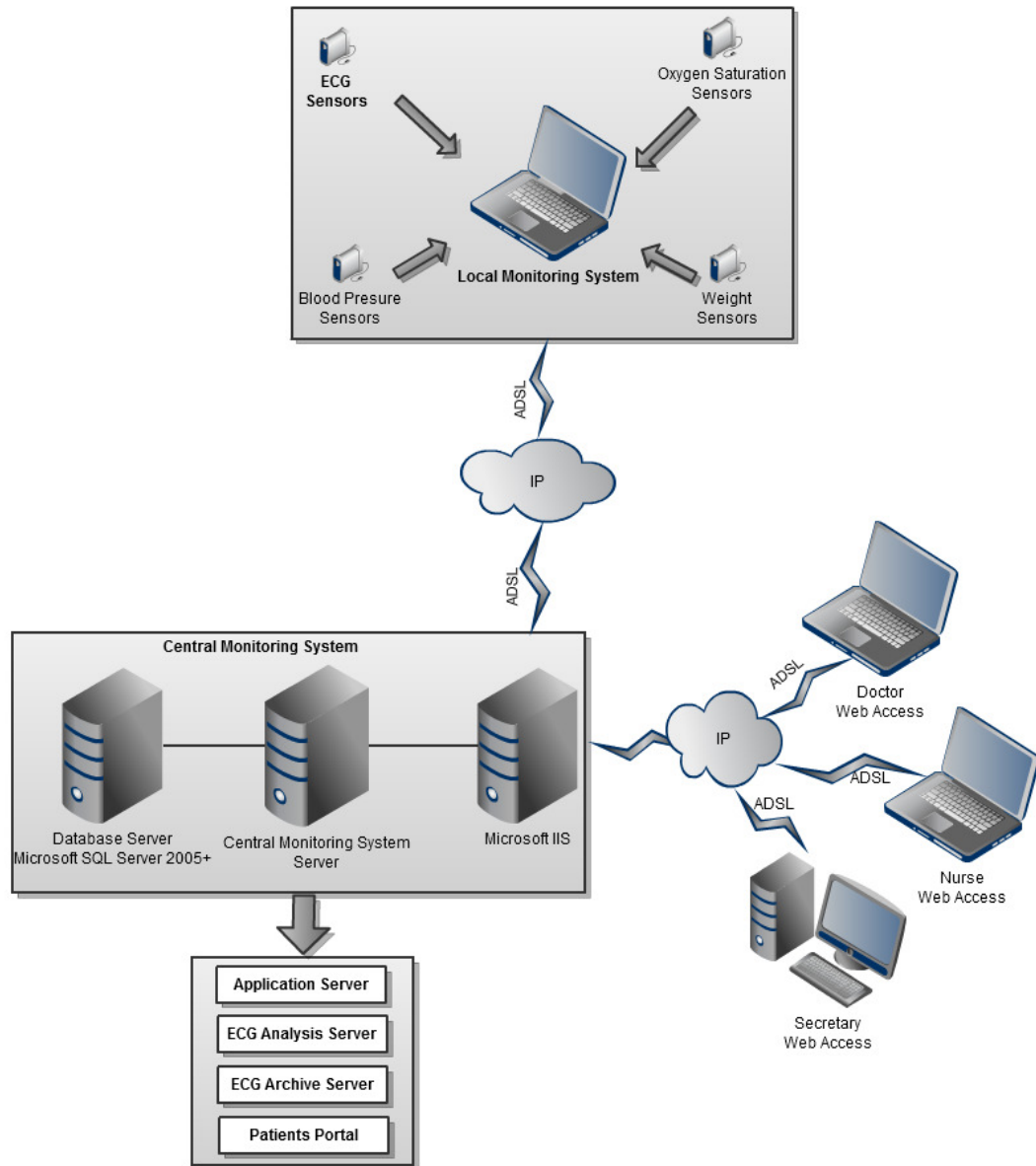
User requirements are analyzed in order to define the system specification that the new system must accomplish. Functional hierarchy shows the functions to be performed by the new system and their relationship with each other [9]. It determines the attributes of the entities which are the data items that need to be held about each entity.

The new system must be designed according the user requirements and the detailed analysis of a new system. This phase is called System Design. This is the phase of system designing. It is a most crucial phase in the development of a system [9].

The features of the new system are specified. The costs of implementing these features and the benefits to be derived are estimated. If the project is still considered to be feasible, we move to the detailed design stage. After that stage, the design of the system becomes more structured. Input, output and processing specifications are drawn up in detail. In the design stage, the programming language and the platform in which the new system will run are also decided.

5.2 System Communication and Interface

5.2.1 Interfaces with the External System



Reference 5.2.1: Technical system interface

The Local Monitoring System

The Local Monitoring System is communication first of all with the ECG sensors, the Blood pressure sensors, the Oxygen Saturation sensors and finally with the weight sensors in order to collect vital information. After the data collection the local system communicates with the

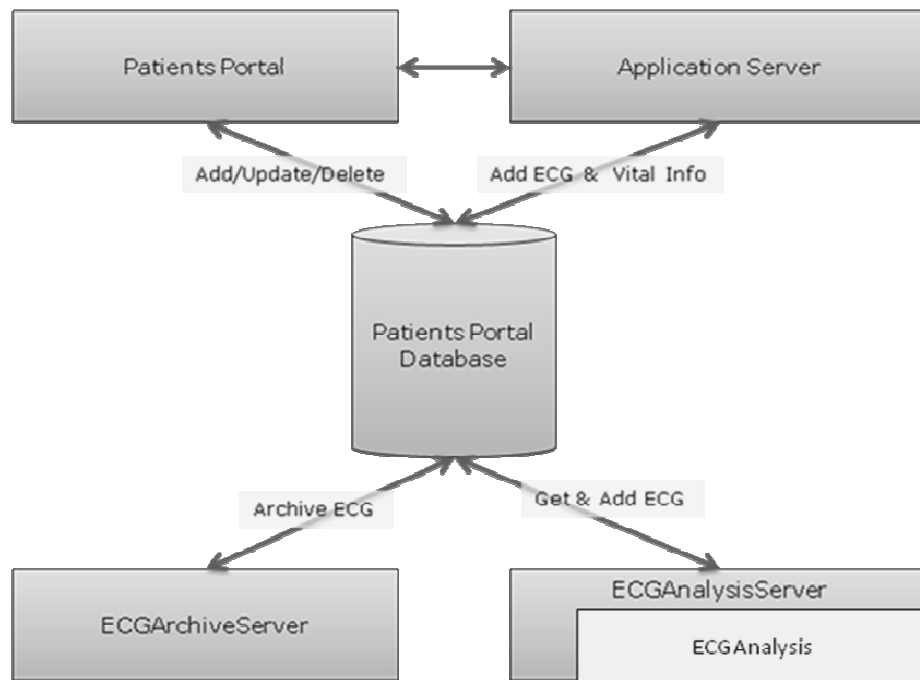
Central Monitoring System. The Local Monitoring System is not going to be examined in this project.

The Central Monitoring System

The Central Monitoring System collects the vital information from the Local Monitoring System using web services over the IP network. Additionally the Central Monitoring System uses the Microsoft IIS server to facilitate the communication with the internet. Furthermore the Microsoft SQL Server 2005 above is used to store all the information that is retrieved from the system. The central system includes four major processes. The first one is the Application Server which is the central process that is used to collect and store vital information and side information. The second one is the ECG Analysis Server which is used to analyze and store the ECG. The third major process is the ECG Archive Server which is used to archive the ECG that was scheduled by the doctor. Finally, the most important process is the Patients Portal, which is used to collect and display the patients' information and their vital information. The portal is accessible from the web; the doctors, nurses and secretaries can apply their user name and password and in this way they are able to maintain and view the patients' information.

5.2.2 Interface with the Internal System

The system consists of the Patients' Portal web application, the Application Server web application, and additionally, it contains the ECG Archive Server which is a console application, and the ECG Analysis Server which is as well a console application; the ECG Analysis Server includes the ECG Analysis module (refer to Reference 5.2.2).



Reference 5.2.2: Technical Local System Interface

Patients' Portal

This is going to be used by the Doctors and Nurses and it is going to be accessible from the Internet. The users will be able to view, add, update and delete information concerning the Patient, Patient treatment and vital information. The Patients' Portal is going to be a web application, and it will treat information from the Patients' Portal Database; furthermore, additional information will be accessed through the Application Server web services.

Application Server

This part of the solution is one of the major processes of the system. It will be used to collect the ECG and Vital information from the patient's holders and will store this information to the Patients' Portal Database. The web service will be provided in order to collect that useful information. Additionally, the web services will be provided in order to offer help functions to the Patients Portal. This solution is also a Patients Portal web application which can be accessible from the Internet.

ECG Archive Server

This part of the solution is going to be a console application, and it is going to be scheduled to the server in order to run all the time by the server. It is going to check if there is any schedule archive information concerning the Patients' ECG; when there is the need, it will delete the ECG from the original table and store it automatically to the archive table. The Patients' Portal Database will be used in this solution as well.

ECG Analysis Server

This part of the solution is going to be a console application, and it is going to be scheduled to the server in order to run all the time from the server. It is going to check if there is an ECG that it has not been analyzed yet. In the case when it finds an unanalyzed ECG it will analyze it and store it back to the Patients' Portal Database.

To analyze the ECG the **ECG Analysis** will be used; this solution is an old C solution that was converted to a .Net C# solution in previous projects.

5.2.3 Patients' Portal User Interface

As far as the user interface is concerned it will be simple enough and easy to use by the average user. Advanced procedures will be avoided if possible. Attractive menus and a descriptive online help will be provided. Refer to Appendix V for the user interface.

5.3 Security and Control

Access to the system will be restricted to unauthorized users; it will only be allowed to the doctors and nurses. The use of a password and a username is required. A Microsoft Membership provider is used to handle the authorization processes.

5.3.1 Microsoft Membership Provider

ASP.NET 2.0 provides login controls that can be used to perform authentication. The controls talk directly to the membership provider. ASP.NET 2.0 also offers controls to support the ongoing maintenance of users, including changing passwords and resetting passwords. All of these controls are built on top of the features of the membership providers [12]. Once we know who a user is, we can find out what we will allow the user to do – this is authorization. The role providers in 2.0 allow us to create roles, and map users into the roles. Given a username, the role manager can tell us to which roles a user belongs. Areas of a web application, or specific operations, can be restricted to exact roles [12]. Refer to Appendix VI for the membership provider installation.

The default Membership Provider passwordFormat is Hashed and it is also the most secure. Hashed passwords are converted using a **one-way hashing algorithm** and a randomly generated "salt" value. There is no way to retrieve a hashed password, so password verification is performed by hashing then the newly entered password is compared to the one stored in the database.

Chapter 6

Implementation Phase

-
- 6.1 Programming Language and Platform
 - 6.2 User Interface
 - 6.3 Testing Specification and Planning
 - 6.4 Conclusion
-

6.1 Programming Language and Platform

For the implementation we are going to use Visual Studio 2008 with ASP.NET and Visual Basic.NET. Additionally, the Database Management System that it is going to be used is the Microsoft SQL Server 2005 express edition for the development and in the server, the Microsoft SQL Server 2008. Furthermore, Ajax Toolkit 3.5 is going to be used to reach user interface. Finally for the graphs, the National Instruments Measurements Studio is going to be used.

6.1.1 ASP.NET 3.5 and Visual Studio 2008

ASP.NET 3.5 and Visual Studio 2008 bring great new functionality around the Web development and design, and make building standards based on the next generation Web sites easier than ever. From the inclusion of ASP.NET AJAX into the runtime, to new controls, the new LINQ data capabilities, to improved support for CSS, JavaScript and others, Web development has taken a significant step forward [13].

6.1.1.1 Visual Studio 2008

Visual Studio 2008 has incorporated a new Web designer that uses the design engine from Expression Web. Moving between design and source view is faster than ever and the new split view capability means you can edit the HTML source and simultaneously see the results on the page. Support for style sheets in separate files has been added as well as a CSS properties pane which clarifies the sometimes-complex hierarchy of cascading styles, so that it is easy to understand why an element looks the way it does. In addition, Visual Studio 2008 has full WYSIWYG support for building and using ASP.NET Nested Master Pages, which greatly improves the ability to build a Web site with a consistent look and feel [13].

6.1.2 ASP.NET AJAX framework

With the ASP.NET AJAX, developers can quickly create pages with sophisticated, responsive user interfaces and more efficient client-server communication by simply adding a few server controls to their pages. Previously an extension to the ASP.NET runtime, the ASP.NET AJAX is now built into the platform and makes the complicated task of building cross platform standards based on AJAX applications easy [13].

6.1.2.1 Visual Studio 2008

The ASP.NET AJAX Control Toolkit is an open-source project built on top of the Microsoft ASP.NET AJAX framework. It is a joint effort between Microsoft and the ASP.NET AJAX community that provides a powerful infrastructure to write reusable, customizable and extensible ASP.NET AJAX extenders and controls, as well as a rich array of controls that can be used out of the box to create an interactive Web experience. The AJAX Control Toolkit contains more than 30 controls that enable you to easily create rich, interactive web pages [13].

6.1.3 Microsoft SQL Server

The Microsoft SQL Server is a relational model database server produced by Microsoft. Its primary query languages are T-SQL and ANSI SQL [1].

The Microsoft SQL Server 2008 provides a trusted, productive, and intelligent data platform that enables you to run your most demanding mission-critical applications, reduce time and cost of development and management of applications, and deliver actionable insight to your entire organization [14].

6.1.4 National Instruments (NI) Measurement Studio

The National Instruments Measurement Studio is an integrated suite of measurement and automation controls, tools, and class libraries for Visual Studio 2008, Visual Studio 2005, Visual Studio .NET 2003, and Visual Studio 6.0. The NI Measurement Studio dramatically reduces application development time with ActiveX and .NET controls, object-oriented measurement hardware interfaces, advanced analysis libraries, scientific user interface controls, measurement data networking, wizards, interactive code designers, and highly extensible classes [15].

Building on more than 20 years of measurement programming expertise, National Instruments created Measurement Studio with tools designed specifically for Microsoft Visual Basic, Visual C# .NET, and Visual C++ to bring you simplified integration with data acquisition and instrument control interfaces for easier hardware integration. With Measurement Studio, you use your Visual Studio programming knowledge to get measurements started quickly and create a complete measurement solution - all the way from acquiring to analyzing or presenting [15].

6.1.5 Visual Basic .NET (VB.NET)

Visual Basic .NET (VB.NET) is an object-oriented computer programming language that is the progression of Microsoft's Visual Basic (VB) which is generally implemented on the

Microsoft .NET Framework. Visual Basic 9.0 was released together with the Microsoft .NET Framework 3.5. For this release, Microsoft added many features, like Anonymous types, Support for LINQ, XML Literals and others.

6.2 User Interface

The user interface will be user-friendly with on-line documentation on each page explaining the different page functions and fields. A “Help” option will be provided as well as a contact page where the users can be directed in order that they might contact and communicate with the systems administrator. Drop-down lists, radio-buttons and other user-friendly options will be provided for the realization of data inputs to the system. Ajax Toolkit will be used to provide Web 2 functionality and nice interface. (Refer to Appendix V for the user interface).

6.3 Conclusion

The final end-product of this phase is the complete system. The coding of the system comes to an end and all types of testing are performed.

The transformation of the client requirements into a completed, documented and thoroughly tested system has been accomplished in such a way that the new system should fulfil the expectations of the client for service and system functionality.

Chapter 7

Installation Phase

7.1	System Installation Method
7.2	Database Installation
7.3	Web Site Installation
7.4	Analysis Configuration
7.5	Membership Provider Installation
7.6	Conclusion

7.1 System Installation Method

The Server on which the system will be installed is good to operate using the Windows 2008 Server. First of all, the system designers need to make sure that the IIS 5 and above is functioning fully. If not, it must be correctly installed. After the installation of the MS SQL Server 2005 and the Visual Studio.NET framework 3.5, a copy of the system Database, must be introduced onto the Microsoft SQL Server.

7.2 Database Installation

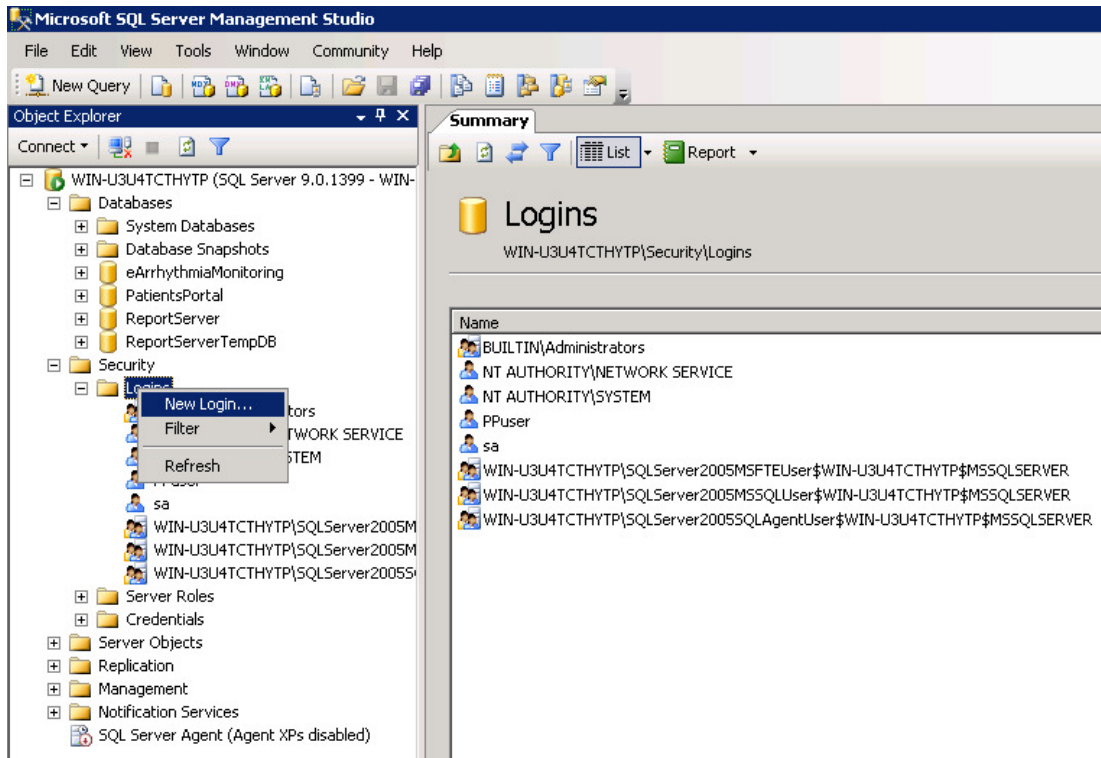
For the database installation first of all you have to create an empty database and then restore the original Patients' Portal Database and after that you have to create a new login.

Steps to restore the database

- Login to Microsoft SQL Server 2005 with the server name and the Authentication mode must be “Windows Authentication”.
- After that, **create New Database** with the database name PatientsPortal.
- Right click on the PatientsPortal database
 - Select Tasks\ **Restore**\ Database
- On the new window “**Restore Database - PatientsPortal**”
 - On the General tab, at “**Source for restore**” section select from the device the path for the “**PatientsPortal.bak**”
 - On the Options tab, select the option “**Overwrite the existing database**”

Steps to create new login

- Go to Security\Logins
 - Right click and select “**New Login...**”
 - Insert new “**PPUser**” to the new “Login name”
 - Then Select SQL Server authentication and insert the password “PPUser”
- When you have completed the new security login creation, select the **PatientsPortal** database, and then select security\users and insert the new user that you have created the “**PPUser**”.



Reference 7.2.1 Create a New Login in the Microsoft SQL Server Management Studio

7.3 Application Installation

7.3.1 wwwroot Installation

To install the website you have to create a **PatientsPortal** folder under the **C:\inetpub\wwwroot** directory. There you have to copy the following files that are shown below:

- \App_data*.mdf
- \App_data*.ldf
- \App_Themes\Default*.css
- \App_Themes\Default*.skin
- \Images*.*
- \Bin*.dll
- \My Project*.myapp

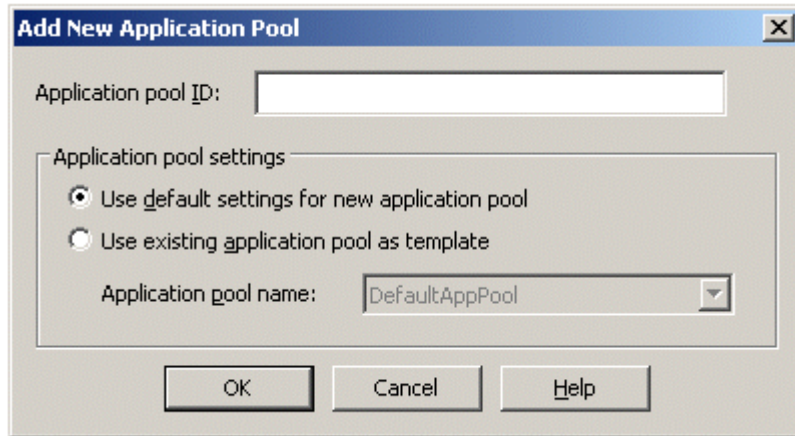
- \My Project*.resx
- \NotSecure*.aspx
- *.aspx
- *.ascx
- \licenses.licx

7.3.2 IIS 6.0 Installation

7.3.2.1 Application Pool Setup

First of all a new Application Pool for each web application (PatientsPortal, ApplicationServer) must be created. An Application Pool can contain one or more applications and allows us to configure a level of isolation between different Web applications [16]. Because each application pool runs in its own worker process, errors in one application pool will not affect the applications running in other application pools [16].

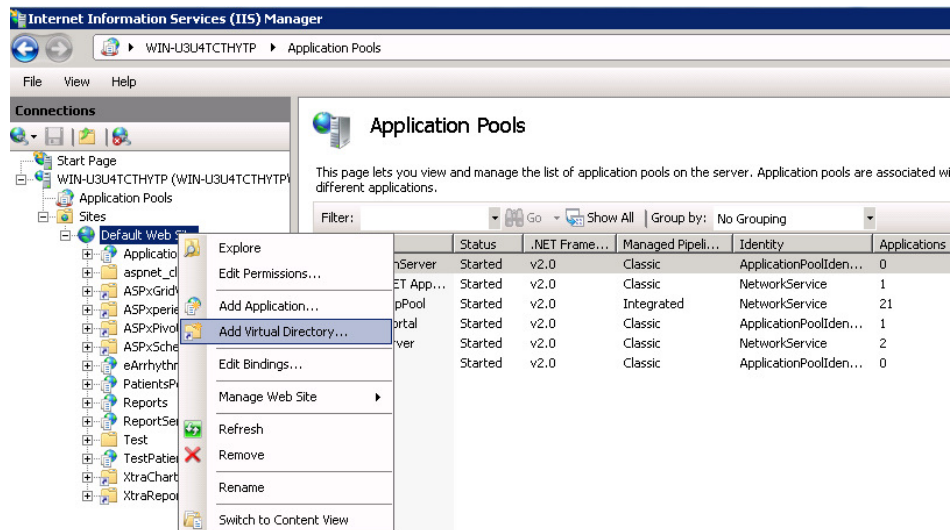
Creating a new application pool is a very simple process that is carried out by using the IIS manager. To create a new application pool, right-click on the **Application Pools** node from the tree view and select **New → Application Pool** [Reference 7.1] from the context menu. You will be presented with the following screen, where you need to enter a name for the application pool which in this case is **PatientsPortal**. When creating a new application, you also have the option of inheriting the settings from an existing application pool [16].



Reference 7.3.2.1 Add New Application Pool

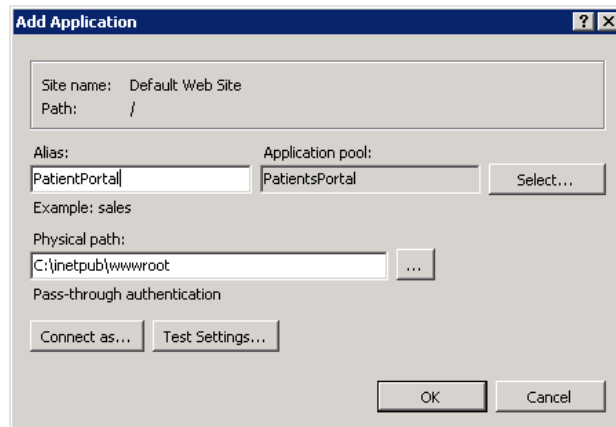
7.3.2.2 Patients Portal Virtual Directory configuration steps

1. The first step is to configure the Application Mapping within the web site properties. Open Internet Services Manager and navigate to the web site hosting your PatientsPortal web application which is the Default Web Site, (refer to Reference 7.2).



Reference7.3.2.2 Internet Information Services (IIS) Manager

2. Right click on the Default Web Site and select Properties. In the Web Site Properties dialog box, click on the Home Directory tab. Make sure that both the Read and Write checkboxes are checked. Browse and select the C:\inetpub\wwwroot\PatientsPortal directory. In the Application name field insert PatientsPortal then select PatientPortal in Application pool.



Reference 7.3.2.3 Add Application

7.3.3 Configuration file changes

Web applications ApplicationServer and PatientsPortal have **web.config** file. Additionally windows and console applications; ECGAnalisysServer and ECGArchiveServer have **app.config** file.

7.3.3.1 Connection string changes

Make the appropriate changes to the connectionString in order to have access to the database server. Insert the **Data Source** name which is the **Database server** then insert the **Initial Catalog** which is the database name which is the PatientsPortal. Note that the connectionString is case sensitive. In the connection string you have to insert the new user that we created before the PPuser in the uid and his password the pwd.

```
<connectionStrings>
  <add name="PatientsPortalConnectionString"
    connectionString="Data Source=WIN-U3U4TCTHYTP;
      Initial Catalog=PatientsPortal;
      Integrated Security=False;
      uid=PPuser;pwd=PPuser;"
    providerName="System.Data.SqlClient" />
</connectionStrings>
<system.web>
```

7.3.3.2 Application Settings changes

Furthermore **applicationSettings** section must change. Update the value section below with the valid URL for the **SystemWS.asmx** web reference for the web service. Note that this section is applicable only to the PatientsPortal **web.config**.

```
<applicationSettings>
  <PatientsPortal.My.MySettings>
    <setting name="PatientsPortal_SystemWSRef_SystemWS"
      serializeAs="String">
      <value>
        http://localhost/ApplicationServer/SystemWS.asmx
      </value>
    </setting>
  </PatientsPortal.My.MySettings>
</applicationSettings>
```

7.3.3.3 ECGAnalysisServer and ECGArchiveServer settings

The ECGAnalysisServer is programmed to loop 5 times on the not analyzed ECG in order to get the data and analyze. In order to update that you have to edit the **MaxLoopCount** based on your needs, in the app.config file.

```
<appSettings>
  <!-- How many time to loop -->
  <add key="MaxLoopCount" value="5"/>
  <add key="LogFilesPath" value="c:\logfiles\"/>
</appSettings>
```

7.3.3.4 Patient Portal E-Mail Settings

With the settings below the system is able to send the E-Mails using the Gmail SMTP service.

```
<system.net>
  <mailSettings>
    <smtp from="patientsportal@gmail.com" deliveryMethod="Network">
      <network
        host="smtp.gmail.com"
        port="587"
        password="avari$2010"
        userName="patientsportal" />
    </smtp>
  </mailSettings>
</system.net>
```

7.3.4 NTFS access

The systems write to a log files folder for logging purposes, in order to have access to do that; create **logfiles** folder in the C:\ drive then give write access to the **ASPNET** user and the **PPuser**.

7.4 Analysis configuration

The ECGAnalysisServer is used to analyze the ECG that has not been analyzed yet. In order to do that it gets the ECG from the database, and then it calls the ECGAnalysis to analyze the ECG. Note that the ECGAnalysis project is an old c program that was converted to a .Net C# program, which in our case needs some extra configuration.

In the folder which contains the **ECGAnalysisServer.exe** you must copy the **ECGAnalysis.dll** and all the **C** and **header** files that are needed.

In some cases the **ECGAnalysis.dll** must be copied under the **C:\WINDOWS\system32** folder to be found from the ECGAnalysisServer.

7.5 Membership Provider Installation

The purpose of the Membership Provider is to provide a layer of indirection between membership controls, like the Login Control, and the data store containing membership information [12]. In order to make changes to the membership provider there is some help information in Appendix IV.

7.6 Conclusion

Note that the same steps that we took for the **Patients' Portal** web application we have to do it for the **ApplicationServer** which contains the web services and **Test** web applications that are used to insert data for testing. For extra information concerning the solution installation refer to chapter 7.

After the installation procedures have been completed, the web site should be “up and running”.

Chapter 8

System Evaluation Phase

-
- 8.1 Testing Specification and Planning
 - 8.2 Test Scenarios and Results
 - 8.3 Conclusion
-

8.1 Testing specification and planning

8.1.1 Test Plan

Professional statistics show that satisfactory project evaluation depends heavily on a thorough testing plan and strategy. Therefore, rigorous testing is demanded for the effective evaluation of the finished end-product. Testing one of the most essential aspects of project implementation is the systematic process of executing the system with the intent of finding and removing all operating “bugs”. Successful testing of the system’s performance is required at each of the following levels:

8.1.1.1 Module Testing

For this type of testing, each individual module will be tested to determine whether all the system’s modules are logically and functionally correct. If an error occurs, a suitable debugging procedure will be followed.

8.1.1.2 Integration Testing

This form of testing will be applied to all interfaces among modules to ensure that transfer of both data and control are performed correctly. This testing method includes the run-time evaluation of all variables that are passed from one module to another.

8.1.1.3 Function Testing

The results and outcomes of the program will be evaluated after the execution of the program in which every functional menu selection has been activated systematically in turn.

After the program has been completed, comprehensive runs will be made so that each of the menu options can be activated in such a way as to trigger every possible program outcome and menu function. The results of the test runs will be compared with the projected outcomes for each of the program's functions and menu options. The outcomes of the program must match the projected outcomes within the program development plan. This procedure will indicate whether the results meet the expected requirements and will indicate where corrections or revisions need to be incorporated into the program or the new system.

8.1.1.4 System Testing

Since the objective of this type of testing is a full test of the entire system on the completion of the system development period, several testing tools e.g. the load test, the unit test that the visual studio 2008 offers will help us with testing in order to discover programming errors and potential problems. Then, a major effort will be made towards entirely debugging the system.

8.1.1.5 Acceptance Testing

Upon completion, the system will be transferred to a trusted Server and a group of friends and lecturers will have the chance to verify that the system is performing according to user

expectations and projections. They will test it using realistic data and within a real-life environment. Through this type of testing, program evaluators can approach the system and its facilities from the standpoint of the potential user. Hence, the users become familiar with the system environment and can compare it with the manner in which the new system was expected to operate.

The system will be tested with real data, with the patients' and doctors' help. The goal is to use this system to the minimum number of 50 patients, in order to be sure that everything is working correctly and it satisfies all requirements.

8.1.2 Programming and Testing

A proper system development demands the implementation of a procedure which consists of the following steps: Examination of the program specifications that were prepared during the technical design phase and the combining of them with the initial system requirements; preparation of a general program structure using the "Use Case" scenarios, entity relationship diagram etc; debugging and testing of the program modules.

8.1.3 User Training Description

As this project is a web application, there will be no need for user training. Therefore, as the system has a user-friendly environment, the users ought easily to be able to understand it. A "Help" option is provided and is available on-line from the site for any user who encounters a procedure or element which is not readily understandable. Additionally, a user's manual will be prepared which explains the functionality of the system and its parts.

As far as users' training is concerned, no special training is expected to be demanded because a competent administrator is required to have previous experience handling several types of

related tools and web servers. Also training material will be prepared for the patients and the nursery in order to help the patients to use it.

8.1.4 System Testing

8.1.4.1 Complete System Test

The activity of a complete system testing comprises two types of tests: the functional and the performance test.

Within functional testing, procedures will be followed to make sure that all the expected and required operations are incorporated and they perform completely and correctly. On the other hand, performance testing has to do with the testing of the quality of the performance of the system, and the instances of exceptional cases are listed and assessed.

8.2 Test Scenarios and Results

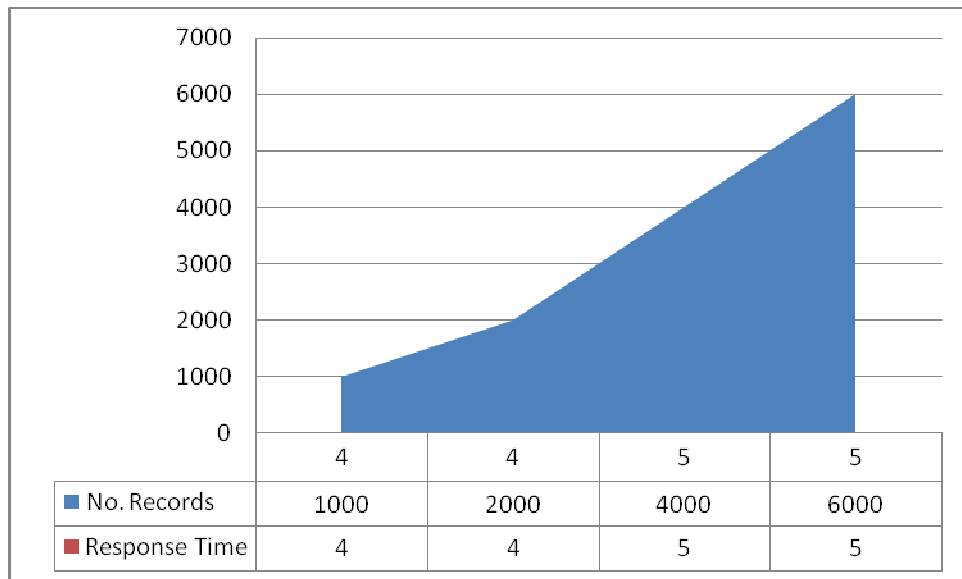
The main scenarios that we are going to examine here is the scenarios that have to do with Patient's vital information which is the main purpose of this project.

8.2.1 Web Service Call Scenarios

Note that the scenarios below were executed calling the web service that was in Paphos Hospital from my local computer located in Nicosia over the internet. The results may be different based on other conditions.

8.2.1.1 ECG input scenario

This scenario concerns the case that the ECG data are sent to the system using the web service from the external system.



Reference8.2.1: ECG Input matrices and graph.

The time is increased based on the number of records. It is a good practice to not sent more than 6000 records using the web service in order to not increase the content length of the http request. It is good practice to sent butches of 6000 ECG records in order to keep the HTTP content length small doing that we avoid data lost and data corruction.

8.2.1.2 Vital Information input scenario

This scenario concerns the case that the patient's Weight, Oxygen Saturation and Blood Pressure are sent to the system using the web service from the external system.

Scenario	Number of Records	Response Time
Weight	1	1 sec
Oxygen Saturation	1	1 sec
Blood Pressure	3	1 sec

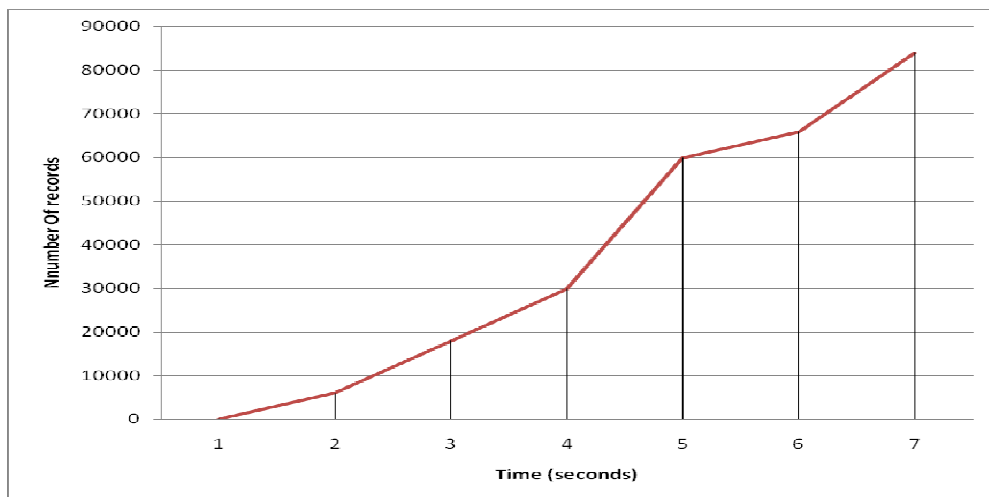
Table 8.1: Weight Input matrices.

8.2.2 ECG Analysis Scenarios

The scenarios below shows the time that was needed to read the data from the Database analyze them and finally store it back to the database. The analysis is done by calling the ECGAnalysisServer. The response time is very good and it is raise based on the records increase.

Number of Records	Response Time/ sec
120	1
6000	2
17982	5
29970	10
59940	18
65934	20
83916	26
215784	67

Table 8.2.2: ECG Analysis matrices.



Reference 8.2.3: ECG Analysis chart.

8.2.3 ECG Archive Scenarios

The scenarios below shows the time that was needed to archive the ECG data. The archive process is done by calling the ECGArchiveServer. We see that the response time have not significant change derived from the record amount.




Number of Records	Response Time (sec)
6000	1
17983	1
41959	1
77923	1
215785	2

Table 8.3: ECG Archive matrices







8.2.4 Patients Portal code metrics

Visual Studio offers the Code Metrics tool that helps users find and act upon complex and unmaintainable areas within an application. Below there are the most important code metrics of the PatientPortal project.

The following table shows the range at which an icon is shown [11]:

-  **High Maintainability** Between 20 and 100 inclusive
-  **Moderate Maintainability** Between 10 and 19 inclusive
-  **Low Maintainability** Between 0 and 9 inclusive

High coupling indicates a design that is difficult to reuse and maintain because of its many interdependencies on other types. Indicates the number of class definitions that extend to the root of the class hierarchy. The deeper the hierarchy the more difficult it might be to understand where particular methods and fields are defined or/and redefined [11].

Hierarchy	Maintainability Index	Cyclomatic Complexity	Depth of Inheritance	Class Coupling	Lines of Code
 PatientsPortal (Release)	84	994	5	156	1,553
 ApplicationServer (Release)	81	105	3	49	487
 Test (Release)	86	101	4	31	168
 ECGAnalysis (Release)	60	59	1	0	96
 ECGAnalysisServer (Release)	44	12	1	27	67
 ECGArchiveServer (Release)	69	2	1	16	10

Reference 8.2.3: Code matrices.

8.2.5 Patients Portal Load Test

Load testing is one of those steps that should be performed for every major system rollout but rarely happens. When a web application exposes complex information structures and implements complex business logic, synchronization problems resulting from simultaneous users accessing and modifying the same data can cause system defects that cannot be detected with single-user mode functional testing tools. These types of defects frequently result in incorrect behavior and/or data corruption - sometimes even complete application lockup or crashing. They are also the hardest to detect and reproduce - and are frequently blamed on other sources, such as the users, when they cannot be easily reproduced by the developers or testers [20].

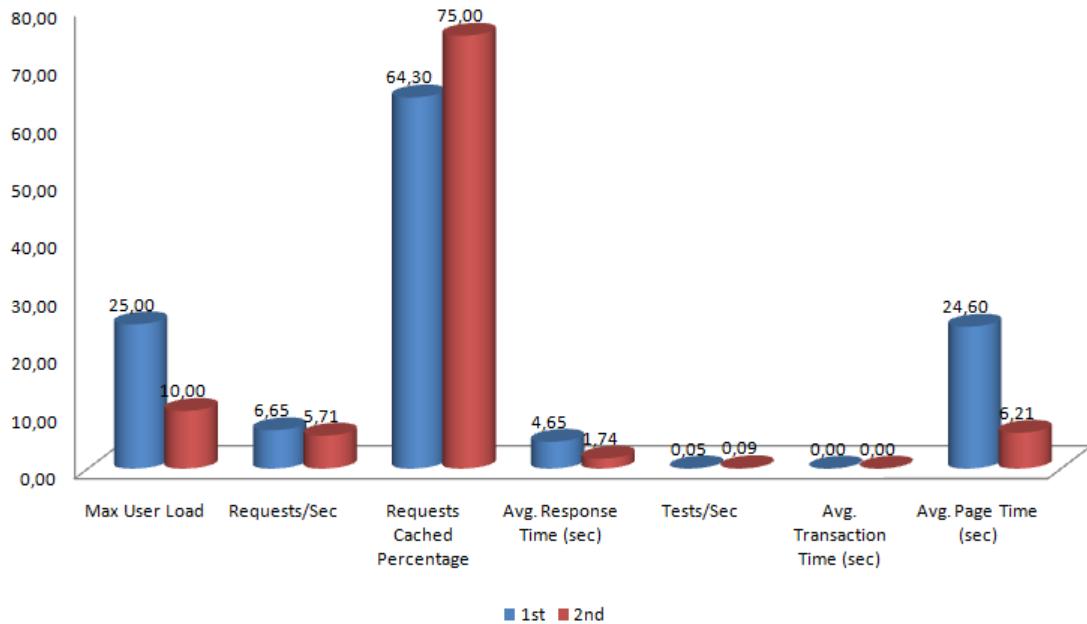
The tests below simulate 25 and 10 users and it was running for 10 minutes the warm-up duration was 30 and 60 seconds respectively. Tests were applied to the pages that have the most significant processing functions like ECG Preview and VitalInfo.

Below there are the overall results and the load test parameters.

Max User Load	25	10
Requests/Sec	6,65	5.71
Requests Cached Percentage	64,3	75
Avg. Response Time (sec)	4,65	1.74
Avg. Content Length (bytes)	9.021	10.179
Tests/Sec	0,048	0.085
Avg. Test Time (sec)	386	116
Avg. Transaction Time (sec)	0	0
Avg. Page Time (sec)	24,6	6.21

The graphical representation of overall results, which can be viewed in Reference 8.2.9. Blue bars display the first case that the scenario was simulating 25 simultaneous accesses to the Patients Portal and the red bars indicates the scenario with 10 users. We notice that the results

of the second case are much better than the first case. Request cached, Average Response Time and the Average Page time are better in the case that we have 10 users accessing the patient portal.

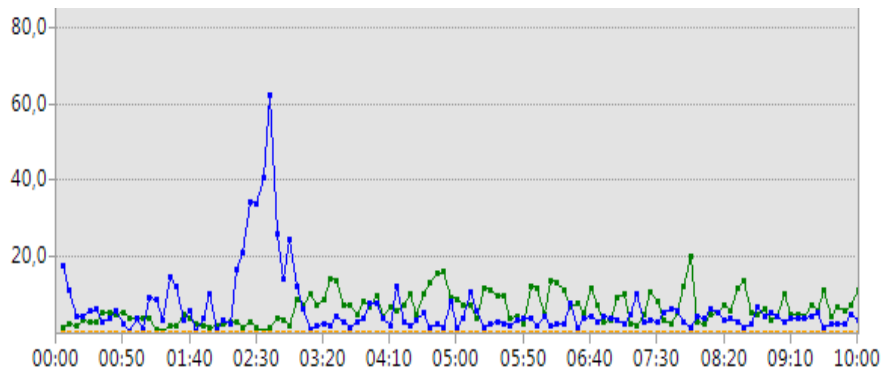


Reference 8.2.4: Overall Results Graph.

The “average page time” from 24.60 seconds it is decreased to 6.21 seconds. Furthermore the cached percentage it is increased in the case that the uses are 10 rather than 24 this minimize the response time.

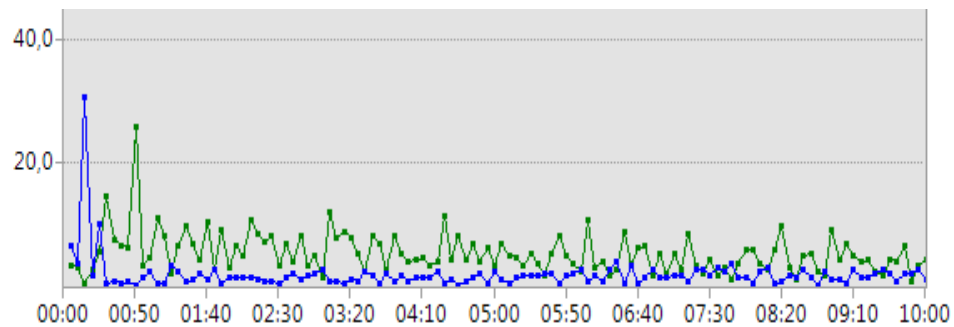
8.2.5.1 Key Indicators

In the graph below we notice that the Request time is normal in all cases with average time 6.65 and maximum time 20.60 seconds. On the other hand the average response time is 4.65 and the minimum response time is 0.92 seconds. Furthermore we see a pick with the maximum 62.8 at 2:30 minutes when the Home.aspx was displayed; this case is acceptable because home page displays huge amount of data and the simultaneous users’ access was 25 which decrease the cache percentage.



Reference 8.2.5: Key indicators for 25 users' simulation.

In the case below we see that the results are much better than the results shown in the Reference 8.2.10. The warm up time below is 1 minute on the other hand the warm up time is 30 seconds on the first experiment. The maximum response time in the first case is 62.8 on the other hand the maximum response time in the second experiment is 31.1 much better.



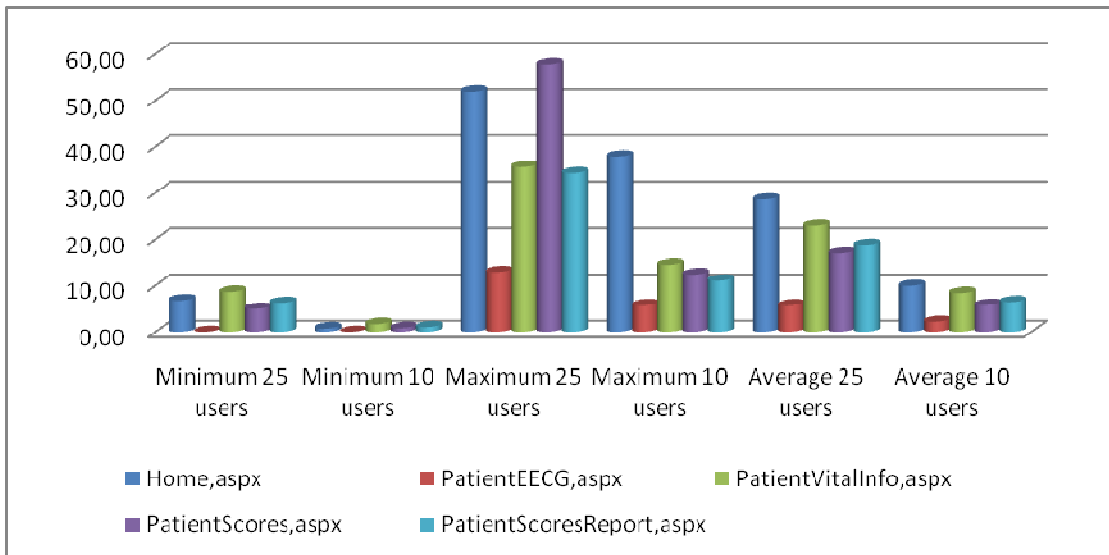
Reference 8.2.6: Key indicators for 10 users' simulation.

Key Indicators		Min	Min	Max	Max	Avg	Avg
		25 users	10 users	25 users	10 users	25 users	10 users
Request/Sec	—+—	0.80	0.80	20.6	26.4	6.65	5.71
Avg. Response Time	—■—	0.92	0.56	62.8	31.1	4.65	1.74

Table 8.4: Key indicators for 10 users' simulation

8.2.5.2 Page Response Time

The graph below shows the response time for the pages. There are no any irregular picks in the response time except the home.aspx. We can see that the Page Response Time for the case that the test was done with 10 users is better.



Reference 8.2.7: Page Response Time for 25 and 10 users' simulation.

Page	Min 25 users	Min 10 users	Max 25 users	Max 10 users	Avg 25 users	Avg 10 users
Home	6,77	0,78	51,90	37,90	28,60	9,95
PatientEECG	0,00	0,00	12,90	5,71	5,68	2,20
PatientVitalInfo	8,67	1,73	35,60	14,50	22,90	8,40
PatientScores	4,97	0,86	57,80	12,40	16,90	5,78
PatientScoresReport	6,28	1,04	34,30	11,10	18,80	6,47

Table 8.5: Page Response Time for 25 and 10 users' simulation

8.3 Compare our system with A Wireless System for Monitoring of Children with Suspected Arrhythmias

Below in table 8.6 there are several comparisons concerning the proposed system; Post-Cardiosurgery Home Monitoring System (PCHMS) with AMEK (A Wireless System for Monitoring of Children with Suspected Arrhythmias) [19].

Information	PCHMS	AMEK
Maintain Patient Information	✓	✓
Patient's Medical Background	✓	
Hospitalization Information	✓	
Hospitalization Symptoms	✓	
Call	✓	
Visits	✓	✓
Questionnaire and Scores	✓	
Follow up information	✓	
24 hours ECG monitoring		✓
Several (5) minutes ECG monitoring	✓	
Real time ECG Analysis		✓
Near Real Time ECG Analysis	✓	
Weight monitoring	✓	
Blood Pressure monitoring	✓	
Oxygen Saturation monitoring	✓	
ECG Analysis Batch	✓	
ECG Analysis 1 record each time		✓

Table 8.6: Comparisons PCHMS vs. AMEK

8.4 Conclusion

The final end-product of this phase is the complete system. The coding of the system comes to an end and all types of testing were performed. The transformation of the client requirements into a completed, documented and thoroughly tested system has been accomplished in such a way that the new system should fulfil the expectations of the client for service and system functionality.

Based on the conditions that we did the tests, the test results indicates that it is good to not to have more than 10 users accessing the application simultaneously, because the response time it is increased.

Chapter 9

Conclusions and Future Work

-
- 9.1 Conclusions
 - 9.2 External System that has to be created
 - 9.3 Internal System additional work
-

9.1 Conclusions

The added value of carrying out this project at National and European level is clear, given the dimension of the growing elderly population in Cyprus. The ageing population affects Cyprus as a whole, and is not particular to any given layer of the society. People in general can expect to live longer lives opens great new opportunities for individuals to fulfil their potential. The combined effect of these achievements in the form of population ageing also presents us with new challenges and will affect the social and economic foundations of the society. Furthermore, it is project's conviction that innovations and technologies for an ageing population should not exclude older people from the production and use of technologies. It is thus vital that this project embraces a general scope, so as to include several end-users to reflect the needs and user specifications of the most possible senior citizens, not just those of a limited group. It will be a highly innovative solution. Enabling safe independent living in the elderly persons preferred environment will contribute to their happiness, security and wellbeing.

Some typical functionality that the proposed system supports includes the following: user management, patient information and finally the most important is the patient's vital information reports and graphs.

User Management includes user registration, which, in our case, users will be the Doctors and the Nurses. The users can manage their account, they can change their account and their personal and contact information. The Patient Information can be added by the nurses or by the doctor that examines the patient. Patient information includes his demographic information, his medical background, his hospitalization information and his symptoms. Furthermore, information concerning his calls and visits and patient follow up information are collected by the system. Additionally, a questionnaire is provided by the system that the patient answers before and after his treatment. The Patient's vital information reports and graphs are generated by the system for each patient. Reports and graphs are provided for the patient's weight, blood pressure, oxygen saturation and, finally and most importantly the ECG graph is generated, in the case that it is not analyzed; it is analyzed by the system with the aim of giving the doctors helpful information. With the help of technology we provide a system that will control and help parties, the patients and the doctors. Technology nowadays provides several tools like sensors that can be used to manage this. The Scores report is generated automatically based on the patient's answers on the questionnaire.

With the use of this system the patients don't have to visit the hospital almost every day just for monitoring purposes for few minutes. With the help of specialized sensors and other equipment, vital information like the ECG, weight, blood pressure and oxygen saturation will be collected by the patient and sent automatically to the doctor (using the external system that will be created in the future. Refer to 9.2 for more information). After that the doctor can process that information and decide what action he/she must take. The solution that will be taken at the patient's home is not going to be implemented at this stage of the project.

The use of the system will both save money and time for the patients and for the doctors. With this system it is not necessary for the patient to visit the hospital every day. The doctor is able to view the vital information that he needs from the system without the need of the patient to be there.

9.2 External System that has to be created

An external system has to be created that will be at the patient's house. This system will collect the patient's vital items of information, which are Weight, Blood Pressure and Oxygen Saturation. Additionally, the most important vital information that has to be collected is the patient's ECG. That vital information will be collected with specialized sensors that will be connected with the system.

An assessment has to be done to verify that the external system has the power to analyse the ECG, in case the system has the power to do it; then it will analyse the ECG and send the Analysed ECG to the Application Server calling the `AddECGAnalyzed` method of the `VitalInfoWS`. In the case that the system doesn't have the power to analyze the ECG then it has to collect the ECG and send it to the system called the `AddECGNotAnalyzed` method of the `VitalInfoWS`.

In addition, the vital items of information that will be collected are the Weight, Blood Pressure and Oxygen Saturation; this vital information has to be sent to the systems calling `AddWeight`, `AddCxygenSaturation` and `AddBloodPressure` methods respectively. The connection with the external system will be done by calling the `VitalInfoWS` web service. For more information refer to Appendix VIII.

9.3 Internal System additional work

The system now has completed its predefined scope. Furthermore some additional information can be provided from the system; this information includes statistical reports and data mining functionality.

The system collects the vital information that is necessary so that the doctor may review his/her patients. Additionally, more information is currently collected concerning the patient; this information is his/her demographic information; his/her medical background, hospitalization information, calls and visits, follow up information and finally and more importantly, a questionnaire is answered by the patient before and after his/her treatment; based on these answers, physical, emotional and global scores are calculated.

Additionally, monthly statistical reports can be generated and be sent to the doctors concerning the patients' vital information and data.

Appendix I

User Input

Patient's Personal Information

ΙΣΤΟΡΙΚΟ

Νοσοκομείο Αρ. Αρχείου.....
Θάλαμος..... Θεράπων Γιατρός.....
Ημερομηνία Ημερομηνία Εισαγωγής
Αρχική Διάγνωση Διάγνωση κατά το εξιτήριο.....

ΔΗΜΟΓΡΑΦΙΚΑ ΣΤΟΙΧΕΙΑ

ΠΡΟΣΩΠΙΚΑ ΣΤΟΙΧΕΙΑ

Όνομα ασθενούς: Επίθετο:
Αριθμός Ταυτότητας: Φύλο: Άρρεν Θήλυ
Ημ. Γέννησης:/...../.....
Εθνικότητα: Ιθαγένεια:
Οικογενειακή κατάσταση Παντρεμένος/η Διαζευγμένος/η
 Χήρος/α Ελεύθερος/η
Επάγγελμα / Ιδιότητα:
Εκπαίδευση: Δημοτικό Λύκειο Ανώτερη Ανωτάτη Μεταπ/κή
Παρούσα κατάσταση: Εργοδοτούμενος Άνεργος Συνταξιούχος Με αναπηρία
Μένει: Με την οικογένεια
 Στο σπίτι μόνος/η με βοήθεια από την οικογένεια

- Στο σπίτι μόνος/η με οικιακή βοηθό
- Στο σπίτι μόνος/η με βοήθεια από την κοινωνική πρόνοια
- Σε οίκο ευγηρίας
- Αλλού: Διευκρινίστε

Προσωπικός Γιατρός:

Τηλέφωνο προσωπικού γιατρού:

ΣΤΟΙΧΕΙΑ ΕΠΙΚΟΙΝΩΝΙΑΣ

Διεύθυνση κατοικίας:.....

Τηλέφωνο: 1. 2.

.....

Πλησιέστερος συγγενής / φροντιστής :

Συγγένεια / Σχέση:

Τηλέφωνο πλησιέστερου συγγενή:

ΣΤΟΙΧΕΙΑ ΕΙΣΑΓΩΓΗΣ

Ωρα εισαγωγής: ΠΜ ΜΜ

Τρόπος Προσέλευσης: Απευθείας προσέλευση στο Τμήμα Πρώτων Βοηθειών

- Προγραμματισμένη εισαγωγή
- Παραπομπή από προσωπικό γιατρό
- Κλήση Ασθενοφόρου

Με συνοδεία: ΝΑΙ ΟΧΙ

Κύριο ενόχλημα κατά την εισαγωγή:

Συμπτώματα / Σημεία κατά την εισαγωγή:

- | | |
|--|---|
| <input type="checkbox"/> Δύσπνοια | <input type="checkbox"/> Κόπωση |
| <input type="checkbox"/> Ορθόπνοια | <input type="checkbox"/> Οίδημα |
| <input type="checkbox"/> Λήθαργος | <input type="checkbox"/> Συριγμός |
| <input type="checkbox"/> Περικάρδιο άλγος / Στηθάγχη | <input type="checkbox"/> Υπέρταση ή Υπόταση |
| <input type="checkbox"/> Αίσθημα παλμών | <input type="checkbox"/> Άλλα: |

ΙΑΤΡΙΚΟ ΙΣΤΟΡΙΚΟ

ΠΑΛΑΙΟΤΕΡΟ ΙΣΤΟΡΙΚΟ

Αλλεργίες :

.....

...

Προηγούμενες εισαγωγές στο νοσοκομείο: ΝΑΙ ΟΧΙ

Αν ναι, αιτία:

Επεμβάσεις:

Παλαιότερα νοσήματα:

Χρόνια συνοδά νοσήματα:

Ρευματική νόσος: ΝΑΙ ΟΧΙ

Χρόνια νεφρική ανεπάρκεια: ΝΑΙ ΟΧΙ

Χρόνια αποφρακτική πνευμονοπάθεια: ΝΑΙ ΟΧΙ

Ασθμα: ΝΑΙ ΟΧΙ

Αγγειακό Εγκεφαλικό Επεισόδιο: ΝΑΙ ΟΧΙ

Άλλα:.....

Φυσική Κατάσταση:

Άθληση / Άσκηση: ΝΑΙ ΟΧΙ

Χρήση ουσιών: ΝΑΙ ΟΧΙ

ΚΑΡΔΙΟΛΟΓΙΚΟ ΙΣΤΟΡΙΚΟ

Οικογενειακό ιστορικό: ΟΧΙ ΝΑΙ

Αριθμός Α Βαθμού Συγγενών:

Παράγοντες κινδύνου:

Υπέρταση Κατάχρηση αλκοόλ Παχυσαρκία

Διαβήτης Υπερλιπιδαιμία Καρδιοτοξικά φάρμακα Κάπνισμα :

ΟΧΙ ΝΑΙ Παθητικό κάπνισμα

Κοινωνικό κάπνισμα

Τακτικός καπνιστής

Ενεργός καπνιστής ; ΝΑΙ ΟΧΙ

Συνολικά έτη καπνίσματος: 1-5 έτη 6-10 έτη 11-20 έτη πάνω από 20

Υποκείμενη Νόσος:

- | | | |
|---|-------------------------------------|--|
| <input type="checkbox"/> Στεφανιαία Νόσος | <input type="checkbox"/> Αρρυθμίες | <input type="checkbox"/> Μυοκαρδιοπάθεια |
| <input type="checkbox"/> Βαλβιδοπάθεια | <input type="checkbox"/> Υπερτασική | <input type="checkbox"/> Χρόνια κολπική |
| <input type="checkbox"/> Άλλο | μυοκαρδιοπάθεια | μαρμαρυγή |

Αγγειογραφία:

ΟΧΙ

.....

ΝΑΙ Ημερομ. :

Με

ευρήματα

Ιστορικό εμφράγματος του μυοκαρδίου:

ΟΧΙ

.....

ΝΑΙ Ημερομ. :

Αγγειοπλαστική (Μπαλονάκι):

ΟΧΙ

.....

ΝΑΙ Ημερομ. :

Αορτοστεφανιαία Παράκαμψη (By Pass):

ΟΧΙ

.....

ΝΑΙ Ημερομ. :

Εμφυτευμένες συσκευές

(implantable devices)

Μόνιμος

ΟΧΙ

.....

Βηματοδότης:

ΝΑΙ Ημερομ. :

Εμφυτευμένος

ΟΧΙ

.....

απνιδωτής (ICD)

ΝΑΙ Ημερομ. :

	Συσκευή			
	συγχρονισμένης			
	βηματοδότησης	<input type="checkbox"/> OXI		.....
	(CRT)	<input type="checkbox"/> NAI	Ημερομ. :	....
	Συσκευή			
	υποβοήθησης			
	αριστερής	<input type="checkbox"/> OXI		.....
	κοιλίας (LVAD)	<input type="checkbox"/> NAI	Ημερομ. :	....
Προσθετικές Βαλβίδες:		<input type="checkbox"/> OXI		.....
		<input type="checkbox"/> NAI	Ημερομ. :	....
Ηλεκτροφυσιολογική				
μελέτη:		<input type="checkbox"/> OXI		.....
		<input type="checkbox"/> NAI	Ημερομ. :	....
Νοσηλεία στη ΜΕΘ:		<input type="checkbox"/> OXI		.....
		<input type="checkbox"/> NAI	Ημερομ. :	....
			Αιτία:	.....
			Ήμερες	
			νοσηλείας:	.....
ΚΑΡΠΑ:		<input type="checkbox"/> OXI		
		<input type="checkbox"/> NAI	Ημερομ. :	.....
Ανάταξη από				
εμφυτευμένη				
συσκευή:		<input type="checkbox"/> OXI		
		<input type="checkbox"/> NAI	Ημερομ. :	.....

ΚΑΤΑ ΤΗ ΝΟΣΗΛΕΙΑ

Διαγνωστικές Εξετάσεις:

- Υπερηχοκαρδιογράφημα Κλάσμα εξώθησης (LV Ejection Fraction) %
 - Συστολική Δυσλειτουργία αρ. κοιλίας
 - Υπερτροφία αριστερής κοιλίας
 - Στένωση μιτροειδούς
 - Στένωση αορτικής βαλβίδας
 - Βαλβιδική παλινδρόμηση αορτική
 - μιτροειδική
 - πνευμονική
 - τριγλωχινική
- Ακτινογραφία θώρακα: Χωρίς ευρήματα Πνευμονικό Οίδημα
 - Πλευριτική συλλογή Πνευμονική λοίμωξη
 - Ατελεκτασία Άλλα παθολογικά ευρήματα
- ΗΚΓ: Ρυθμός Φλεβοκομβικός Κολπική Μαρμαρυγή
 - Βηματοδοτούμενος Άλλος
- Παλιό ΕΜ ΝΑΙ ΟΧΙ
- BNP τιμή
- NT-pro BNP τιμή
- Απεικόνιση με ραδιονουκλίδια (σπινθηρογράφημα)
 - Ευρήματα
- Καθετηριασμός Ευρήματα.....
- Μαγνητική τομογραφία (MRI) / Αξονική τομογραφία (CT)

Αιματολογικός – Βιοχημικός έλεγχος

Τιμές της πιο πρόσφατης ανάλυσης

Ημερομηνία

ΣΤΟΙΧΕΙΑ ΚΑΤΑ ΤΟ ΕΞΙΤΗΡΙΟ

Ταξινόμηση κατά NYHA I II III IV

Βάρος: Ύψος: ΔΜΣ:

- Εξιτήριο: Στο σπίτι
 Σε κλινική αποκατάστασης
 Σε οίκο ευγηρίας
 Σε συγγενείς
 Άλλού

Συμπτώματα / Σημεία κατά το εξιτήριο:

- | | |
|---|--------------------------------------|
| <input type="checkbox"/> Δύσπνοια | <input type="checkbox"/> Κόπωση |
| <input type="checkbox"/> Ορθόπνοια | <input type="checkbox"/> Αναιμία |
| <input type="checkbox"/> Προκάρδιο άλγος/Στηθάγχη | <input type="checkbox"/> Ζάλη |
| <input type="checkbox"/> Αίσθημα παλμών | <input type="checkbox"/> Ασκίτης |
| <input type="checkbox"/> Ακροαστικά πνευμόνων | <input type="checkbox"/> Συριγμός |
| <input type="checkbox"/> Ανορεξία | <input type="checkbox"/> Άλλα: |
| <input type="checkbox"/> Οίδημα: <input type="checkbox"/> Σφυρών <input type="checkbox"/> Γαστροκνημίας <input type="checkbox"/> Μηρών <input type="checkbox"/> Κοιλιακή χώρα | |

ΑΠ κατά το εξιτήριο:

Καρδιακός ρυθμός κατά το εξιτήριο:

- Συχνότητα ΦΚ
 Κολπική Μαρμαρυγή
 Βηματοδοτούμενος
 Έκτακτες συστολές
 Άλλο

Φαρμακευτική Αγωγή κατά το εξιτήριο

<input type="checkbox"/> Διουρητικό Αγκύλης	Σκεύασμα	.....	Δόση	.....
<input type="checkbox"/> Διγοξίνη	Σκεύασμα	.....	Δόση	.....
<input type="checkbox"/> Σπιρονολακτόνη	Σκεύασμα	.....	Δόση	.....
<input type="checkbox"/> Β-αποκλειστές	Σκεύασμα	.....	Δόση	.....
<input type="checkbox"/> Αναστολείς Διαύλων Ca ⁺⁺	Σκεύασμα	.....	Δόση	.....
<input type="checkbox"/> AMEA / AT II	Σκεύασμα	.....	Δόση	.....
<input type="checkbox"/> Θειαζίδη / Μετολαζονη	Σκεύασμα	.....	Δόση	.....
<input type="checkbox"/> Νιτρώδη	Σκεύασμα	.....	Δόση	.....

<input type="checkbox"/> Σπρέι Νιτρογλυκερίνης	Σκεύασμα	.....	Δόση	.....
<input type="checkbox"/> Ασπιρίνη	Σκεύασμα	.....	Δόση	.....
<input type="checkbox"/> Κουμαρινικά	Σκεύασμα	.....	Δόση	.....
<input type="checkbox"/> Στατίνες	Σκεύασμα	.....	Δόση	.....
Άλλα: 1.....	Σκεύασμα	.....	Δόση	.....
2.....	Σκεύασμα	.....	Δόση	.....
3.....	Σκεύασμα	.....	Δόση	.....
4.....	Σκεύασμα	.....	Δόση	.....
5.....	Σκεύασμα	.....	Δόση	.....
6.....	Σκεύασμα	.....	Δόση	.....

ΕΚΠΑΙΔΕΥΣΗ:

Εκπαίδευση κατα το εξιτήριο: ΝΑΙ ΟΧΙ
Δόθηκε έντυπο εκπαιδευτικό υλικό: ΝΑΙ ΟΧΙ
Εκπαίδευση της οικογένειας: ΝΑΙ ΟΧΙ

Patient's Questioner & Score Information [10]

LIVING WITH HEART FAILURE QUESTIONNAIRE

These questions concern how your heart failure (heart condition) has prevented you from living as you wanted during the last month. The items listed below describe different ways some people are affected. If you are sure an item does not apply to you or is not related to your heart failure then circle 0 (No) and go on to the next item. If an item does apply to you, then circle the number rating how much it prevented you from living as you wanted.

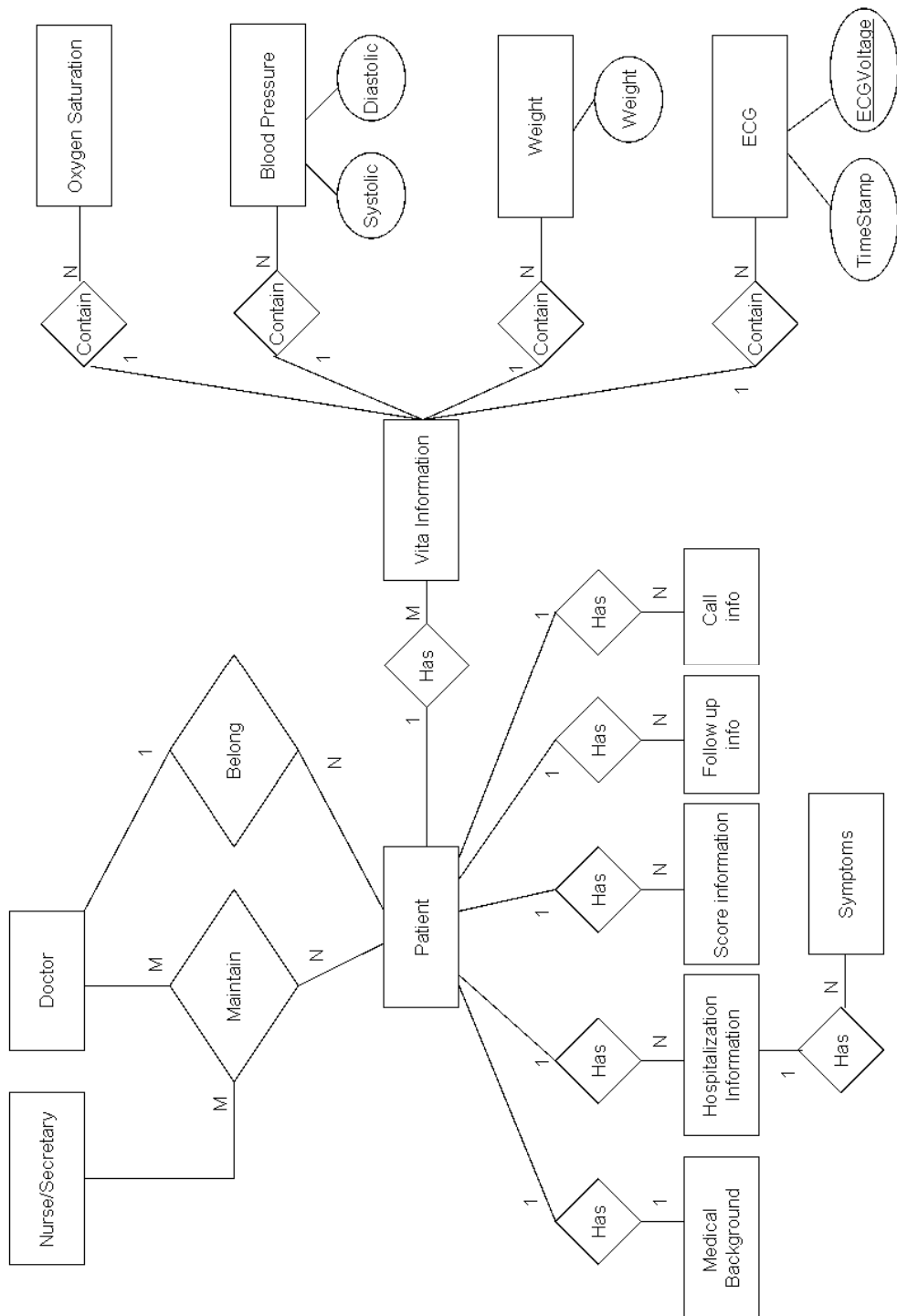
Did your heart failure prevent you from living as you wanted during the last month by:

	No	Very little				Very much
1. Causing swelling in your ankles, legs, etc.?	0	1	2	3	4	5
2. Making you sit or lie down to rest during the day?	0	1	2	3	4	5
3. Making your walking about or climbing stairs difficult?	0	1	2	3	4	5
4. Making your working around the house or yard difficult?	0	1	2	3	4	5
5. Making your going places away from home difficult?	0	1	2	3	4	5
6. Making your sleeping well at night difficult?	0	1	2	3	4	5
7. Making your relating to or doing things with your friends or family difficult?	0	1	2	3	4	5
8. Making your working to earn a living difficult?	0	1	2	3	4	5
9. Making your recreational pastimes, sports or hobbies difficult?	0	1	2	3	4	5
10. Making your sexual activities difficult?	0	1	2	3	4	5
11. Making you eat less of the foods you like?	0	1	2	3	4	5
12. Making you short of breath?	0	1	2	3	4	5
13. Making you tired, fatigued, or low on energy?	0	1	2	3	4	5
14. Making you stay in a hospital?	0	1	2	3	4	5
15. Costing you money for medical care?	0	1	2	3	4	5
16. Giving you side effects from medications?	0	1	2	3	4	5
17. Making you feel you are a burden to your family or friends?	0	1	2	3	4	5
18. Making you feel a loss of self-control in your life?	0	1	2	3	4	5
19. Making you worry?	0	1	2	3	4	5
20. Making it difficult for you to concentrate or remember things?	0	1	2	3	4	5
21. Making you feel depressed?	0	1	2	3	4	5

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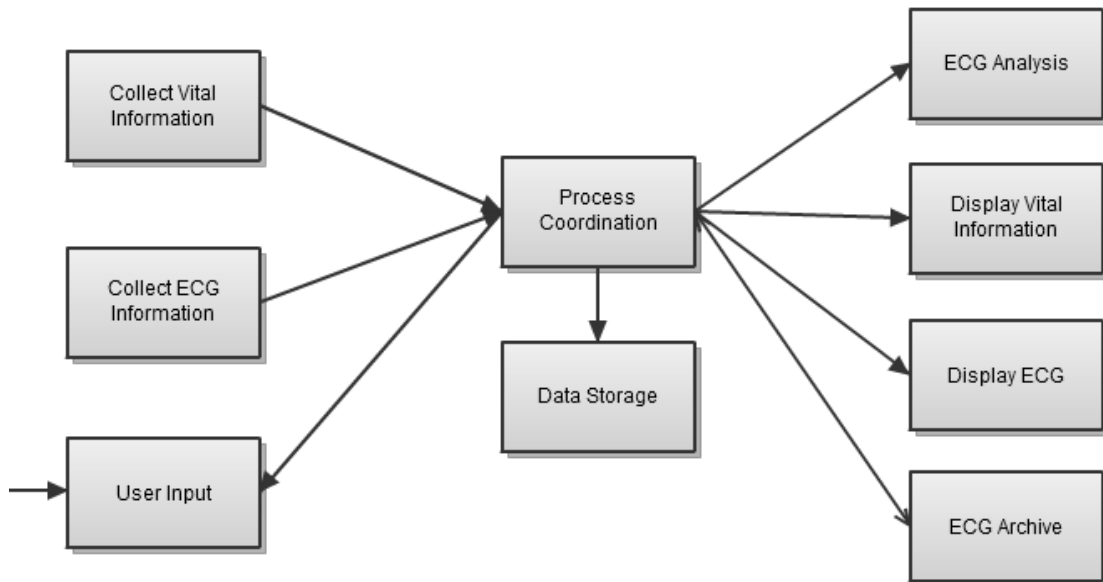
Appendix II

Entity Relationship Diagram (ERD)



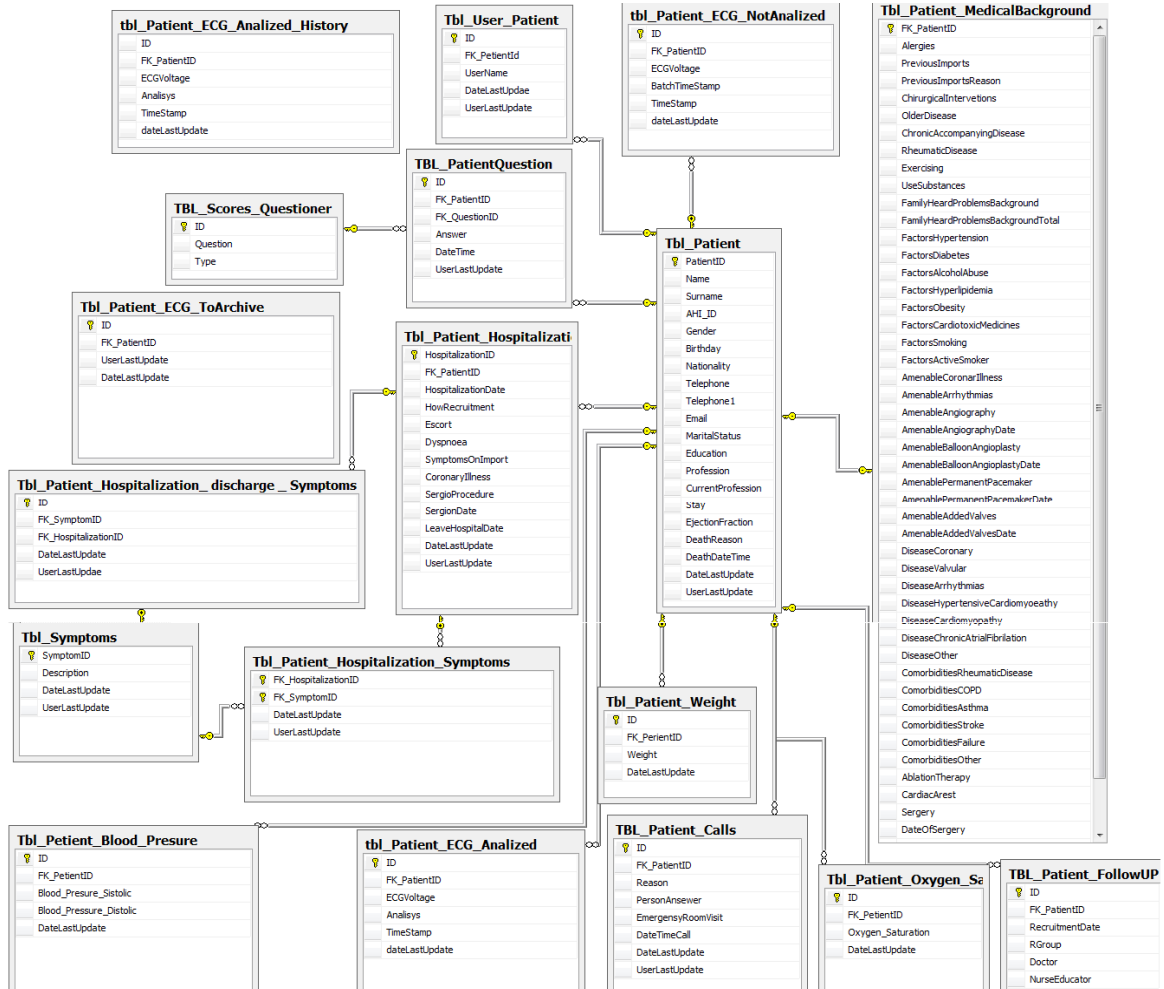
Appendix III

Process Flow Diagram (PFD)



Appendix IV

Database Structure



Appendix V

Patients Portal User Interface

Registration Page

Sign Up for Your New Account

User Name:

Password:

Confirm Password:

E-mail:

Security Question:

Security Answer:

Login Page

Log In

User Name:

Password:

Remember me next time.

Change Password Page

Change Your Password

Password:

New Password:

Confirm New Password:

Patient's Maintenance page

Name	<input type="text"/>
Surname	<input type="text"/>
AHI ID	<input type="text"/>
Gender	<input type="radio"/> Male <input type="radio"/> Female
Date of birth	<input type="text"/>
Nationality	<input type="text"/>
Telephone	<input type="text"/>
Telephone1	<input type="text"/>
Email	<input type="text"/>
<hr/>	
Marital Status	<input type="radio"/> Married <input type="radio"/> Divorced <input type="radio"/> Widower <input type="radio"/> Free
<hr/>	
Education	<input type="radio"/> Public school <input type="radio"/> Lyceum <input type="radio"/> Superior education <input type="radio"/> Maximum education <input type="radio"/> Postgraduate
Profession	<input type="text"/>
Current Profession	<input type="radio"/> Employed <input type="radio"/> Unemployed <input type="radio"/> Pensioner <input type="radio"/> Disabled
Stay	<input type="radio"/> With Family <input type="radio"/> Home alone with family help <input type="radio"/> Home alone with domestic help <input type="radio"/> Home alone with social providence <input type="radio"/> Home alone with family help
<hr/>	
<u>Insert</u> <u>Cancel</u>	

Patient's Hospitalization page

Patient *	Antreas Antreou ▼
Hospitalization Date	<input type="text"/>
Way of arrival	<input type="radio"/> Department of First Aid <input type="radio"/> Schedule visit <input type="radio"/> Personal doctor sent him/her <input type="radio"/> Ambulance call
Accompanied during admission	<input type="checkbox"/>
Majort Symptom On Admission	<input type="text"/>
Dyspnoea - NYHA classification	<input type="radio"/> NYHA I <input type="radio"/> NYHA II <input type="radio"/> NYHA III <input type="radio"/> NYHA IV
Coronary artery disease	<input type="checkbox"/>
Date of Surgery	<input type="text"/>
Surgical Procedure	<input type="text"/>
Leave Hospital Date	<input type="text"/>
Insert Cancel	

Patient's Hospitalization Symptoms page

Select	Symptom
<input type="checkbox"/>	Orthopnoea
<input type="checkbox"/>	Lythargy
<input type="checkbox"/>	Angina
<input type="checkbox"/>	Palpitations
<input type="checkbox"/>	Fatigue
<input type="checkbox"/>	Edema
<input type="checkbox"/>	Wheeze
<input type="checkbox"/>	Hypertension or hypotension
<input type="checkbox"/>	Stable Status
<input type="checkbox"/>	Lung findings - Congestion
<input type="checkbox"/>	Malnutrition Cachexia
<input type="checkbox"/>	Anemia
<input type="checkbox"/>	Dizziness
<input type="checkbox"/>	Ascites

[Save](#)

Patient's Call and Visits page

Patient *	Maroulla Antreou
Emergency Room Visit	<input type="checkbox"/>
Reason *	<input type="text"/>
Person Ansewer *	<input type="text"/>
Date Time Call *	<input type="text"/>
Insert Cancel	

Questioner page

No. Question	0	1	2	3	4	5
1 Causing swelling in your ankles, legs, etc.?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2 Making you sit or lie down to rest during the day?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3 Making your walking about or climbing stair difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4 Making your walking around the house or yard difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5 Making your going places away from home difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6 Making your sleeping well at night difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7 Making your relating to or doing things with your friends or family difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8 Making your working to earn a living difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9 Making your recreational pastimes, sports or hobbies difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10 Making your sexual activity difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11 Making you eat less of the foods you like?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12 Making you short of breath?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13 Making you tired, fatigued, or low on energy?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14 Making you stay in hospital?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15 Costing you money for medical care?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
16 Giving you side effects from medications?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17 Making you feel you are a burden to your family or friends?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18 Making you a loss of self-control in your life?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19 Making you worry?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20 Making it difficult for you to concentrate or remember things?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
21 Making you feel depressed?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Save

[Export Questioner to Word](#)

Patient's Scores page

8/1/2010 6:20:12 μμ	
Emotional	5
Physical	15
Global	28
Sum Score (Emotional & Physical)	20
8/2/2010 6:20:52 μμ	
Emotional	11
Physical	19
Global	24
Sum Score (Emotional & Physical)	30

Patient's Follow Up page

Patient *	Maroulla Antreou ▼
Group	<input type="radio"/> Intervention <input type="radio"/> Control
Doctor	<input type="text"/>
Nurse Educator	<input type="text"/>
Recruitment Date	<input type="text"/>
<u>Insert</u> <u>Cancel</u>	

Schedule ECG Archive page

Select Patient: [Schedule Patient's ECG Archive](#)

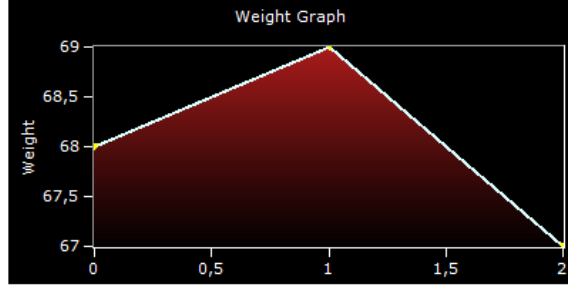
Patient ID	Name	User	Date
7	Antreas Antreou	Nosokoma	6/3/2010 3:48:23 μμ
11	Maroulla Antreou	Nosokoma	17/3/2010 6:20:21 μμ

Patient's Vital Info page

Weight Information

Weight	Date
68,000	23/1/2010 9:35:37 µµ
69,000	23/1/2010 9:35:35 µµ
67,000	23/1/2010 9:35:30 µµ

Total Measures: 3

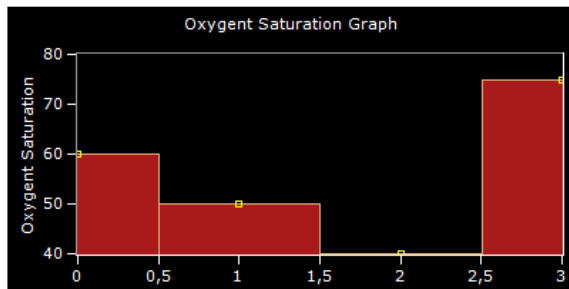


Average:
68
Minimum:
67
Maximum:
69

Oxygen Saturation Information

Oxygen Saturation	Date
60	23/1/2010 9:35:20 µµ
50	23/1/2010 9:35:23 µµ
40	23/1/2010 9:35:26 µµ
75	10/2/2010 8:24:55 µµ

Total Measures: 4

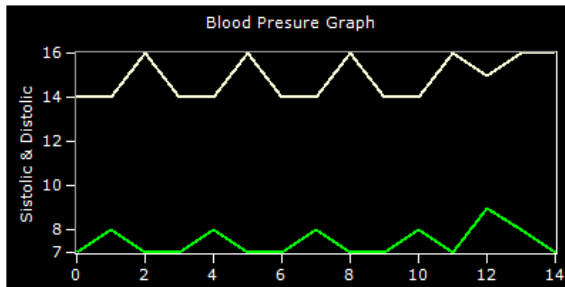


Average:
56,25
Minimum:
40
Maximum:
75

Blood Pressure Information

Sistolic	Distolic	Date
7	14	23/1/2010 9:35:13 µµ
8	14	23/1/2010 9:35:13 µµ
7	16	23/1/2010 9:35:13 µµ
7	14	23/1/2010 9:35:14 µµ
8	14	23/1/2010 9:35:14 µµ
7	16	23/1/2010 9:35:14 µµ
7	14	23/1/2010 9:35:15 µµ
8	14	23/1/2010 9:35:15 µµ
7	16	23/1/2010 9:35:15 µµ
7	14	23/1/2010 9:35:15 µµ

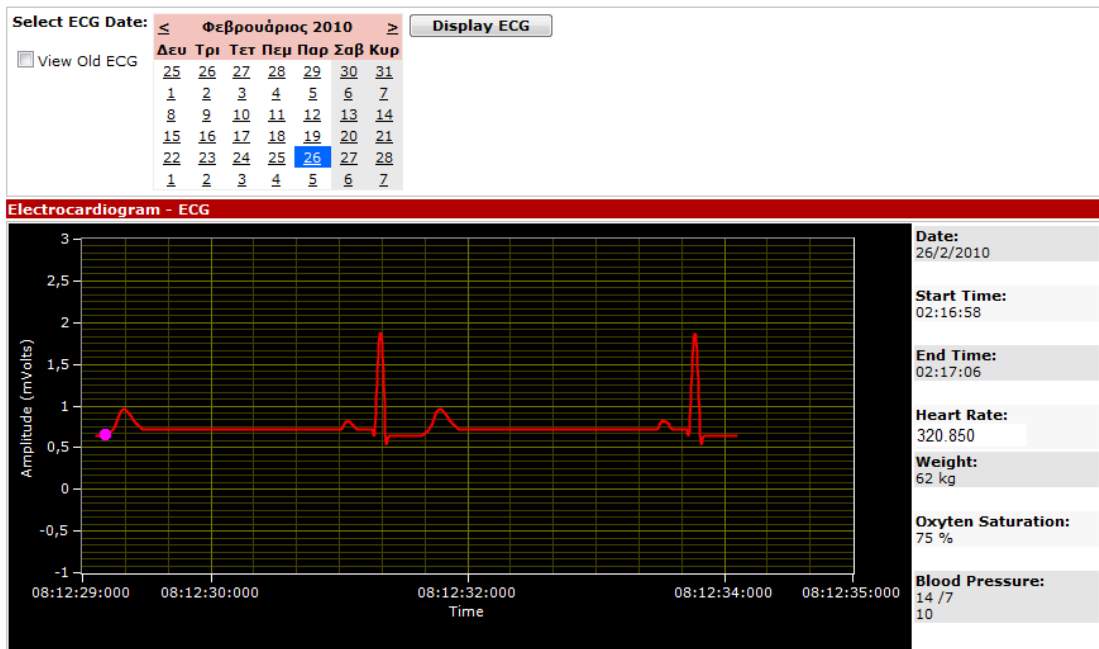
1 2



Average:
Systolic:7,47
Diastolic:14,87
Minimum:
Systolic:7
Diastolic:14
Maximum:
Systolic:9
Diastolic:16

Total Measures: 15

Patient's ECG Info page



Appendix VI

Membership Provider Installation

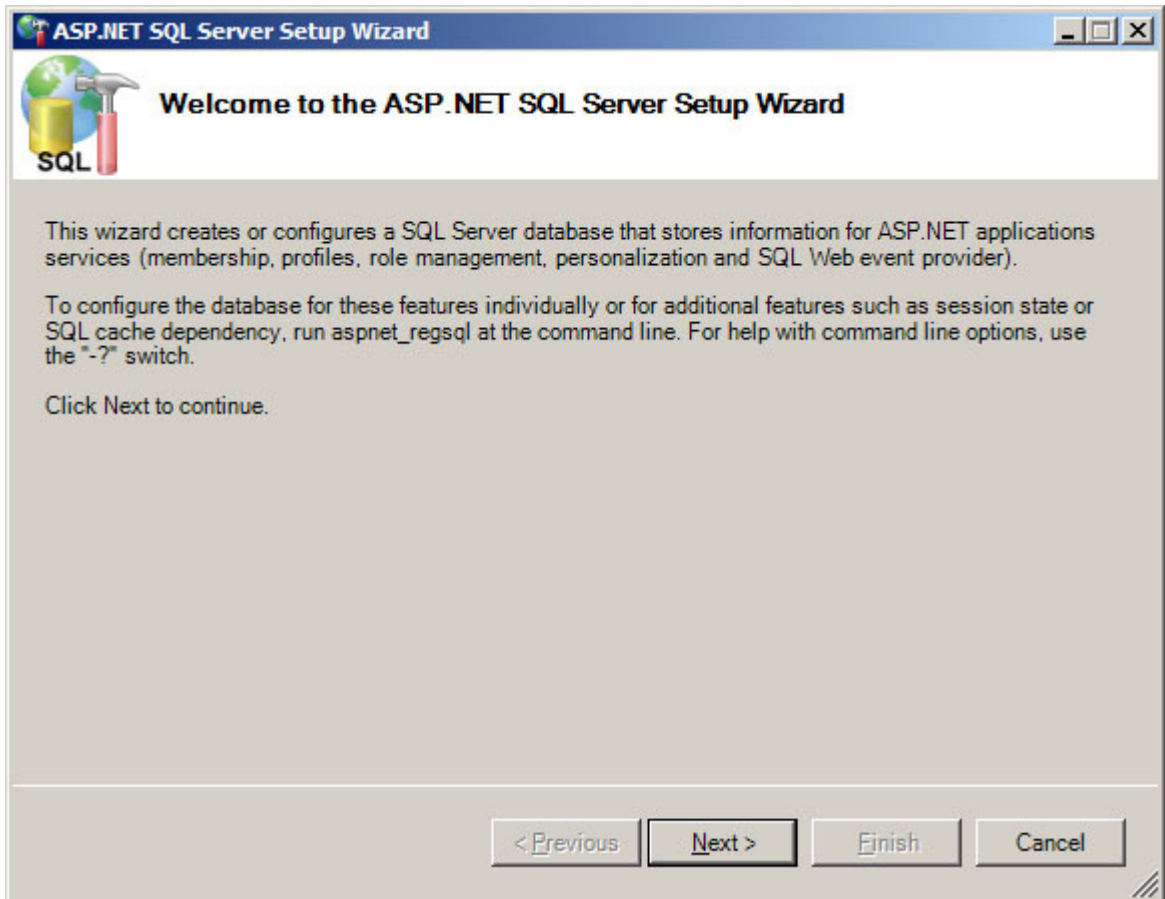
MEMBERSHIP PROVIDER INSTALLATION [18]

ASP.NET MVC Forms Authentication With SqlMembershipProvider

The ASP.NET MVC Website Template comes pre-configured to use SqlMembershipProvider which manages storage of membership information for an ASP.NET application in a SQL Server database.

But before you can use this properly you will need to setup your database, which will be very easy because Microsoft shipped .NET 2.0 with a nice utility to do it! You can find this on your computer, at this path:

C:\Windows\Microsoft.NET\Framework\v2.0.50727\aspnet_regsql.exe



Your database should have these tables:

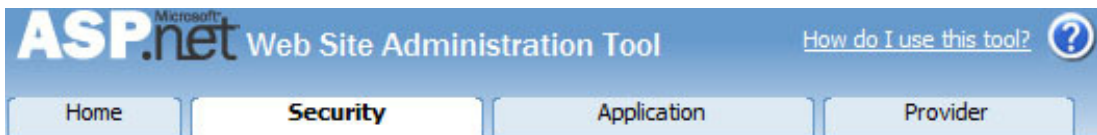
- [-] Tables
 - [+] System Tables
 - [+] dbo.aspnet_Applications
 - [+] dbo.aspnet_Membership
 - [+] dbo.aspnet_Paths
 - [+] dbo.aspnet_PersonalizationAllUsers
 - [+] dbo.aspnet_PersonalizationPerUser
 - [+] dbo.aspnet_Profile
 - [+] dbo.aspnet_Roles
 - [+] dbo.aspnet_SchemaVersions
 - [+] dbo.aspnet_Users
 - [+] dbo.aspnet_UsersInRoles
 - [+] dbo.aspnet_WebEvent_Events

Now lets tell our ASP.NET MVC Website's configuration where to find this database. Open the web.config and change the ApplicationServices connection string to point to your SQL Server. You should now rebuild your solution to avoid any problems in the next step!

view plaincopy to clipboardprint?

```
1. <connectionStrings>
2.   <add name="ApplicationServices"
3.     connectionString="Data Source=localhost;
4.       Initial Catalog=database;
5.       Persist Security Info=True;
6.       User ID=user;
7.       Password=password"
8.     providerName="System.Data.SqlClient"
9.   />
10. </connectionStrings>
```

It's all good and nice but now we need Users in this database otherwise it's completely useless! So open up your ASP.NET MVC Solution in Visual Studio and go to **Project » ASP.NET Configuration**. This will open the ASP.NET Web Application Administration website. In the Security tab you can Add/Manage Users and Roles. For the moment, add a user so we can try the login. I've added user **Mike**.



You can use the Web Site Administration Tool to manage all the security settings for your application. You can set up users and passwords (authentication), create roles (groups of users), and create permissions (rules for controlling access to parts of your application).

By default, user information is stored in a Microsoft SQL Server Express database in the Data folder of your Web site. If you want to store user information in a different database, use the Provider tab to select a different provider.

[Use the security Setup Wizard to configure security step by step.](#)

Click the links in the table to manage the settings for your application.

Users	Roles	Access Rules
Existing users: 1 Create user Manage users Select authentication type	Roles are not enabled Enable roles Create or Manage roles	Create access rules Manage access rules

You can now run your application and click on [Log On] at the top right corner of the page, this will redirect you to the logon form.

The screenshot shows the 'Log On' page of 'My MVC Application'. The page has a blue header with the title 'My MVC Application' and a '[Log On]' link. Below the header are 'Home' and 'About' buttons. The main content area is titled 'Log On' and contains the text: 'Please enter your username and password. [Register](#) if you don't have an account.' Below this is a form titled 'Account Information' with the following fields: 'Username:' with the value 'Mike', 'Password:' with masked characters '•••••', and a checkbox for 'Remember me?'. A 'Log On' button is at the bottom of the form.

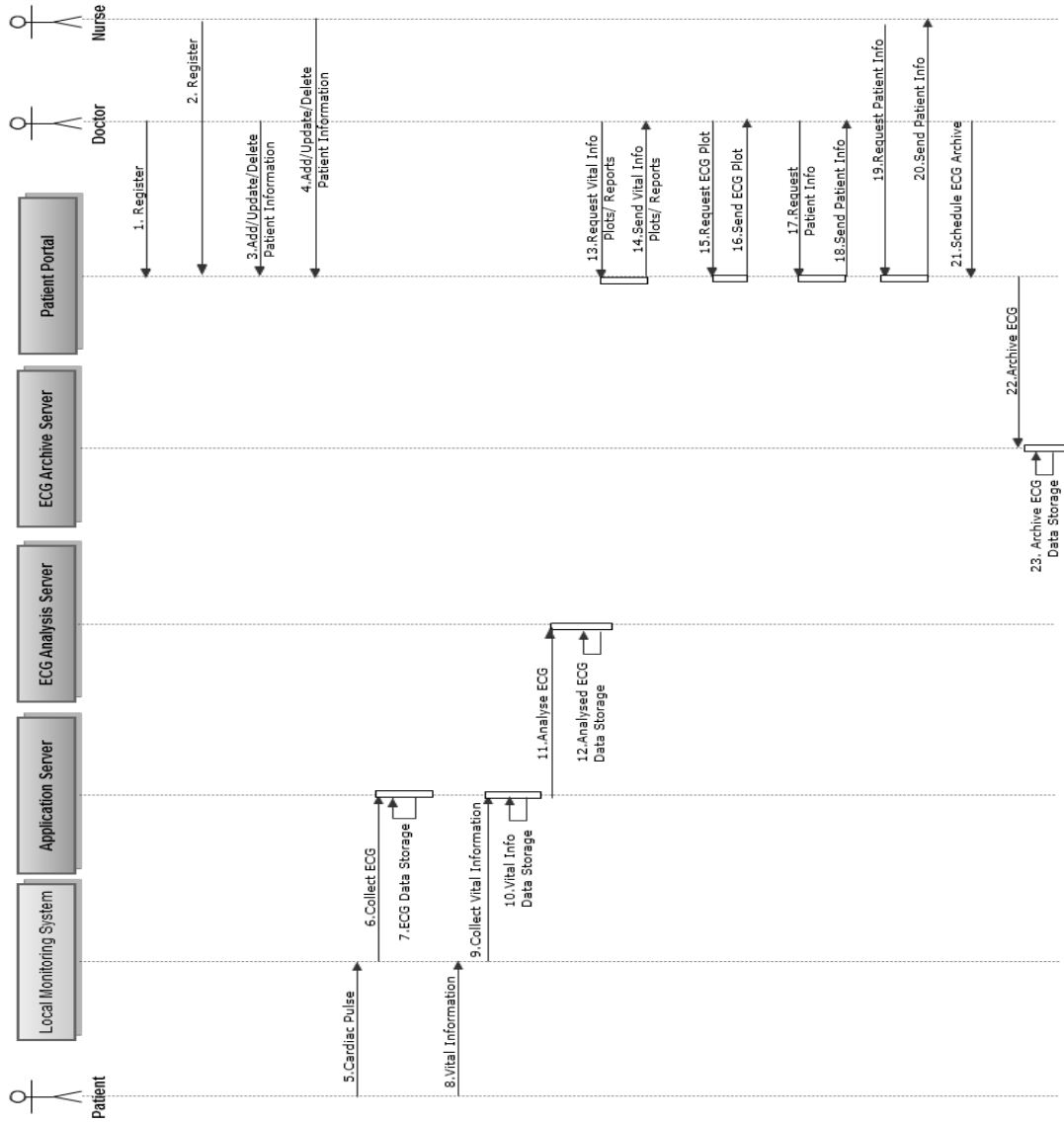
If you entered the correct credential you should be redirected to the home page of the site and you will see your name and a Log Off button instead of the Log On button.

The screenshot shows the home page of 'My MVC Application' after logging in. The page has a blue header with the title 'My MVC Application' and a 'Welcome Mike! [Log Off]' link. Below the header are 'Home' and 'About' buttons. The main content area contains the text: 'Welcome to ASP.NET MVC!' and 'To learn more about ASP.NET MVC visit <http://asp.net/mvc>.'

Well congratulations! You now have SqlMembershipProvider working on your website, wasn't so hard, was it? Not a single line of code required! I'll be posting again soon to show you how to use Roles in your applications.

Appendix VII

Sequence Diagram



Appendix VIII

Web Service – VitalInfoWS

Web service: VitalInfoWS

The system includes a web service that will be called by the patient's system. This web service will help the two systems to communicate and transfer data from the patient's system to the system on the server. The web service has the name **VitalInfoWS**, and it contains several methods which are AddWeight, AddOxygenSaturation, AddBloodPressure, AddECGAnalyzed and AddECGNotAnalyzed.

Web Service Methods

All functions return "Result" Value

Note that all methods return a "**Result**" parameter, which is an enumeration value and defines if there was some processing error or not. The Return value can have the following values:

- **"_Undefined"** There was an unhandled error.
- **"Success"** Process completed successfully
- **"ValidationFailed"** One or more input parameters contains invalid values
- **"Failed"** There was an error in the process and it didn't complete successfully.
- **"InvalidPatientID"** The input patient ID is invalid
- **"NoData"** There wasn't any data for the search criteria

Add Weight Method

The method **AddWeight** can be used to set the patient's weight. It takes three parameters; the PatientID which indicates the system identity of the patient and it must be numeric, the Weight which takes numeric values and indicates the patient's weight and the DateTimeStamp which is of type DateTime and it indicates the time that the patient measured his/her weight.

```
Public Function AddWeight(ByVal PatientID As Integer, _  
                          ByVal Weight As Double, _  
                          ByVal DateTimeStamp As DateTime) As Result
```


Add Oxygen Saturation method

Another method that is provided by the web service is the **AddOxygenSaturation** which can be used to set the patient's Oxygen Saturation. This method takes three parameters; the PatientID which indicates the system identity of the patient and must be numeric, the OxygenSaturation which must be numeric and it indicates the patient's oxygen saturation and the DateTimeStamp which is of type DateTime and indicates the time that the patient measured his/her oxygen saturation.

```
Public Function AddOxygenSaturation(ByVal PatientID As Integer, _  
                                   ByVal OxygenSaturation As Double, _  
                                   ByVal DateTimeStamp As DateTime) As Result
```

Add Blood Pressure method

The method that takes the patient's Blood pressure is the **AddBloodPressure**. This method contains three parameters as well: the PatientID which was mentioned above, the BloodPressure parameter which is an array of type BloodPressure and can take two values: the systolic and diastolic blood pressure , and the last parameter is the DateTimeStamp which was mentioned above.

```
Public Function AddBloodPressure(ByVal PatientID As Integer, _  
                                ByVal BloodPressure() As BloodPresure, _  
                                ByVal DateTimeStamp As DateTime) As Result
```

Add ECG Not Analyzed method

The next and most important method is the **AddECGNotAnalyzed** method, which is used to collect a batch of ECG measurements for a specific patient. This method takes four parameters. The first parameter is the PatientID that was mentioned before, the second parameter is an array of integers which indicates the series of ECGVoltage. The third parameter is the SampleRate which is the number of bits that are processed per unit of time. Finally the last parameter is the DateTimeStamp which was mentioned above.

```
Public Function AddECGNotAnalyzed(ByVal PatientID As Integer, _  
                                   ByVal ECGVoltage() As Integer, _  
                                   ByVal SampleRate As Integer, _  
                                   ByVal DateTimeStamp As DateTime) As Result
```

Add ECG Analyzed method

The method **AddECGAnalyzed** is used to collect a batch of an analyzed ECG measurement for a specific patient. The first parameter is the PatientID that was mentioned before, the second parameter is an array of type ECG and it takes 2 values the ECG – Voltage and the analysis result. The third parameter is the SampleRate which was mentioned above. Finally the last parameter is the DateTimeStamp which was mentioned above.

```
<WebMethod()> _  
Public Function AddECGAnalyzed(ByVal PatientID As Integer, _  
                               ByVal ECG() As ECG, _  
                               ByVal SampleRate As Integer, _  
                               ByVal DateTimeStamp As DateTime) As Result
```

Appendix IX


















User Manual

1	Menu
2	Patient maintenance pages
3	Patients' reports
4	User account pages
5	Log Files

1. Menu

The Menu is used to access all the actions of the system. It is divided into several sections.

- “Home” is used to access the home page.
- “Patients” is a list of the patients.
- After that, there are the maintenance screens concerning each patient.
- Following that, there are the links for the reports.
- User account links can be found next and
- Finally the help links can be found.

 Home
<hr/>
 Patients
<hr/>
 Medical Background
 Hospitalization List
 Calls & Visits
 Questionnaire
 Follow UP
 Schedule ECG Archive
<hr/>
 Vital Info
 View ECG
 Scores
 Scores Chart
<hr/>
 My Account
 Change Password
<hr/>
 Help
 About
 Contact us
<hr/>

1.1 Home page

Patients e-Health System Nosokoma [Logout](#)

Home Home

- [Patients](#)
- [Medical Background](#)
- [Hospitalization List](#)
- [Calls & Visits](#)
- [Questionnaire](#)
- [Follow UP](#)
- [Schedule ECG Archive](#)
- [Vital Info](#)
- [View ECG](#)
- [Scores](#)
- [Scores Chart](#)
- [My Account](#)
- [Change Password](#)
- [Help](#)
- [About](#)
- [Contact us](#)

Patients' Oxygen Saturation

Date	Name	Oxygen Sat.	View
06/04/2010	Efi Kourri	79	View
29/03/2010	Kwstakis Kwstantinou	76	View
29/03/2010	Maria Mariannou	76	View
26/02/2010	Maroulla Antreou	75	View
26/02/2010	Efi Kourri	75	View
26/02/2010	Kwstakis Kwstantinou	76	View
10/02/2010	Kwstakis Kwstantinou	75	View
10/02/2010	Maria Mariannou	75	View
10/02/2010	Maroulla Antreou	75	View
31/01/2010	Maroulla Antreou	72	View

Electrocardiography - ECG

Date	AHI ID	Name	Telephone	Doctor	View
29/03/2010	895478	Maria Mariannou	99565789	Panayota	View
29/03/2010	8965449	Kwstakis Kwstantinou	99566999	Giattros1	View
29/03/2010	778456	Efi Kourri	22669988	Elena	View
29/03/2010	778456	Efi Kourri	22669988	Giattros1	View
29/03/2010	778456	Efi Kourri	22669988	Panayota	View
29/03/2010	1256321	Maroulla Antreou	22121215	Doctor	View
26/02/2010	8965449	Kwstakis Kwstantinou	99566999	Giattros1	View
24/02/2010	895478	Maria Mariannou	99565789	Panayota	View
24/02/2010	8965449	Kwstakis Kwstantinou	99566999	Giattros1	View
06/04/2010	778456	Efi Kourri	22669988	Elena	View

Patients' Blood Pressure

Date	Name	Sys.	Diast.	View
06/04/2010	Efi Kourri	7	16	View
06/04/2010	Efi Kourri	8	14	View
06/04/2010	Efi Kourri	7	14	View
29/03/2010	Kwstakis Kwstantinou	9	16	View
29/03/2010	Kwstakis Kwstantinou	16	15	View
29/03/2010	Kwstakis Kwstantinou	5	15	View
29/03/2010	Maria Mariannou	9	16	View
29/03/2010	Maria Mariannou	10	15	View
29/03/2010	Maria Mariannou	9	15	View
26/02/2010	Maroulla Antreou	6	12	View

Patients' Weight

Date	Name	Weight	View
06/04/2010	Efi Kourri	64,000	View
06/04/2010	Efi Kourri	64,000	View
29/03/2010	Kwstakis Kwstantinou	46,000	View
29/03/2010	Maria Mariannou	85,000	View
26/02/2010	Maroulla Antreou	62,000	View
26/02/2010	Efi Kourri	62,000	View
26/02/2010	Kwstakis Kwstantinou	75,000	View
10/02/2010	Maroulla Antreou	67,000	View
10/02/2010	Maroulla Antreou	62,000	View
10/02/2010	Efi Kourri	62,000	View

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Designed by Panayota Chimonidou

Home page is used as a menu page for the doctors; they can see the latest information concerning their patients. The first list that they see is the last ten records of Analyzed ECG information that were inserted in the system; by clicking the button near the patient's name they will be redirected to the ECG page, in order to view the ECG. Then the patient's scores are presented. Additionally Patient's Blood Pressure, Oxygen Saturation and Weight lists are presented; by clicking the button the doctor will be redirected to the Vital Information page.

1.2 Home – View Patients page









The screenshot displays the 'Patients e-Health System' interface. At the top, there is a navigation bar with 'Patients e-Health System' on the left, 'Nosokoma' in the center, and 'Logout' on the right. Below the navigation bar, there is a sidebar on the left with various menu items: Home, Patients, Medical Background, Hospitalization List, Calls & Visits, Questionnaire, Follow UP, Schedule ECG Archive, Vital Info, View ECG, Scores, Scores Chart, My Account, Change Password, Help, About, and Contact us. The main content area shows a search bar with the text 'Search (Telephone or Name or AHI ID):' and a 'Find' button. Below the search bar is a table with the following data:

ID	AHI ID	Name	Telephone	Telephone1	Actions
7	5632597	Antreas Antreou	99563289	22656987	[Edit] [Medical Background] [Hospitalization List] [Calls & Visits] [Questionnaire] [Follow UP] [Schedule ECG Archive] [Vital Info] [View ECG] [Scores] [Scores Chart] [My Account] [Change Password] [Help] [About] [Contact us]
8	895478	Maria Mariannou	99565789		[Edit] [Medical Background] [Hospitalization List] [Calls & Visits] [Questionnaire] [Follow UP] [Schedule ECG Archive] [Vital Info] [View ECG] [Scores] [Scores Chart] [My Account] [Change Password] [Help] [About] [Contact us]
9	8965449	Kwtakis Kwstantinou	99556699		[Edit] [Medical Background] [Hospitalization List] [Calls & Visits] [Questionnaire] [Follow UP] [Schedule ECG Archive] [Vital Info] [View ECG] [Scores] [Scores Chart] [My Account] [Change Password] [Help] [About] [Contact us]
10	778456	Efi Kourri	22669988		[Edit] [Medical Background] [Hospitalization List] [Calls & Visits] [Questionnaire] [Follow UP] [Schedule ECG Archive] [Vital Info] [View ECG] [Scores] [Scores Chart] [My Account] [Change Password] [Help] [About] [Contact us]
11	1256321	Maroulla Antreou	22121215	22563256	[Edit] [Medical Background] [Hospitalization List] [Calls & Visits] [Questionnaire] [Follow UP] [Schedule ECG Archive] [Vital Info] [View ECG] [Scores] [Scores Chart] [My Account] [Change Password] [Help] [About] [Contact us]

At the bottom of the page, there is a copyright notice: 'Copyright © 2010 University of Cyprus Designed by Panayiota Chimonidou'.

This page displays the patients that are attached to the login doctor. Additionally the “**Add New Patient**” link can be used to add a new patient.

A **Search option** is provided. The user can search by patient Name, Telephone and AHI ID.

- **Edit** the patient by clicking the  button
- **Patient Medical Background** can be accessed by clicking the  button
- **Hospitalization list** is open by clicking the  button
- **Patient Scores** can be viewed by clicking the  button
- **Patient Calls & Visits** can be viewed by clicking the  button
- **Patient Follow up** page is available by clicking the  button
- **Vital Information** is accessible by clicking the  button
- **ECG preview** is available by clicking the  button

2 Patient Maintenance Pages

2.1 Patient's Maintenance

Patient's Maintenance Select Patient: Kwst
[Home\Patients\Patient](#)

Insert Patient's Informatio **Select the doctor that treats the Patient**

Patient ID: 9
Name: Kwstakis Kwstantinou

Doctors that examine the patient:
Select Doctor: Elena

Doctor User Name	Doctor Name	Telephone	Mobile Phone	
Giatros1				Remove Doctor
Elena	Elena Kyriakou	22142536	99153654	Remove Doctor

This page can be used to Add, Edit and Delete a patient. User information is stored for logging purposes.

Additionally here you can Add or remove a cooperating doctor by clicking on the **[Select Doctor]** dropdown list. And then press **Add Doctor** link. To remove a doctor from viewing the patient's information click the **Remove Doctor** link near the doctor's user name.

2.2 Patient Medical Background

Patients e-Health System

- [Home](#)
- [Patients](#)
- [Medical Background](#)
- [Hospitalization List](#)
- [Calls & Visits](#)
- [Questionnaire](#)
- [Follow UP](#)
- [Schedule ECG Archive](#)
- [Vital Info](#)
- [View ECG](#)
- [Scores](#)
- [Scores Chart](#)
- [My Account](#)
- [Change Password](#)
- [Help](#)
- [About](#)
- [Contact us](#)

Patient Medical Background

Patient *

Allergies

Previous Hospitalizations

Reason of previous Hospitalizations

Previous Surgeries

Previous Disease

Comorbidities

Exercising

Drug user

Family History

Risk Factors

Underlying disease

Angiography

Angiography Date

Revascularization

Revascularization Date

Permanent Pacemaker

Amenable Permanent Pacemaker Date

Added Valves

Amenable Added Valves Date

Disease

Maria Mariannou

skoli meli

Yes No

lipothimies

tiflo

tiflo

Yes

Yes

Yes

Family History

Total cognate:

Hypertension Alcohol Abuse Obesity

Diabetes Hyperlipidemia Cardiotoxic Medicines

Smoking: Former Smoker Current Smoker

Arrhythmias CoronarIllness

Yes

14/05/2008

Yes

Yes

Yes

Yes

Coronary

Valvular Disease

Arrhythmias

Hypertensive Cardiomyoeathy

Cardiomyopathy

Chronic Atrial Fibrilation

This page can be used to Add and Edit Patient Medical Background information.

2.3 Patient's Hospitalization

The screenshot shows the 'Patients Hospitalization' page in the 'Patients e-Health System'. The page has a dark red header with the system name and user information (Nosokoma, Logout). A navigation menu on the left includes Home, Patients, Medical Background, Hospitalization List, Calls & Visits, Questionnaire, Follow UP, Schedule ECG Archive, Vital Info, View ECG, Scores, Scores Chart, My Account, Change Password, Help, About, and Contact us. The main content area is titled 'Patients Hospitalization' and includes a 'Select Patient:' dropdown menu with 'Maria Mariannou' selected. Below this, there are several form fields: 'Patient *' (dropdown), 'Hospitalization Date' (text input), 'Way of arrival' (radio buttons for Department of First Aid, Schedule visit, Personal doctor sent him/her, Ambulance call), 'Accompanied during admission' (checkbox), 'Major Symptom On Admission' (text input), 'Dyspnoea - NYHA classification' (radio buttons for NYHA I, NYHA II, NYHA III, NYHA IV), 'Coronary artery disease' (checkbox), 'Date of Surgery' (text input), 'Surgical Procedure' (text input), and 'Leave Hospital Date' (text input). At the bottom of the form are 'Insert' and 'Cancel' buttons. The footer contains copyright information: 'Copyright ©2010 University of Cyprus Designed by Panayiota Chimonidou'.

This page is used to **Insert**, **Update** and **Delete** patients' Hospitalization information. Here Hospitalization date, Way of Arrival, information concerning the Major Symptoms on Admission, Surgery Date and Procedure, if it is applicable, and finally Classification and Leave Hospital Date are provided.

2.4 Hospitalization List

The screenshot shows the 'Patients' e-Health System interface. At the top, there is a dark red header with the text 'Patients' e-Health System' on the left, 'Nosokoma' in the center, and 'Logout' on the right. Below the header, the page title is 'Hospitalization List'. To the right of the title is a dropdown menu labeled 'Select Patient:' with 'Michalis Chatzigiannis' selected. Below the title and dropdown is a breadcrumb trail: 'Home \ Patients \ Hospitalization List'. On the right side of the page, there is a link 'Add new Hospitalization'. The main content is a table with the following data:

No.	Symptoms	In	Out		
22	zalades	11/4/2010 12:00:00 πμ	14/4/2010 12:00:00 πμ	Select	Symptoms on hospitalization
23	Lipothimies	25/4/2010 12:00:00 πμ	29/4/2010 12:00:00 πμ	Select	Symptoms on hospitalization

This screen is used to view the list of the hospitalizations of the selected patient and to change a patient, just select his name from the patient dropdown list above. In order to add new hospitalization for the patient select “**Add new Hospitalization**”.

The list displays the major symptoms, the hospitalization date and the date that the patient has left the hospital. Additionally, to add the Symptoms that the patient was having on his admission to the hospital click the link “**Symptoms on hospitalization**” and you will be redirected to the Patient Hospitalization symptoms page.

2.5 Patient Hospitalization Symptoms

Patient Hospitalization Symptoms
[Home](#) \ [Patients](#) \ [Hospitalization List](#) \ Symptoms

Hospitalization ID= 22 [Back to Hospitalization List](#)

Select	Symptom
<input type="checkbox"/>	Orthopnoea
<input checked="" type="checkbox"/>	Lethargy
<input type="checkbox"/>	Angina
<input checked="" type="checkbox"/>	Palpitations
<input type="checkbox"/>	Fatigue
<input type="checkbox"/>	Edema
<input checked="" type="checkbox"/>	Wheeze
<input type="checkbox"/>	Hypertension or hypotension
<input checked="" type="checkbox"/>	Stable Status
<input type="checkbox"/>	Lung findings - Congestion
<input type="checkbox"/>	Malnutrition Cachexia
<input type="checkbox"/>	Anemia
<input type="checkbox"/>	Dizziness
<input type="checkbox"/>	Ascites

[Save](#)

The only thing that you have to do is to select the symptoms that the patient was having his hospitalization and then press **Save**. To return to the Hospitalization list click “**Back to Hospitalization List**”.

2.6 Calls & Visits

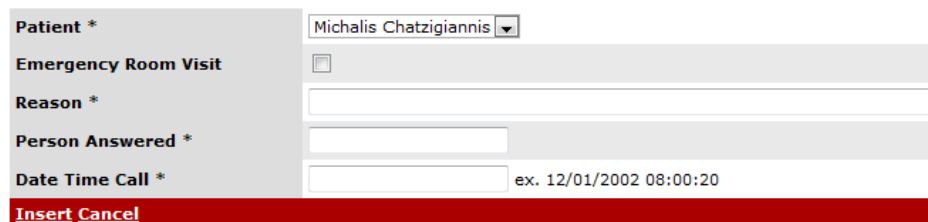


The screenshot shows the 'Patients e-Health System' interface. The top navigation bar includes 'Home', 'Calls & Visits', and 'Select Patient: [Efi Kourti]'. The left sidebar contains menu items: 'Patients', 'Medical Background', 'Hospitalization List', and 'Calls & Visits'. The main content area displays a table of calls and visits with the following data:

Call ID	Reason	Emergency Room Visit	Date Time Call	Person Answerer	Date Last Update	User
15	Kepoiros logos tha yparxei	<input checked="" type="checkbox"/>	10/01/2010 11:30	maria	24/01/2010 15:20	Giatros1 Select
16	Adiathesia, Panikos	<input checked="" type="checkbox"/>	10/01/2010 11:40	Maria	24/01/2010 15:20	Giatros1 Select

An [Add Call & Visit](#) link is located at the top right of the table.

This page displays a list of the calls and visits that the patient did. To had a new call and visit click the “Add Call & Visit” link. By selecting a call or by pressing “Add Call & Visit” the list below will appear. This allows you to Insert, Edit or Delete the entry.



The form contains the following fields:

- Patient ***: A dropdown menu with the selected value 'Michalis Chatzigiannis'.
- Emergency Room Visit**: A checkbox.
- Reason ***: A text input field.
- Person Answered ***: A text input field.
- Date Time Call ***: A text input field with the example text 'ex. 12/01/2002 08:00:20'.

At the bottom of the form, there are two buttons: **Insert** and **Cancel**.

2.7 Questionnaire

Questioner Select Patient: Michalis Chatzigiannis ▾
 Home \ Patients \ Questioner

No.	Question	0	1	2	3	4	5
1	Causing swelling in your ankles, legs, etc.?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2	Making you sit or lie down to rest during the day?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3	Making your walking about or climbing stair difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4	Making your walking around the house or yard difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5	Making your going places away from home difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6	Making your sleeping well at night difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7	Making your relating to or doing things with your friends or family difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8	Making your working to earn a living difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9	Making your recreational pastimes, sports or hobbies difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10	Making your sexual activity difficult?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11	Making you eat less of the foods you like?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12	Making you short of breath?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13	Making you tired, fatigued, or low on energy?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14	Making you stay in hospital?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15	Costing you money for medical care?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
16	Giving you side effects from medications?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17	Making you feel you are a burden to your family or friends?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18	Making you a loss of self-control in your life?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19	Making you worry?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20	Making it difficult for you to concentrate or remember things?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
21	Making you feel depressed?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

[Export Questionnaire to Word](#)

The questionnaire can be answered and then by pressing the “**save**” button it will be saved. To download it click “**Export Questionnaire to Word**” link and a Microsoft word version will appear.

2.8 Patient Follow Up page

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This page is used to add follow up information for the patient. To add new follow up information, press “**Add new entry**” link. To **Edit** or **Delete** press **Select** and then the list below the table will appear.

2.9 Schedule ECG Archive

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Here the user can schedule ECG Archive. To do that **Select Patient** and then click on **Schedule Patient’s ECG Archive**. Then the Patient’s name, the user name of the person that did the schedule and the time are displayed on the list below. After some time the scheduler will run and archive the ECG.

3 Patient's Reports

3.1 Patient's Vital Information Report

Patients e-Health System
Nosokoma [Logout](#)

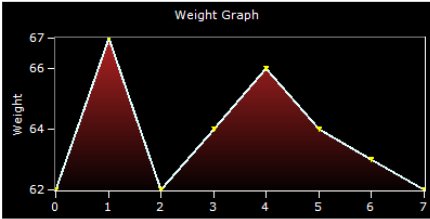
- [Home](#)
- [Patients](#)
- [Medical Background](#)
- [Hospitalization List](#)
- [Calls & Visits](#)
- [Questionnaire](#)
- [Follow UP](#)
- [Schedule ECG Archive](#)
- [Vital Info](#)
- [View ECG](#)
- [Scores](#)
- [Scores Chart](#)
- [My Account](#)
- [Change Password](#)
- [Help](#)
- [About](#)
- [Contact us](#)

Patient Vital Information Report
Select Patient:

Weight Information

Weight	Date
62,000	26/2/2010 2:15:56 μμ
67,000	10/2/2010 8:24:44 μμ
62,000	10/2/2010 8:24:40 μμ
64,000	31/1/2010 7:28:42 μμ
66,000	31/1/2010 7:28:38 μμ
64,000	31/1/2010 7:28:34 μμ
63,000	31/1/2010 7:28:31 μμ
62,000	31/1/2010 7:27:46 μμ

Total Measures: 8



Average: 63,75

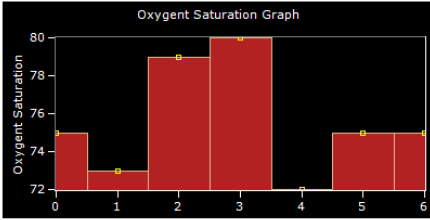
Minimum: 62

Maximum: 67

Oxygen Saturation Information

Oxygen Saturation	Date
75	31/1/2010 7:27:50 μμ
73	31/1/2010 7:28:47 μμ
79	31/1/2010 7:28:51 μμ
80	31/1/2010 7:28:55 μμ
72	31/1/2010 7:28:59 μμ
75	10/2/2010 8:24:49 μμ
75	26/2/2010 2:15:58 μμ

Total Measures: 7



Average: 75,57

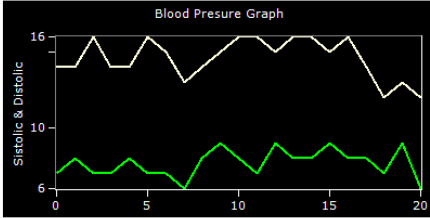
Minimum: 72

Maximum: 80

Blood Pressure Information

Sistolic	Distolic	Date
7	14	31/1/2010 7:27:54 μμ
8	14	31/1/2010 7:27:54 μμ
7	16	31/1/2010 7:27:54 μμ
7	14	31/1/2010 7:29:02 μμ
8	14	31/1/2010 7:29:02 μμ
7	16	31/1/2010 7:29:02 μμ
7	15	31/1/2010 7:29:15 μμ
6	13	31/1/2010 7:29:15 μμ
8	14	31/1/2010 7:29:15 μμ
9	15	10/2/2010 8:25:15 μμ

Total Measures: 21



Average:

Sistolic: 7,67

Diastolic: 14,57

Minimum:

Sistolic: 6

Diastolic: 12

Maximum:

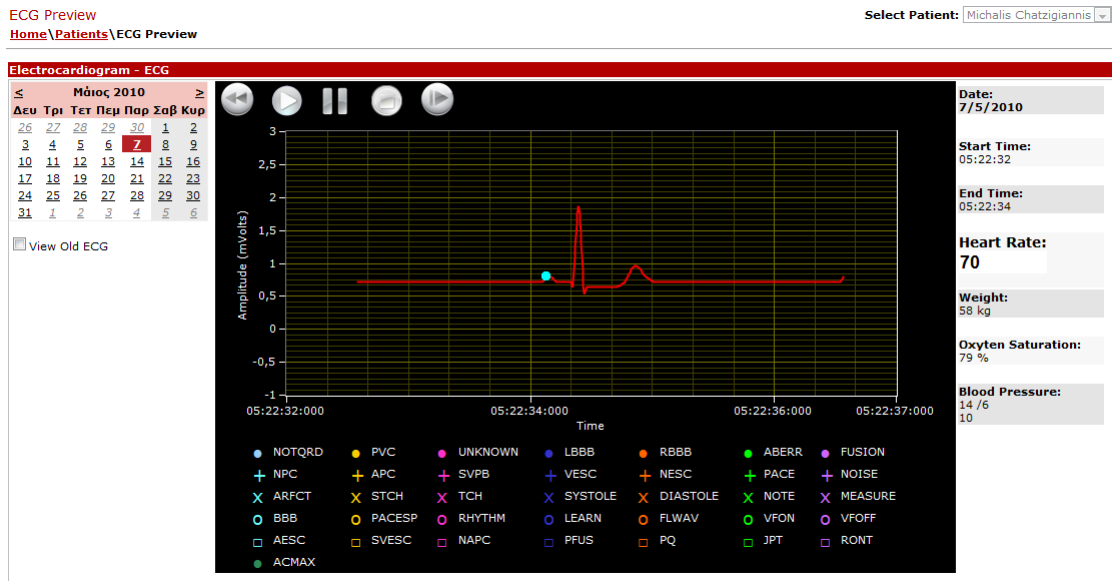
Sistolic: 9

Diastolic: 16

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 Designed by Panayiota Chimonidou

The user here can see the vital information of the selected patient. That vital information is the weight, oxygen saturation and blood pressure. For each set of data we see the table of content with the date and time and the graph. At the right of each graph the average, minimum and maximum are shown. Under each table we see the total measurements that the patient has done.

3.2 ECG Preview



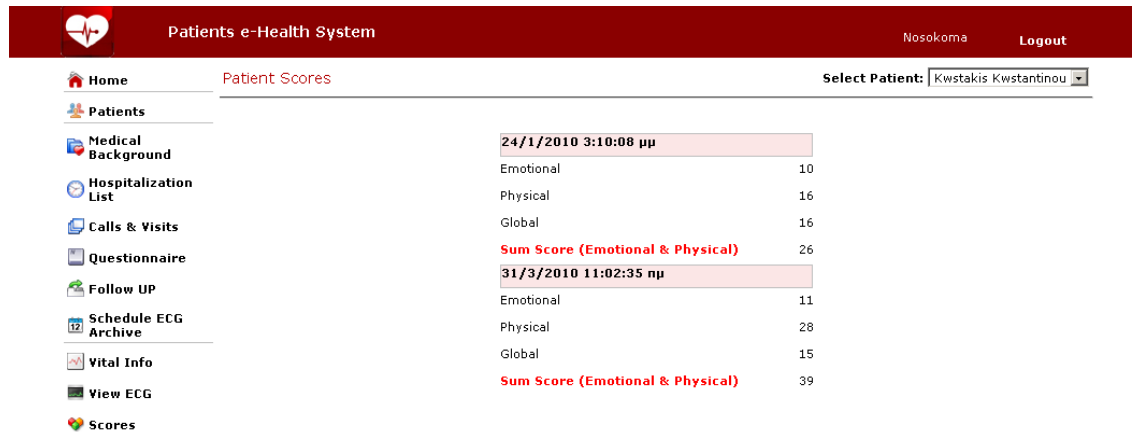
The user here can see the ECG for the selected patient and the selected date.

The **calendar** indicates the dates that there is ECG data to present (the dates that the patient measured his ECG). In the case that the ECG was archived then select the **View Old ECG** which will update the calendar with the dates of the old ECG.

By selecting a date and then clicking the  **Display ECG** button the ECG Graph will start to animate. Several ECG arrhythmias are recognized and indicated in the graph.

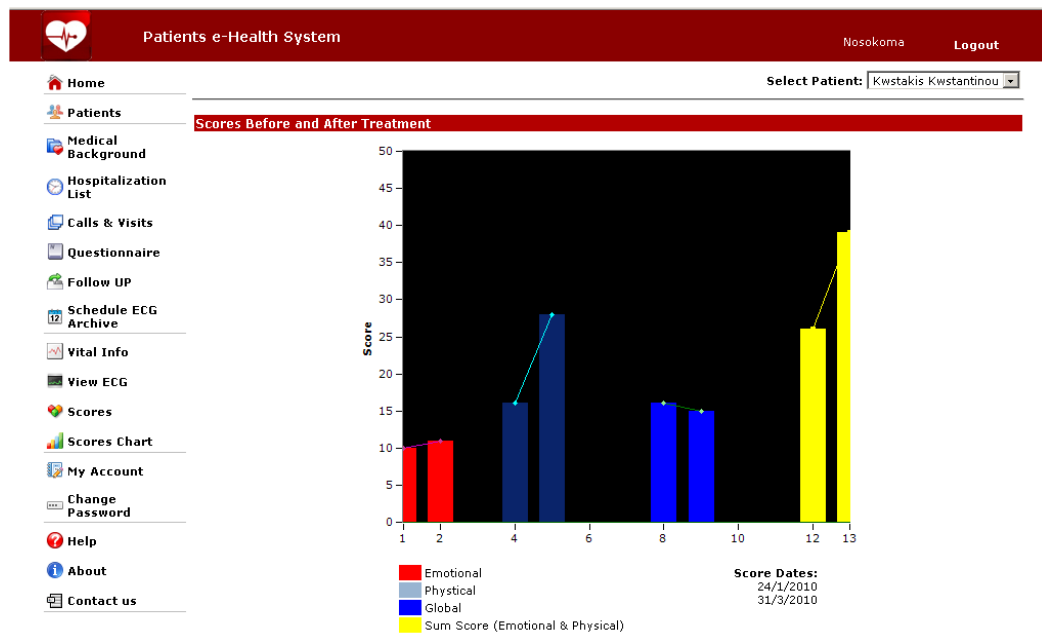
Vital information for the selected date is displayed near the ECG Graph. That information is the Start Time and the End Time of the ECG measurement, the Heart Rate, the Weight, the Oxygen Saturation and the Blood Pressure.

3.3 Patient Scores Report



Those scores are calculated based on the answers that the patient gave on the questionnaire (refer to 2.7 for more details) and some predefined scores for each question. Here the report displays for each time that the patient answers the questionnaire the following scores: Emotional, Physical, Global and Sub Score (which is the Emotional & Physical).

3.4 Patient Scores Chart Report



This report indicates the scores Emotional, Physical, Global and Sub Score which is the Emotional plus the Physical graphically. The dates that the questionnaire was answered are indicated below the bar chart.

4 User account pages

4.1 Sign Up For Your New Account

This page is used to register a new user. There are three steps for the user registration.

Step 1 – Sign up information:

In the first step the user must define his login information: User Name and Password are mandatory fields.

The screenshot shows the 'Sign Up for Your New Account' form within the 'Patients e-Health System' interface. The form is titled 'Sign Up for Your New Account' and contains the following fields: 'User Name:', 'Password:', 'Confirm Password:', 'E-mail:', 'Security Question:', and 'Security Answer:'. The 'User Name' and 'Password' fields have red asterisks indicating they are mandatory. A 'Save' button is located at the bottom right of the form. The interface includes a navigation menu on the left with options like 'Home', 'Patients', 'Medical Background', 'Hospitalization List', 'Calls & Visits', 'Questionnaire', 'Follow UP', 'Schedule ECG Archive', and 'Vital Info'. The top navigation bar includes 'Home', 'Sign Up for Your New Account', 'Login', and 'Register'.

Step 2 – Personal Information:

The user here must define his contact and personal information, like his telephone number, address and date of birth. By pressing Insert link button the user will be redirected to the last step.

The screenshot shows the 'Personal Information' form within the 'Patients e-Health System' interface. The form is titled 'Personal Information' and contains the following fields: 'Name', 'Telephone', 'Mobile Phone', 'Address', 'Birthday', and 'Profession'. Below the 'Profession' field, there are 'Insert' and 'Cancel' buttons. A 'Next' button is located at the bottom right of the form. The interface includes a navigation menu on the left with options like 'Home', 'Patients', 'Medical Background', 'Hospitalization List', 'Calls & Visits', 'Questionnaire', 'Follow UP', 'Schedule ECG Archive', 'Vital Info', and 'View FCC'. The top navigation bar includes 'Home', 'Sign Up for Your New Account', 'Login', 'Forgot Your Password?', and 'Register'.

Step 3 – Select Role:

The user here must select his role, which might be Doctor or Nurse and then press the Finish link button.

The screenshot shows the 'Patients e-Health System' interface. The user is logged in as 'Marianna'. The main navigation menu includes Home, Patients, Medical Background, Hospitalization List, Calls & Visits, and Questionnaire. The current page is 'Sign Up for Your New Account'. A modal window titled 'Select Role' is displayed, containing three radio button options: Doctor, Doctor Viewer, and Nurse. At the bottom of the modal are 'Previous' and 'Finish' buttons.

4.2 Change Your Password

The screenshot shows the 'Patients e-Health System' interface. The user is logged in as 'Nosokoma'. The main navigation menu includes Home, Patients, Medical Background, Hospitalization List, Calls & Visits, and Questionnaire. The current page is 'Change Your Password'. A modal window titled 'Change Your Password' is displayed, containing three input fields: Password (masked with dots), New Password, and Confirm New Password. At the bottom of the modal are 'Change Password' and 'Cancel' buttons.

This page gives the user the opportunity to change his password.

4.3 My Account Information

The screenshot shows the 'Patients e-Health System' interface. The user is logged in as 'Nosokoma'. The main navigation menu includes Home, Patients, Medical Background, Hospitalization List, Calls & Visits, Questionnaire, Follow UP, Schedule ECG Archive, and Vital Info. The current page is 'My Account Information'. A table displays the user's personal information, with 'Update' and 'Cancel' buttons at the bottom.

User Name	Nosokoma
Name	Maria Ioannou
Telephone	2215635
Mobile Phone	99152654
Address	12 Makariou, Larnaka
Birthday	12/6/1975 1
Profession	Nosokoma
Update Cancel	

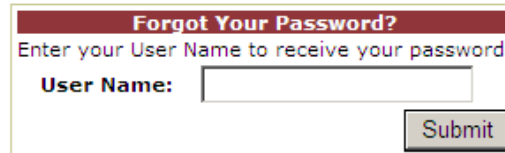
This page gives the user the opportunity to insert or update his/her personal information.

4.4 Forgot Your Password?

This page is used to reset the user's password. There are three steps for the Forgot your password process.

Step 1 – Forgot your password?

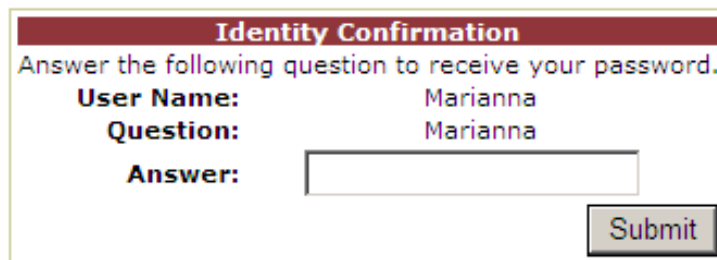
In this step the user must insert his user name and the Press **Submit** button.



The screenshot shows a web form titled "Forgot Your Password?". Below the title, it says "Enter your User Name to receive your password." There is a text input field labeled "User Name:" and a "Submit" button.

Step 2 – Identify Confirmation

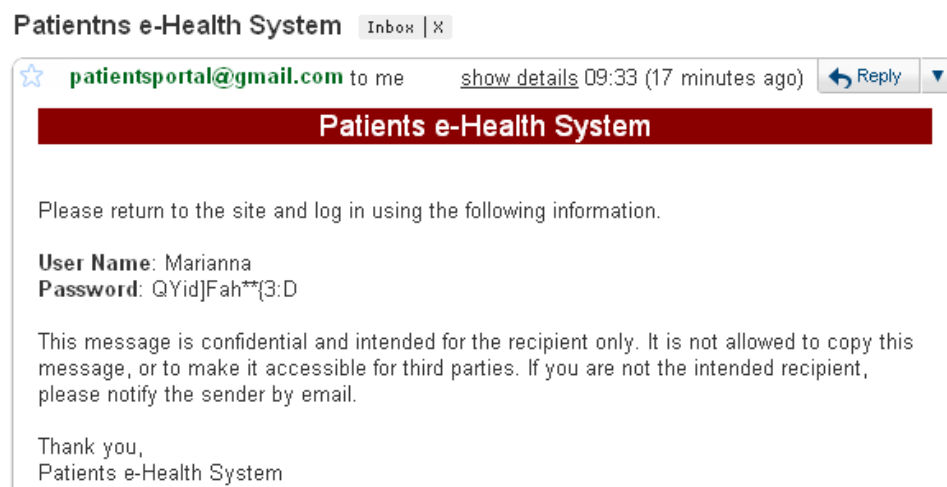
If the first step is valid then this step will appear. In this step the user has to define his Answer to his secret question. In the case that it is correct then an E-mail will be sent to the user with his new password.



The screenshot shows a web form titled "Identity Confirmation". It asks the user to "Answer the following question to receive your password." The form displays "User Name: Marianna" and "Question: Marianna". There is a text input field for the "Answer:" and a "Submit" button.

Step 3 – E-mail

In the E-mail the user can find his User name and his new Password, which can be changed in Change Your Password (see 4.2 for more details).



The screenshot shows an email interface for "Patientns e-Health System". The email is from "patientsportal@gmail.com" to "me", received at "09:33 (17 minutes ago)". The email content includes a red header "Patients e-Health System", a message to return to the site, and login information: "User Name: Marianna" and "Password: QYid]Fah**{3:D". It also contains a confidentiality notice and a sign-off: "Thank you, Patients e-Health System".

5 Log Files

Several Log files are created from the system, those log files log necessary information to trace errors.

5.1 Analysis Log File

An Analysis Log File is created every day when the ECG Analysis Server is run. This file indicates the Date and time that the analysis was run, the Patient ID, the BatchDateTime of the sample and the Result which must be Success. In the case that the Result is not Success then there was an error. When the Analysis ends, the Total Records are indicated for the patient and there is a proof that his ECG has been analyzed.

```
129094336006838832 Date: 2010-01-31 19:46:40Z
129094336006838832 PatientID: 10
                        BatchDateTime: 31/1/2010 10:57:08 μμ
                        Result: Success
129094336978778832 -----
129094336978778832 Date: 2010-01-31 19:48:17Z
129094336978778832 Total Records: 11988
129094337128508832 -----
129094337128508832 Date: 2010-01-31 19:48:32Z
129094337128508832 PatientID: 11
                        BatchDateTime: 31/1/2010 7:29:18 μμ
                        Result: Success
```

5.2 Interface Log File

An Interface Log File is created when an error is found with the communication with the external system that sends the vital information. For example below we see that the external system sent Patient ID 150 to the VitalInfoWS, but this patient does not exist in the system.

```
129107304809400000 -----
129107304809400000 Date:2010-02-15 20:01:20Z
129107304809400000 InvalidPatientID, Input PatientID=150
```

5.3 Trace Log File

A Trace Log File is created when an exception error is found in the solution; this error is written in the file in order that you may trace it and able to correct it.

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