# REMOTE PATIENT MONITORING SYSTEM USING WLAN-ENABLED MOBILE PHONES IN TIKRIT EDUCATIONAL HOSPITAL

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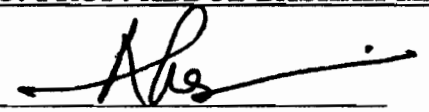
*(Signature)* : 

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# ABSTRACT

This study aims to provide an applicable simulation on implementing a Remote Patients Monitoring System Via WLAN to improve the existed system in the Educational Hospital of Tikrit, Iraq, and gives the hospital staff the ability to access the vital information of the patients who are in emergency cases through the internet by using WLAN-enabled mobiles. In this study, the process of patient diagnosis will be shown in order to enable remote access of the data stored and updated in the Medical Monitoring Center under critical environments which surrounding the territory of the city. In addition to that, there will be a justification of choosing WLAN among the other technologies.

## *ACKNOWLEDGMENTS*

First of all, my praise to Allah S.W.T whose blessing and guidance have helped me to get entire my dissertation. Peace be upon our Prophet Mohammad S.A.W, who has given light to mankind.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AP | Access Point |
| API | Application Program Interface |
| ASF | Apache Software Foundation |
| BAN | Body Area Network |
| BP | Blood Pressure |
| BT | Body Temperature |
| DBMS | Data Base Management System |
| DHCP | Dynamic Host Configuration Protocol |
| DNS | Domain Name Service |
| DSN | Digital Sensor Network |
| ECG | electrocardiogram |
| ECR | Electronic Care Recorder |
| EHR | Electronic Heath Record |
| FTP | File Transfer Protocol |
| GNP | Gross National Product |
| GPRS | General packet radio service |
| GSM | Genera Service for Mobile |
| GUI | Graphical User Interface |
| GL | Glucose level |
| HF | Heart Fail |
| HIS | Hospital Information System |
| HIT | Hospital Information Technology |
| HR | Health Record |
| HRV | Heart Rate Variability |
| HD | Hard Disc |
| ISDN | Integrated Services Digital Network |
| IT | Information Technology |
| JSP | Java Server Page |
| MA | Medical Assistants |
| MAC | Media Access Control |
| MFP | Mobile Flash Player |
| MMC | Medical Monitoring Center |
| OS | Operating System |
| OZWC | Optimal Zonal Wavelet-base ECG data Compression |
| PC | Personal Computer |
| PDA | Personal Digital Assistants |
| PER | Patient Electronic Record |
| PHR | Patient Heath Record |

| | |
|---|---|
| PMS | Patient Monitoring System |
| RPMS | Remote Patient Monitoring System |
| SE | Software Engineering |
| SDLC | Software Development Life Cycle |
| UML | Unified Modeling Language |
| UMTS | Universal Mobile Telecommunications System |
| VPN | Virtual Private Network |
| WAP | Wireless Access Point |
| WDSN | Wireless Distributed Sensor Network |
| WLAN | Wireless Local Area Network |
| WML | Wireless Markup Language |
| WSN | Wireless Sensor Network |
| XML | Extensible Markup Language |
| 3G | Third Generation |

# CHAPTER ONE

# INTRODUCTION

## 1.0 Introduction

Recently, an advancement of Information Technology (IT) enables computers and mobiles via networks to play a vital role in the modern medical care and patient monitoring systems. The use of these technologies in the medical field brings new era of medicine. One of the most important technologies is the mobile phones technologies such as the new generations of Wireless Local Area Network (WLAN)-enabled mobile phones that support these mobiles to work and perform like most of the computers.

Some of the most notable technologies applied in this field are General Packet Radio Service (GPRS) and Third Generation (3G) network which helped drastically to shape the new forms of telemedicine systems. That system can allow physicians to get the accessibility to asses patient vital signs. Furthermore, the telemedicine defined by (Kogure et al. , 2005) as the essentially use of both IT and telecommunication for providing health services or supporting health service provision over a distance.

The terms of telemedicine has been mentioned early in 1990s. Many researchers have discussed and dealt with these technologies such as Pavlopoulos (Pavlopoulos et al. , 1998). Moreover, (Varady et al. , 2002) believes that the patient monitors are the most important diagnostic devices in the Critical Care Units (CCUs) of hospitals, providing continuous display and interpretation of the patient's vital functions. The developers of these systems are increasingly verify and modify the manners of dealing with health

care and patient monitoring system that drives to spend more and more on new technologies inventions and increase the cost for delivering services. For example, it has been mentioned by (Kern & Jaron, 2003)

Statistically, that the share of U.S. Gross National Product (GNP) spent on healthcare roses was from 6% to 13.5% in the point between 1965 and 1995. At the times of study, it is projected at approximately 15% of the GNP, which equates to 1.5 U.S. trillion. It is suggested by (Istepanian and Petrosian, 2000), that the financial influence on improving technologies increased lifespan of patients throw pervasive monitoring of health indicators to detect diseases in early stages. It may also potentially save lives.

This issue of increasing cost has created challenges for this study which is the reduce of the cost and setting more applicable and practical solutions for the monitoring systems. Moreover, to provide this service to an increasing number of patients by using limited financial resources. Traditionally, the primary prominent monitoring systems was the Holter's monitor that invented by Dr. Norman J. Holter. This system is a wearable/portable electrocardiogram (ECG) device that allows gathering of data for around 24 hours. After that, The data is recorded, retrieved and processed by a physicians. The disadvantage of their usage is the limitations of sensors integration and the interference that occurred through the communication channels.

Recently, we should realize that one of most usable and applied technologies for patient monitoring is the mobile phone. Since, the use of cell phones are more accessible than the use of other communication technologies to exchange data such as personal information management, integrated camera, and application platform that makes mobile technologies rapidly increasing (Kogure et al. , 2005). Finally, the rapid

evolution of electronics and information technologies produce more powerful bedside patient monitors that capable of complex biosignal processing and interpretation. Usually, this systems equipped with some specialized communication interface.

## 1.1 Problem Statement

Since U.S. invasion of Iraq on February 2003, the security measures have been implemented nationally. Those measures such as curfew have been imposed from 11 p.m. till 6 a.m. daily. This will create a restrictive for doctors or health staff to monitor their patients on a personal bases.

Political and sectarian violence on a national scale have been increased and cause more accidents and too many civilians need for hospital cure. Moreover, these patients require emergent treatment that is practically complicated due to the lack of communications and the availability of medical services.

The researcher lives in Tikrit city, he notice that the hospital in the city needs for RPMS because it is surrounded by concrete walls that divide the city into three parts. In addition, curfew enforced whenever the Iraqi government and U.S. military fail to control the situation on the ground. Therefore, the doctors in the curfew place unable to reach the hospital and monitor the patient on the bases mode.

The situation in Tikrit hospital is to some extent difficult where the U.S. army and Iraqi security forces occupy their positions around the city hospital, and periodically impose an unknown time for the curfew in accordance with the situation of the city. Furthermore, the area around the hospital witnesses many terrorist attacks.

The residents of Tikrit and other besieged cities drew attention to the difficulty of the medical treatment and monitoring patients in the hospitals where many of them require periodic and nonstop supervision to assess their health conditions by the medical doctors. Sometime during the daytime only pedestrians allow to be in the streets under bad circumstances. Therefore, medical services are from time to time inaccessible to most people's because the hospital is located far from the center of the city on the far side which is separated from the rest of the city.

Many security checkpoints made by the security forces that cause severely slow down movement on the city. In addition, the coverage of mobile is limited and unstable due to the security measures, the only left option in communication is WLAN.

## 1.2 System Objective

The main objective of the study is to look for the possibility of extending the existing Patient Monitoring System in Tikrit Educational Hospital by introducing Remote Patient Monitoring System using WLAN technology.

The sub objectives are:

- To investigate the requirements of Remote Patient Monitoring System.
- To simulate Remote Patient Monitoring System.

## 1.3 Existing System

To access the Remote Patient Monitoring System, the existing system in Tikrit hospital must be fully understood, it is called SafeBed IP (DVM2008). It consists of Emfit's

patented sensor installed under the mattress and the bed-side control unit utilizing advanced digital signal processing connecting to a standard data network.

The system has database to store all the processed data like vital information (Text-base), alarms and events. The System database is managed by SQL server Data Base Management System (DBMS).

The database is updated sequentially and the period of update can be managed. All the processed data that monitored by the staff of the Medical Monitoring Centre room (MMC) can be migrated outside the system via LAN.

## 1.4 Scope

The scope of the study is to assess the possibility of implementing Remote Patient Monitoring System using the existing system in Tikrit Educational Hospital/ emergency cases part. Figure 1.1 shows the existing system and the prototype overview.

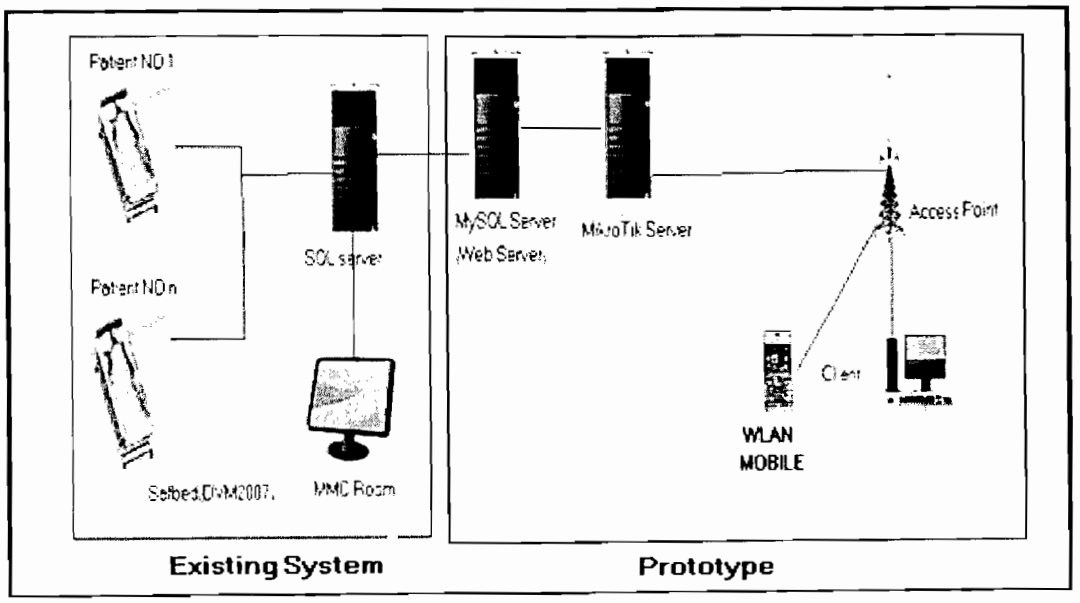

**Figure 1.1 : Existing system and the prototype overview**

By using the data migration features in Safebed IP (DVM2008), we will assume that the data was migrated to our server (MySQL) which acts as a gateway between the hospital and the internet in the real world.

The server includes the web base system based on Java platform by using Java Server Page (JSP) to get an independent platform.

As the system will be connected to the public network, the privacy of the collected data must be protected. The system will be managed by MikroTik Routing Operating Systems. This server will control and manage the administration and security access to the system. MikroTik will be used to simulate WLAN access point with Dynamic Host Configuration Protocol (DHCP) fetchers.

In order to access the system, the client should scan the available access points. After that, the client can connect to the right access point. The client will be connected to the Access Point (AP) only if his Media Access Control (MAC) listed in the access point.

By key-in the server IP and port, a Hotspot page asks the client to enter the user name and password to access the system. The user name and password managed by the system administrator. Once the user key-in the correct user name and password, he is directed to the next server (MySQL). The user can monitor the patient vital information after he/she has been granted to the system.

## 1.5 Significance of Study

Wi-Fi is always available all over Tikrit comparing to the other types of wireless networks and mobile networks in the place of study. This can be considered as the most significant issue.

The developed system has some advantages; one of these advantages is to allow the hospital staff to monitor the patient remotely. The staff can be informed through this system in case of any critical situation that may occur in some other place. In our study, the hospital of Tikrit gets the most of these advantages due to the bad situation of the city. Since, communication and transportation are always reach the extreme level of inflexibility that leads to an obstacle for the medical monitoring and stuff availability.

This system allows sending text-based data such as (respiration rate, BP, heart rate, temperature, glucose level, oxygen saturation) to remote the client out of the hospital. Furthermore, it takes into consideration the low cost of this system comparing with other remote monitoring systems that use 3G which is not available in that territory. Furthermore, the city is almost under unstable mobile phone coverage.

This system more suitable and accessible since the satellite connection available and covers the whole city through wireless LAN. In addition, the bit rate of data transference is (11 Mbit/s for 802.11b), which is higher than other mentioned systems (56-114 kbit/s for GPRS).

# CAPTER TWO

# LITERATURE REVIEW

## 2.0 Introduction

This chapter explains an investigation of the Patient Monitoring System (PMS) and Wireless Local Area Network technology (WLAN) that is used in the Remote Patient Monitoring System (RPMS). The chapter includes a comprehensive definition and explanation on the Sensor System, Wireless Sensor Networks (WSN) and Body Area Network (BAN). Furthermore, the studies that related to this particular area will be discuss, including RPMS taxonomy interaction environments.

The internet technology development, digital cellular telephony technology, wireless network and sensor systems contribute to make new demands on patient monitoring systems. These technologies will be cover in this chapter .

## 2.1 Health Information Technology

Health Information Technology (HIT) refers to The application of information processing involving both computer hardware and software that deals with the storage, retrieval, sharing, and use of health care information, data, and knowledge for communication and decision-making (Goodman et al. , 2005 ). This includes applications such as network technology's, Internet technology's and sensors systems .

The central part of HIT is the Electronic Health Record (EHR) or Electronic Care Record (ECR) (Goodman et al. , 2005 ), a patient's medical file, which is stored

electronically and maintained by the health care supplier. The Electronic Health Record can help to ordering prescriptions and tests, informing clinical decision, developing a longitudinal files of actions, and information pertaining to a patient's care. EHR systems include such capability as viewing, order, messaging, document, care organization, analysis and reporting (Shekelle et al. , 2006 ). The HIT is a vital included part in the modern E-government perspective (Kamar.N, 2007).

## 2.2 Hospital Information System

A Hospital Information System (HIS), also called Clinical Information System (CIS), is a complete integrated information system intended to manage the administration, financial and clinical aspect of a hospital. Clinical Information System are sometimes separated from Hospital Information System, in that the former focus on patient related and clinical state related data where as the last keeps track of administration issues.

HIS can be consider as a base element of the current hospital information infrastructure thereto the fact that one of the most recent challenges in the field of critical care is the integration of patient monitoring into the hospital information system (Kogure et al. , 2005).

The Patient Health Record (PHR) or Patient Electronic Record (PER) are considered the primary elements of HIS and basics for the efficient delivery of high quality health care in hospitals (Laerum et al. , 2005). PHR refers to an individual patient's medical record in digital arrangement.

The patient data in the PMR is either stored as searchable text and numbers or as document images and the co-ordinate of the storage and retrieval of individual records

is go on with the aid of computers. As a part of the PHR, the vital information are stored in the computer as well if there is a PMS. The final result of the PMS are updated in the PHR. Eventually, the changes will updated in the EHR. PHRs and PMSs are usually accessed on a computers, often over a network. It may be made up a monitoring of electronic health records from many locations and/or sources. Finally, (Kogure et al. , 2005), believes that PHR systems are plays vital rules in reducing human errors.

## 2.3 Remote Patient Monitoring System

The Remote Patent Monitoring System improves the patient's life quality by granting them more freedom to continue their daily routine. It is very important and vital particular field in the Health Information Technology's area as long as it is help to guard patient live and reduce human errors and costs. There are many studies in the area of remote clinical care. In a matter of fact that the first notable pioneer study in the field of remote patient monitoring system was produced by (Pavlopoulos et al. , 1998). The study aimed to manage contributions for emergency case survival, especially in cases of serious head injuries, spinal cord, and internal organs by developing a portable medical device that allows telediagnosis, long distance support, and teleconsultation of mobile healthcare providers by expert physicians. The limitation of this study is related to the usability issues, the portable medical device was very heavy around 3 KG.

The primary and modern study produced by (Zhang et al. , 2007). Figure 2.1, it was developing a remote patient monitoring system for doctors to enable them to monitor the patients vital signals who are in isolated area.

The system works on the mobile that has 3G and Java-enable technology's. The doctor can monitor the patient on a real time base.

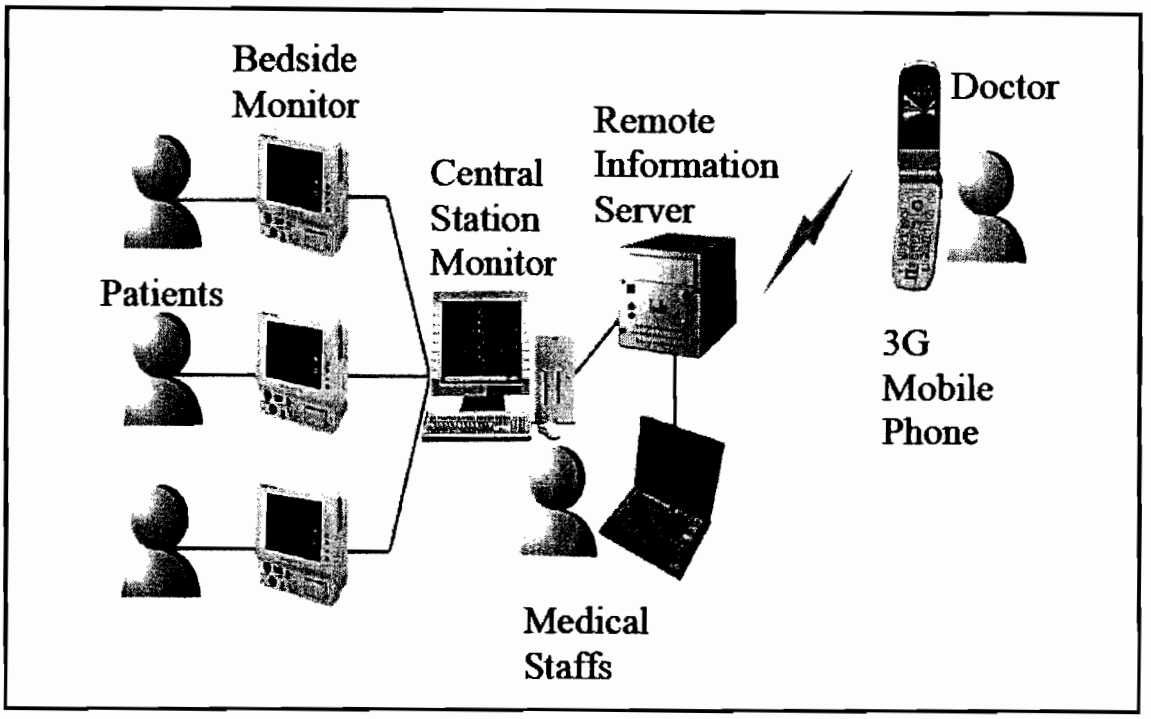


**Figure 2.1: RPMS Flow (Zhang et al. , 2007)**

Two servers are used in the system development: the first one is to collect the data from the patient and process it and, the second one is to manage the connection between the doctor's phone and the medical serve. This study is related to our study, but they are using mobile network to manage the connection between patients and doctors, which is unavailable in Tikrit city. Furthermore, The data processing perform from the patient

side to the hospital side. In our study, the data acquiring start from the hospital side to be send to the staff side. Where, the patient is located in the hospital.

A low cost real time patient monitoring system designed to enhanced the existing service in china produced by (Jiehui and Jing, 2007). The system consists from sensor system unit, server unit and the Medical Assistant (MA) unit. The medical data (ECG) are collected by the sensor system and transmitted to the server via a medical hub, the collected data stored in the server and displayed by medical assistant room. We supposed that the designed system is robust, affordable, and ideal in terms of meeting the health care needs of the population people in chain. If we compare it with our system, the data acquiring also start from the hospital side to be send to the staff side. Where, the patient is located in the hospital.

The study that produced by (Pollard et al. , 2001) was the one of the primary studies that used the internet and intranet in the field of medical care. This can be by allowing the remote supervision and consolation by developing a prototype (hardware and software) to demonstrate a real time data acquisition wireless transmission and reception and connection to the world wide web (www). The main challenge was how to convert the analog signal to a digital signal and how to insure the minimum bit error rate. The system is able to acquire the patient Glucose Level only, which is conceder as one of the system limitation as long as the patient has many others vital sign should be monitored.

The study that done by (Varady et al. , 2002) was the developing of Remote Patient Monitoring System to overcome the increasing cost of the communication technology by inventing and implementing a system base on the existing industry standard in the communication networks. These authors saw that the open architecture system design

offers scalability, standardization in interfaces and flexible signal interpretation possibilities.

The system that developed by (Mendoza and Tran, 2002) was to monitor the patient with HF (Heart Fail) in a home base. The main purpose of the developed portable system is to acquire the heart signals like electrocardiogram (ECG) and Heart Rate Variability (HRV) by sending the information wirelessly to a central server in the patient home area. The server analyses the data and generate a report. Therefore, the monitoring will be in a local base. The system able to transmit the data only in the area that surround the hospital. Therefore, The patient have no free to move. Thus, That can be conceders as one of the system limitations and weaknesses. In our system, we try to make sure that the users are free to move, since the data exchanging will be accrue using WLAN, which is available almost all around the city.

The system that developed by (Pavlopoulos et al. , 1998) was one of the primary notable studies in the field on remote monitoring to monitor the patient during the transition process in the ambulance. The portable medical device allows the transmission of vital information and keep images of the patient via Genera Service for Mobile (GSM) mobile network. The main goal of the system was to allow the doctors to gives the ambulance staff the right instructions to keep patients life who are in an emergence cases until they reaches the hospital. The system is no longer use, because of the limitation of GSM mobile network.

The use of Wireless Technology in the health care system reduce the costs and improve the quality of service(Varshney, 2003). The author lists the challenges in the health care industry. The first founding was: most of the existing implementations of the health care system do not interoperate.

The second foundation is: the security and privacy of the medical data. Furthermore, the availability of data anywhere and anytime should be granted to the authorized person only. (Kara, 2001) gave an effective measures to address the situation privacy and security in the monitoring system base audio and video via the internet to the bedridden patient by introducing a new encryption model. In addition, The author defined the confidently and authentication requirement to insure the secure communication through the internet.

A study produced by (Anogianakis et al. , 1998) to serve the multinational crews who are working in the isolation oceans. The study used telemedicine based on Integrated Services Digital Network (ISDN) and provide a model for the provision of health care, and that model is not limited to medical diagnostics but it encompasses all cases in which the actual delivery of health care services involve a patient who is not located where the provider is. Furthermore, The limitation and unavailability of ISDN can be count as weakness point in this study.

The Remote Health care even includes the weight scale (Zimmerman and Chang, 2008). The objective of the study is helping the patient to control their diet by presenting a home health system to manage heart disease that monitors patient weight and symptoms and supports oral communication between the patient and the health care staff. The system is not concern about the vital task of the RPMS, which is help to protect the patient life.

Furthermore, a study is done by (Khoor et al. , 2001), it was one of the main studies that investigate on middle ware between the sensor system and the hospital end user staff in the Patient Monitoring room. The objective of the study was to develop a wireless communication protocol using Bluetooth technology for short distance (10-20

m) radio frequency data transmission. The use of Bluetooth technology can be consider as weakness point in the system design duo to the limitation of the coverage area. The developed protocol was to overcome the delay in time that happen between the sensor side and the internet or intranet gateway side.

Moreover, the study that produced by (Kogure et al. , 2005) was one of the pioneer studies in the field of RPMS. The study was to develop a system module to enable the doctor to monitor the patient when both of them are away from the hospital. The data acquired from the patient via sensor systems, then it is sent to the hospital server via internet gateway. The data is send again to the doctor mobile via third generation (3G) mobile network. Furthermore, the patient and doctor mobile booth should be java enabled platform to insure the properly works of the system.

Recently, while the revolution and advancement in the modern patient monitoring system, the U.S. Federal Communication Commission (FCC) designs a protected frequency bands to guard medical telemetry from the potential interference of the other elementary base devices. By using FCC protecting frequency Gieras in 2003 developed a wireless medical portable telemetry systems to enable hospitals to provide professionally high value patient care. The system gives the patient the comfort and mobility around the coverage area. In addition, that will facilitate the patient recovery and reduce the hospital stay time, which is the main objective of this study.

The rapidly growth in the telecommunications and information technologies enable the patient monitor system developer to look for low-cost systems.

For example, a wireless house calls system using the communication technology is developed by (Boric and Lubecke, 2002) as in Figure 2.2. The system to monitor the

elderly and chronic patient. The system is to reduce the 24 hours availability of nurse in the bedridden patient. Eventually, cost of treatment will reduced.

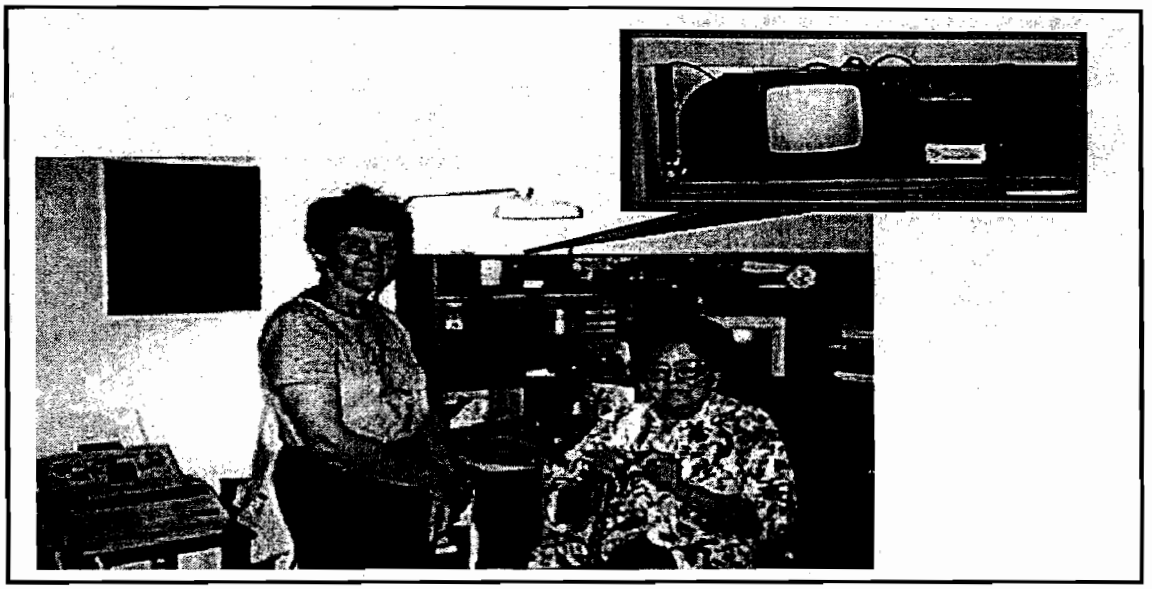

**Figure 2.2:Live-video in-home support communications system (Boric and Lubecke, 2002)**

Since, most the in-home wireless Patient Monitoring System capable of acquiring ECG or oxymetry or temperature measurement. A study is made by (Perakis et al. , 2008) was to acquire all the previous data.

The main technical feature of the device is paying special attention to the wireless technology utilizes for the transmission of the biosignals. The developed system provide the means of easy follow up from bedridden patient home environment. The author uses ZigBee technology in the data transition between the patient sensors and the monitoring stations.

One of the first systems that support the epileptic patient was developing a wireless 32-channal system ECG system recorder developed by (Modarreszadeh, 1997). The

system works under Microsoft windows operation system. Furthermore, the system allow the ECG signal to be viewed in the real time recording on the Hard Disc (HD) to be analyzed later. The system uses the serial portal to enter data to the patient Personal Computer (PC).

## 2.4 Sensors Systems

The most important aspect in PMS is the sensors systems, as long as the process of data transition from the patient to the server operate via sensor. Then, the data can be analyzed via machine learning techniques. The sensor system is a combined action of emerging mobile medical computing, medical sensor technologies and communication technologies (Stuntebeck et al. , 2008).

The network of sensors brings many different problems to manage such as sensor integration, configuration, deployment, data acquisition and communication, data privacy, software infrastructure and user interface (Kulkarnia and Ozturk, 2004).

In the same time the advances in wireless sensor networking have opened up new opportunities to healthcare systems. The integration of existing specialized medical technology with pervasive wireless wearable health monitoring sensors is pushing to new boundaries. Pervasive sensor technologies co-exist with the installed infrastructure, augmenting data collection and real-time responses.

Wireless sensor networks have become increasingly common in everyday applications due to decreasing technology costs and improvements in product performance. It can easily observed that during the last decade the sensor fusion open new avenues for the

implementation of wireless network for the telemedicine (Bauer et al. , 2000). An ideal application for wireless sensor networks is a biomedical patient monitoring tool.

The recent study in the field of sensor system produced by (Ryan and Venkatesan , 2007), the study explores an application of wireless biomedical sensor networks, which attempts to monitor patients for a specific condition in a completely non-invasive, non-intrusive manner. This non-invasive technique uses an accelerometer to determine if a person's arm movement is similar to that person who suffering from seizure. Moreover, the effectiveness of the presented algorithm has been verified on test subjects and shown rare occurrences of false positives.

A study done by (Stuntebeck et al. , 2008) was to introduce a unique biosensors, the framework was to automated detection of the health events (e.g pain or itching), that cannot be detected or observed by the other systems. This health sensor assumes that the occurrence of health-related events is associated with events that can be observed. The sensors can interact and feedback-enable from the patient and the system designed to be flexible by accommodating any type of condition and all varieties of sensors. Additionally, a life protector prototypes to sense pulse waves and users actions, postures and capture contextual photos and continuous voices was done by (Suzuki and Doi, 2001) as shown in Figure 2.3.

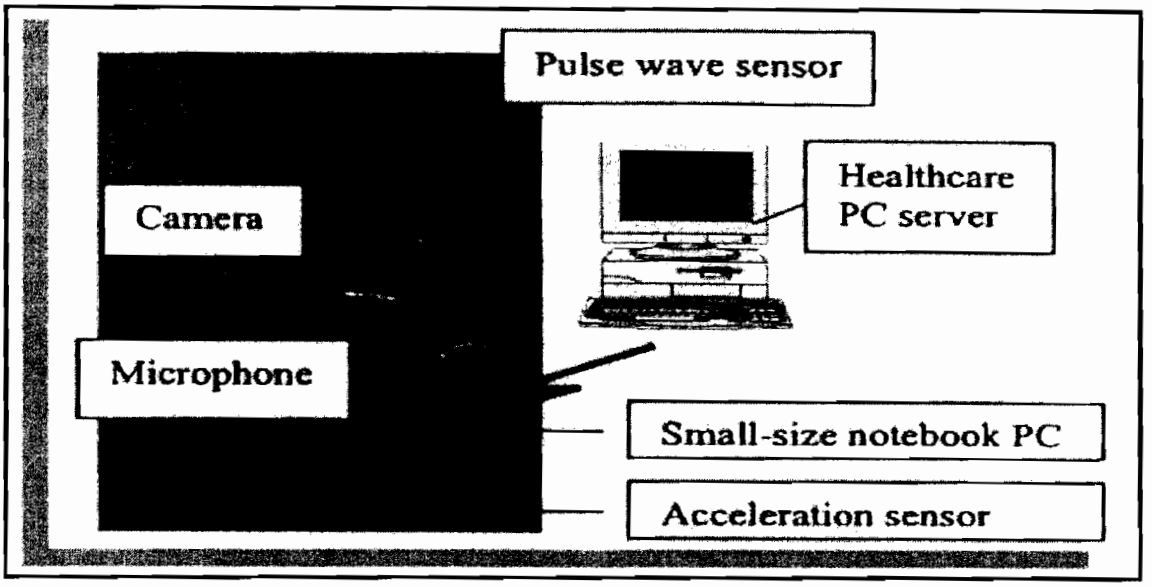


**Figure 2.3:System Overview of the life minder prototype (Suzuki and Doi, 2001)**

The collected data are sent synchronously to the health care server, the stored data are in a Extensible Markup Language (XML) formats so it is easy to extend the prototype and make it available online and retrieved as a web page.

An Optimal Zonal Wavelet-base ECG data Compression (OZWC) integrated designed approach and method for mobile telecardiology model is presented by (Istepanian and Petrosian, 2000). Furthermore, the implementation issues of this wavelet method is a GSM base are also modeled in this study.

Furthermore, (Bhargava and Zoltowski, 2003) are discuss the security and safety issues in the medical care systems. Additionally, an investigate research on the status of smart wearable health research development produced by (Lymberis, 2003).

The author consider that the smart wearable sensors have potential to offer a minimally obtrusive telemedicine platform for the individual health services that are easily and timely accessible.

Finally, a wearable Ring- base sensor 24 hours monitoring equipped with a optoelectrical (the branch of physics that deals with the inter conversion of electricity and light) components for monitoring a patients arterial blood flow in a finger base. The wireless transmitter on the ring sensor sends measured signals to home computer through multiple receivers for diagnosing and abnormality detection, the system is introduce by (Rhee et al. , 1998).

As a final point, (Ryan and Venkatesan, 2007) believes that the wireless patient monitoring systems improve quality of life for the subject by granting them more freedom to continue their daily routine, which would not be feasible if wired monitoring equipment were used.

### 2.4.1 Wireless Sensor Network

Decreasing technology costs and the enhancement in product performance make the Wireless Sensor Network (WSN) becomes more and more common in every day application, which is not feasible if wired monitoring tools are in use.

WSNs are emerging as one of the key human monitoring technologies in assistive environment applications. A lot of PMS nowadays use the Wireless Sensor Network to transmitted data between the patient and monitoring room.

WSNs have been applied in numerous real-world applications, such as surveillance, healthcare, inventory tracking, industry automation, military uses and security.

In 2007, Ryan and Venkatesan, introduce an application of WNS. This network attempts to monitor the patients in a specific state in a totally non invasive (technique uses an accelerometer to determine if a person's arm movement is similar to that of a

person suffering from a seizure), non intrusive way (patients are less likely to become non compliant with the monitoring).

The main objective of the study was to develop application able to detect the patient abnormal movement that could be analytical of a serious health danger. The developed system is a real time base on low power uses.

The study that made by (Becker et al. , 2008), describes an architecture to integrate the Web with Wireless Sensor Networks for an assistive environment and how it was implemented in the context of experiments. The study foundation was the integration of www and WSNs can make the sharing of data collected by WSNs easier for people to access and visualize.

### 2.4.2 Distributed Sensor Network

Distributed Sensors Networks (DSN) are one of the important sensor system technology's that applied in the field of Patient Monitoring System.

The advances in digital cellular telephony technology, wireless network and distributed sensor networks during the last decade and sensor fusion peon new avenues for the implementation of DSN for the telemedicine (Bauer et al., 2000).

There are many studies investigate on the DSN. For example, a three layer Wireless Distributed Sensor Network (WDSN) for a Patient Monitoring System introduced by (Bauer et al. , 2000). The first layer: is the patient sensors, the second layer is: consists of the supervisory processor residing with each patient, the final layer: residing at a central monitoring facility. A synchronized physiological monitoring using a wireless distributed intelligent data acquisition system uses wireless intelligent sensors to

evaluate a group of subjects is prepared by (Jovanov et al. , 2003). The system is convenient for prolonged stress monitoring during stressful training and normal activity.

A prolonged telemetric HRV system is introduced by (Jovanov et al. , 2002). The system uses the wireless distributed intelligent sensors and mobile gateway to the data transition. The system is based on mobile client devices and mobile gateway. The authors use a Personal Digital Assistant (PDA) as a mobile gateway to collect the data from individual monitors and synchronize collected records with the existing records on the telemedical server. The client device uses a flash memory as a temporary storage until the reliable commotion with the mobile gateway is established, this can be count as one of the system limitations.

### 2.4.3 Body Area Network

According to (Jones, 2006) Body Area Network (BAN) can be defined as a network of communicating devices worn on, around or in the body which provides mobile services to the user. BAN consists of a set of mobile and compact intercommunicating sensors, either wearable or implanted into the human body, which monitor vital body parameters and movements.

These devices, communicating through wireless technologies, transmit data from the body to monitoring base station, from there the data can be forwarded to a hospital.

The WBAN technology is still in its primitive stage and is being widely researched. Once, the technology accepted and adopted, is expected to be a breakthrough invention in healthcare, leading to concepts like m-health.

The University of Twente was made a lot of studies and prototypes regarding the development of BAN.

They introduce a BAN for trauma care and homecare by (Jones et al, 2001) in 2001. The first prototype is funded under the IST FP6 project MobiHealth (2002-2004), and the development continues under the Dutch FREEBAND project AWARENESS and the European eTEN project HealthService24.

In the RPMS, the BAN communicate to remote users such as healthcare providers via external network services such as GPRS or Universal Mobile Telecommunications System (UMTS). The generic BAN has been specialized for different mobile health applications targeted at different clinical conditions to provide a variety of telemonitoring and teletreatment services. Each specialization of the BAN is equipped with a certain set of BAN devices and associated application components as appropriate to the clinical application.

As we mentions before, the University of Twente adopted the development of BAN and mobile healthcare applications in 1999. Since, 2002 the University of Twente and partners have been developing health Body Area Networks (BANs) and a BAN service platform.

In Mobile health care systems the ideas of Body Area Networks (BANs), wireless communications and wearable devices such as sensors, actuators, etc. All about acquiring the vital information from the patient and provide that information to the m-health services for patients and health professionals. For example, a personal health monitoring system based on BAN was developed by (Jovanov et al. , 2002).

The objective of the designed system, is to be used during the selection process, as part of a psycho physiological evaluation of military members undergoing intense training.

The system designed to be used in the military soldier selection process. It is used to measure the HRV to quantify soldier stress level . Figure 2.4, shows the BAN process to send the information to the clinical server via a mobile gateway.

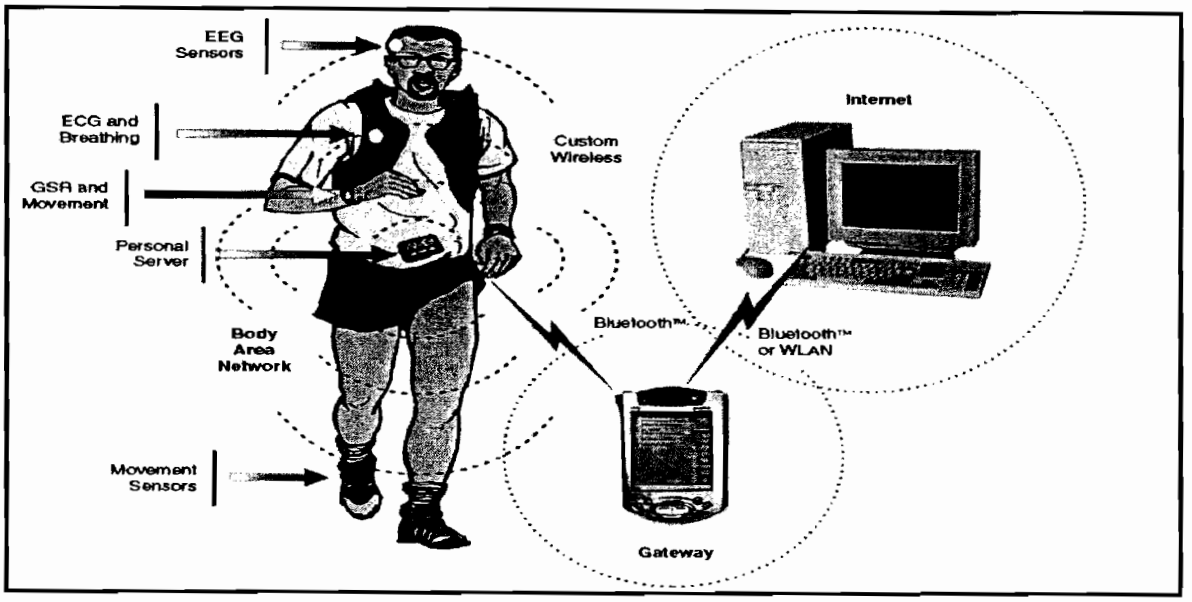


**Figure 2.4: WBAN for military soldier selection (Jovanov et al, 2002)**

One of the famous studies made by (Kulkarnia and Ozturk, 2004) which is tend to design network generally have a multi-tiered system architecture. Figure 2.5, shows an example of a body sensor network employing wireless sensors that communicate with a personal server PDA. At the first level Bluetooth protocols will be used to transfer the vital information from the BAN and sensors to the gateway via Bluetooth.

The PDA acts as a personal server and can communicate with medical servers which are located in the hospital or in the medical care over the internet via GSM/ GPRS cellular networks. Furthermore, the second level is responsible to transfer data from PDA to the public network (internet), in the third level, hospitals, emergency services,

physicians and nursing homes are connected by using a network of remote healthcare servers and databases. The requirements for a medical network sensor system depend on the specific application and deployment environment.

In mobile Patient Monitoring Systems , one of the most important and vital part is the biosensor and the design of BAN because it is the only source for clinical diagnosis and acquiring the vital information. The following Figure 2.5 shows the use of BAN in the patient monitoring system.

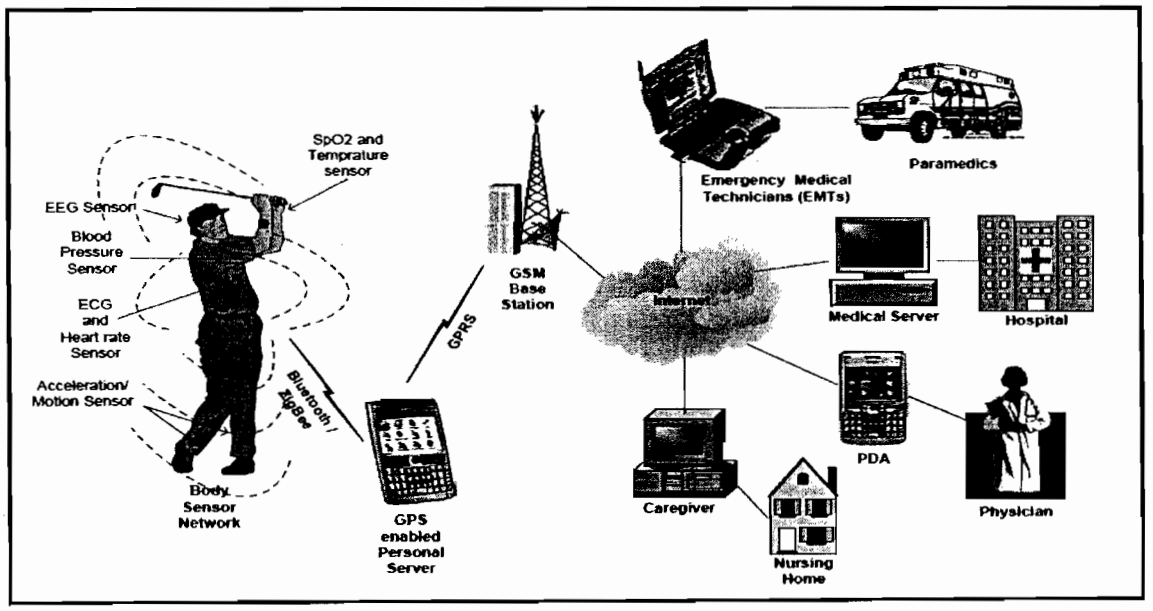


**Figure 2.5: WBAN for pervasive health monitoring (Kulkarnia and Ozturk, 2004)**

## 2.5 Wireless Local Area Network

IEEE 802.11b is the most reliable technology in supporting patient monitor in diverse environment including hospitals. That is the foundation of the study that produced by (Varshney, 2006). The study was to investigate on the RPMS transition media

requirements. Thus, IEEE 802.11b is the technology that it is used in our study. There is a large attention in using Wireless Local Area Network and mobile technologies in patient monitoring in diverse environments as well as hospitals and patient homes. WLANs have been planned to provide support for mobile computing in the small region, such as a building, park or office complex. There are two basics types of WLAN connection technologies.

The first approach is infrastructure which is central access point covering users in an area. the second type is ad hoc mode, which is peer-to-peer communications without an access point configurations, both can be designed and work in the same area.

The WLANs can provide wireless connectivity to hosts (computer, mobile phones, machinery or systems) that require rapid use in a limited area place. These hosts can be stationary, portable or mobile and may be handheld or mount on a moving vehicle. The main attraction is the flexibility and mobility that is supported by a WLAN and the bandwidth considerations are secondary. Although the situation may change with widespread deployment of 802.11a and 802.11g, standards that allow up to 54 Mbps channel bit rate.

The primary uses of WLANs have been LAN extension, nomadic access in hot spots and broadband access (2 Mbps or more per user) to the internet. The integration between the mobile enable WLAN , and the technology of WLAN will lead to a shining future to the use of clever mobile in the remote patient monitoring systems and location-based services (Varshmey, 2006). By emerging WLAN in the medical care systems, doctors and staff can review, evaluate and update a patient's medical records from any location using a handheld device. Entering diagnostic information and taking

notes electronically eliminate the need for time-consuming manual dictation and errors associated with.

## 2.6 The uses of WLAN in Patient Monitoring Systems

Wireless LANs and personal area networks make it possible to continually monitor patients almost anywhere and immediately notify healthcare workers, the nearest hospital, or an emergency service of any critical change in status. Such networks can quickly route biomedical and environmental data from sensors deployed on the body, in a room, or throughout a building to a central computer system for processing. Building in context awareness would help to avoid false-positive alerts in the future. With remote monitoring, patients are undergoing postoperative care who are no longer in acute danger but are still subject to a relapse or other complications can be safely transferred earlier to other units within a hospital. Many can move to less costly assisted care facilities or even return home more (Varshney, 2003).

The first notable studies in the field of using WLAN is made by (Mendoza and Tran, 2002). They design home wireless monitoring system to monitor the patients with Heart Failure (HF). The purpose of study was to design a system(hardware and software) for real-time, wireless, remote acquisition of cardiac and other physiologic information from HF patient while they are in the home environment, the patient information includes electrocardiogram ( ECG or EKG is a recording of the electrical activity of the heart over time produced by an electrocardiograph), heart rate variability. After acquiring the information will wirelesses to central server located elsewhere in the home for signal processing and data storage. Finally, we should relays

that fact the primary success key in the healthcare application is the reliability of using WLAN to exchange and transmit vital data between both side, hospital to patient side, or patient to hospital side.

## 2.7 Patients Vital Data

The patient vital data can be classified into two types. The graphical data like (ECG) electrocardiogram which is a graphical recording of the electrical activity of the heart. The output is usually in the form of a long scroll of paper displaying a printed graph of activity. Newer models output the data directly to a computer and screen, although a print-out may still be made.

The second type of patient vital data is the text-based information which will be used in this study. The definition and explanation of the data that will be used in this study will be elaborated in the next paragraph.

**All the medical definitions are taken from Medical Dictionary by (Mikel, 2008)**

- **Blood Pressure (BP)**

Is the pressure of the blood within the arteries. It is produced primarily by the contraction of the heart muscle. Its measurement is recorded by two numbers. The first (systolic pressure) is measured after the heart contracts and is highest. The second (diastolic pressure) is measured before the heart contracts and lowest. A blood pressure cuff is used to measure the pressure. Elevation of blood pressure is called "hypertension". The normal measured values for a resting, healthy adult human is

115 mmHg systolic and 75 mmHg diastolic (written as $^{115}/_{75}$ mmHg, and spoken (in the US) as "one fifteen over seventy-five"). Pulse pressure is the difference between systolic and diastolic pressures.

- **Heart Rate (HR)**

It means the number of heart beats per unit time, usually per minute. The heart rate is based on the number of contractions of the ventricles (the lower chambers of the heart). The heart rate may be too fast (tachycardia) or too slow (bradycardia). The pulse is bulge of an artery from the wave of blood coursing through the blood vessel as a result of the heart beat. The pulse is often taken at the wrist to estimate the heart rate. The average resting human heart rate is about 70 bpm for adult males and 75 bpm for adult females. Heart rate varies significantly between individuals based on fitness, age and genetics. Endurance athletes often have very low resting heart rates. Heart rate can be measured by monitoring one's pulse. Pulse measurement can be achieved by using specialized medical devices like clever sensors in the PMS

- **Body Temperature (BT)**

Also known as normothermia or euthermia, is a concept that depends upon the place in the body at which the measurement is made. The value of 36.8 °C ±0.7 °C, or 98.2 °F ±1.3 °F is the common oral measurement. Rectal measurements taken directly inside the body cavity, is typically about a half degree Celsius (1 °F) higher. The core body temperature of an individual also tends to vary during the day and with activity level,

with the lowest value in the second half of the sleep cycle. This is a low point and it is called nadir, is one of the primary markers for circadian rhythms.

- **Glucose Level (GL)**

Glucose level or Blood sugar concentration, refers to the amount of glucose presents in a mammal's blood. Normally, the blood glucose level is maintained at a reference range between 4 and 6 mM (mmol/l). It is tightly regulated in the human body as a part of metabolic homeostasis. Other sugars (eg, fructose) do not participate in the control mechanisms and are, thus, largely irrelevant to metabolic control. Normal blood glucose levels are about 90mg/100ml, equivalent to 5mM (mmol/l) (since the molecular weight of glucose, $C_6H_{12}O_6$, is about 180 g/mol daltons). Normally, the total amount of glucose in circulating human blood is therefore about 3.3 to 7g (assuming an ordinary adult blood volume of 5 litres, plausible for an average adult male).

- **Oxygen Saturation**

The fraction of the hemoglobin molecules in a blood sample that are saturated with oxygen at a given partial pressure of oxygen. Normal saturation is 95% to 100%.

## 2.8 Chapter Summary

This chapter includes an explanation of the Health Information Technology Taxonomy, since the PMSs are inherits from the HIT. The terms of Hospital Information System and Patient Medical Record are elaborated and explained. Furthermore, the chapter includes the pioneer studies in the field of RPMS. The terms of Body Area Network, Wireless Sensor Network and Sensors systems are defined and elaborated. Finally, the classification of the patient vital data are listed. The explanations includes the Text-based data which is used in this study.

# CHAPTER THREE

# METHODOLOTY

## 3.0 Introduction

This chapter discusses research process which has some of sub processes, following by the outcome of each process and its relation to the objectives as shown in Figure 3.1.

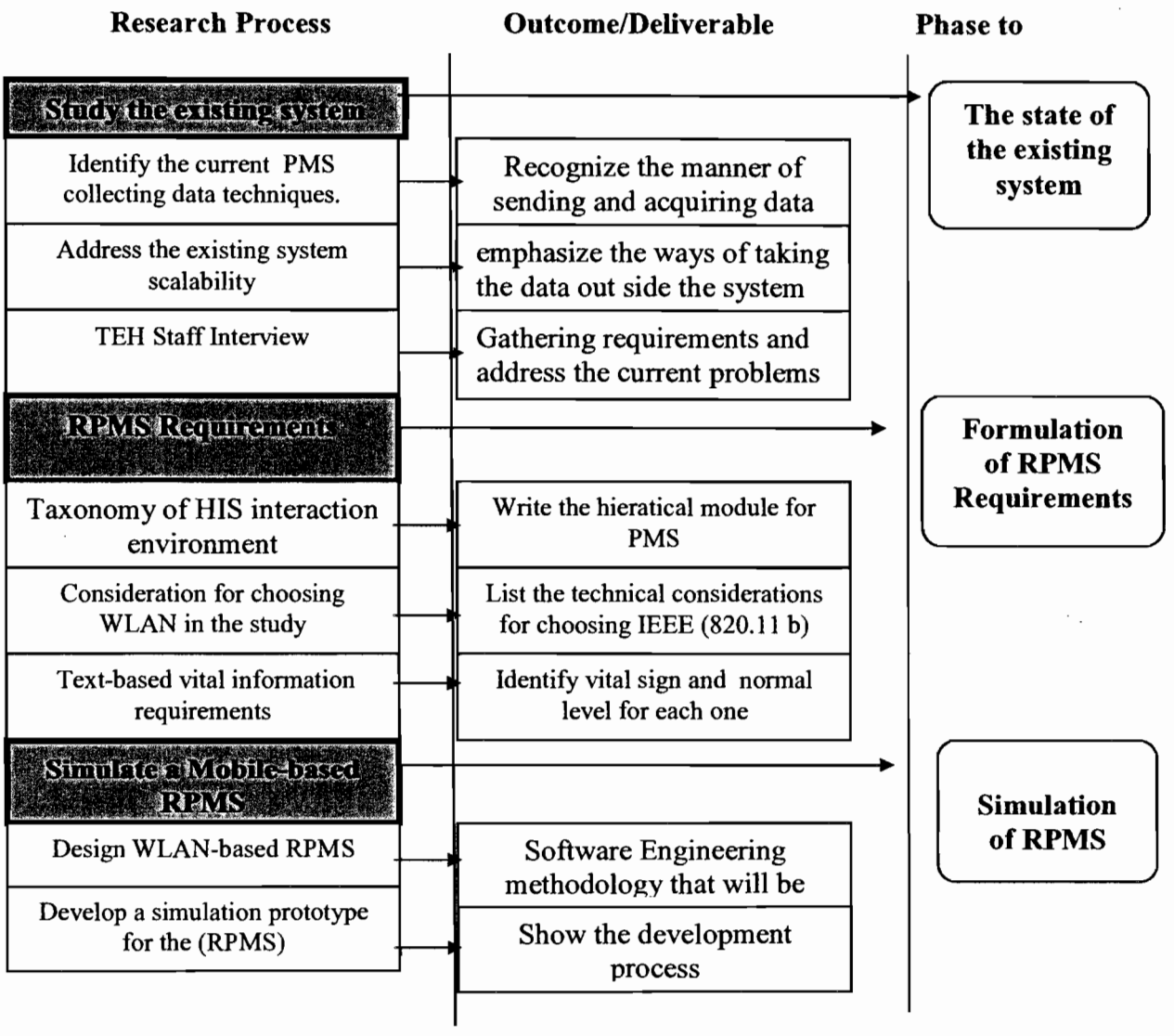


**Figure 3.1: Research methodology structure and its related to the objectives**

## 3.1 Study the Existing System

The existing system in Tikrit Educational Hospital called SafeBed IP devices, DVM2008 is the software which is work on. SafeBed IP is an innovative patient monitoring and nurse-call system with integrated non body contact vitals monitoring. Discreet Vitals Monitoring (DVM) technology measures the basic physiology (e.g. respiration rate, BP, heart rate, temperature, glucose level, oxygen saturation) from below the patient's mattress Figure 3.2. This can be done without any electrodes, leads or cuffs. All measurements and recognitions from the patient bed are sensed with this thin-film sensor, which converts every movement to an electrical signal to be converted to digital data. Further, it will processed by the SafeBed IP server. Moreover, the end-user application software are running on the main monitoring server. The system is flexible that can be used for delivering various alarms, notifications and monitoring patient vital signals.

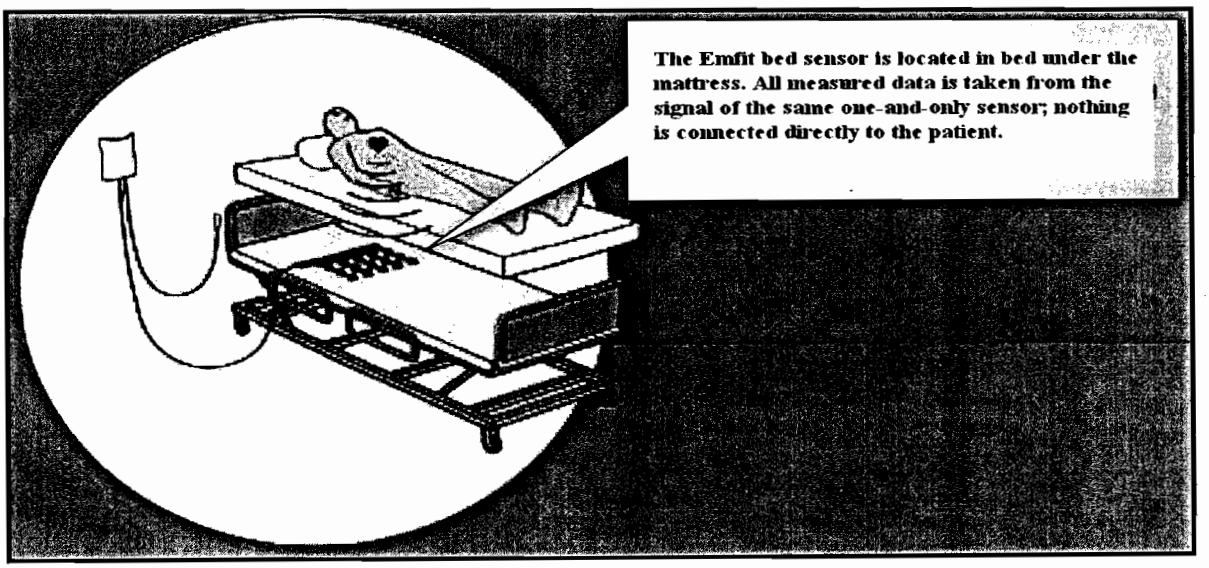


**Figure 3.2: Sensor System which is located under the mattress(SafeBed IP manual)**

### 3.1.1 Identify Collecting Data Techniques for the Current PMS

This system consists of patient sensors installed under the mattress and a bed-side control unit utilizing advanced digital signal processing connected to a standard data network (LAN) which acts as the media for all communications.

Conventional nurse call buttons are included at the bed-side device. DVM2008 software installed in one monitoring computers communicates with bed-side devices and, that computer located at Medical Monitoring Center (MMC) room. Moreover, that computer has a Video Graphic Adapter (VGA) splitter which enables the user to plug many monitors to that server or computer.

The sensor responds to small pressure changes in the blood and respiration movements, then generates a respective output voltage signal. The Digital data acquisition and signal processing unit use special algorithms to calculate heart and respiration rates. The system transmits all alerts, events, and monitoring data over standard data network by using standard IP protocol to the main server as it shown in Figure 3.3.

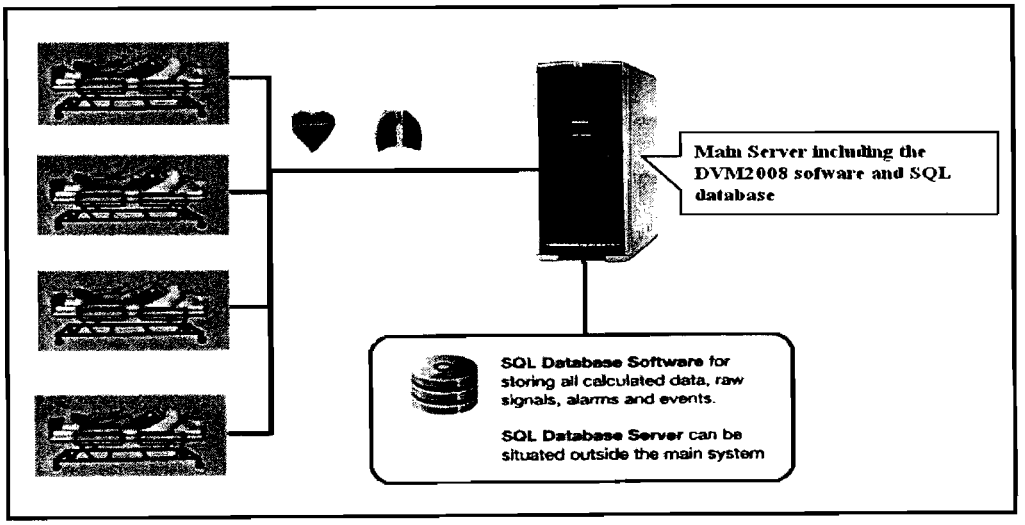


**Figure 3.3: Existing System Descriptions (SafeBed IP manual)**

SQL database is used to storage patient vital data. It can be used to generate reports in relation to the patient status.

The operation of acquiring data from the patient sensors can be managed by main computer software. The users can monitor the patient in real-time base or it can be operated by doing changes in the system configuration to gain data every 5 seconds, 10 seconds, 15 second ... etc.

### 3.1.2 Address the Existing System Scalability

Two important factors related to the study success should be well defined. The first, concerns is to simplify the method of sending the data out side the SafeBed IP main server. Secondly, the study justify the technique to migrate the data outside the main server. Finally, data are store in a DBMS server for analyzing and mining processes. Both factors work to achieve one purpose which is to send the data outside the safeBed IP system and gives the Information Technology staff the reliability to add more characteristic to the system.

- **LAN Interfaces to Network Extensions**

SafeBed IP system in the main server has a free Local Area Network interface port (RG45) used to extend the network. Furthermore, It is used to migrate the data outside the main system.

- **The Data are Migrateable out Side the Main Server**

The system software SafeBade IP (DVM 2008) has the facility to migrate the data outside the main server and store it in MySQL or Oracle DBMS because all of them have the same metadata.

The data can be migrated only to this two kinds of DBMS. The migrated data can be used to the future analysis or it can be used to generate reports. In our study this fetchers, will be used to migrate the data to MySQL server to make the mobile web-based system possible.

### 3.1.3 Tikrit Educational Hospital Staff Interview

The interview method was applied when the researcher hold face to face meeting to the respondent or customers directly. The interview considered an important and powerful way of gathering information when the researcher has a sensitive or complex issues to discuss. Furthermore, it can be used when the researcher has open-ended questions to collect data.

The interview method also allows the interviewer to gather information and obtain feedbacks. The interview technique can be divided into structured and semi-structured interview. In this study, we use semi-structured technique to conduct the interview, that is selected when the researcher is free to manage the interview questions and answers. The interviewer may want to ask a question that is not originally predetermined. Furthermore, the interviewer has the choice to answer the questions. The semi structured interview has an overall structure and direction, but allows a lot of flexibility to include unstructured questions.

The interview should start with an explanation to the main goals of the study. In this study, the main goal is to extend the existing Patient Monitoring System in Tikrit

hospital and make it accessible remotely using the WLAN-enabled mobile phone via internet connection. The problem statement is justified and clarified, which is to enable the physician to monitor the patient vital data under critical environments surrounding the territory of the city. Moreover, the bad security measures and enforced curfew during the night hours which prevent the hospital staff to access the hospital. Two interviews are conducted to gathers the information from the technical and medical staff in the hospital.

- **First Interview**: The first interview conducted with IT manager in Tikrit hospital. It was aimed to identify the current PMS techniques of collecting data. Moreover, it was expected to address the main scalability characteristic that makes the existing system extendable. The questions are listed in appendix B, the interview outcome can be list in to this points.

  - The system use new data acquiring and measuring technology via sensors installed under the patient mattress.
  - All the collected information supposed to transmitted to the main server where (DVM 2008) software are installed, to be processed and stored in SQL DBMS.
  - The hospital staff can monitor the patient data in the MMC room.
  - The system enables the staff to monitor some of the patients who are in emergency cases in Real-Time based.
  - The system collect the data from the patient if there is some changes in the patient vital data. Or else, it will collect data every 5 min.
  - The period of data acquiring are managed via the main server.
  - The system doesn't support the client-server architecture .
  - The system has scalability characteristic like LAN port and data migration feature.

- **Second Interview:** The interview conducted with three of TEH staff who are using the existing PMS. I used power point slides to highlight the importance of the project and its vital value which is serving the staff to monitor their patients in a remote-base via internet connection using the WLAN-enabled mobile phones. Furthermore, I explain the current development in the area of RPMS.

  The questions that I used in this interview are listed in appendix B, that questions can be clustered into three groups.

  Questions 1, 2 and 3 concern about the understanding and usability of the internet and WLAN technology. Most of the audience are using a WLAN-enabled mobile phone and they have a good understanding of the importance of WLAN network because it is the only reliable network connection in the city.

  Question 4, 5 and 6 concern about the limitations and problems that the staff expect through using the RPMS. Questions aimed to discuss the concerns of using RPMS. They just worry about the reliability of data that they will got via the internet connection. Moreover, the important point that they want from the system the security, that means the system cannot be entered only by the authorized users in authorized way.

  Questions 7 and 8 concern about the important and usefulness of the RPMS. All the audience agreed that the system will help them to far extent in monitor the patients remotely and it will be very helpful to save the patients' life.

  The most important data that the staff want to monitor are Blood Pressure, Heart Rate Variability, Temperature Degree and Sugar level.

## 3.2 RPMS Requirements

Within the increasing ways of monitoring patients' scenarios, it becomes a very difficult task to investigate on the requirements of the patient care system. The following table, Table 3.1 discusses the general requirements of patient monitoring system.

**Table 3.1:General requirements of patient monitoring**

| Process | Challenges | Comments |
|---|---|---|
| Patient related | 1-Transmission of vital signs (BP, heart rate, temperature, glucose level, oxygen saturation ).<br>2-The size of device and data acquiring method is a usability issue. | 1-The frequency of vital sign acquiring must be determined.<br>2-each individual patient might need some type of data. |
| Network Related | 1-The network type and reliability of information transition.<br>2-Routing, delay or traffic and other performance issues if we have a real time-based system.<br>3-Scalability and network managements issues. | 1-The networks requires to be dependable and available.<br>2-Requies a sophisticated staff for network managements to information availability insurances. |
| Health care system related | 1-The system cost.<br>2-Number of patient that can the device process.<br>3- System Scalability.<br>4-Sensor type and data acquiring methods. | 1- The information type(Text-based or graphic-based ). |

- **Patient Related Requirements**

The patient monitoring requirements comprises periodic broadcast of routine vital information signs and transmission of alerting signals when vital signs cross a threshold, patients cross a certain boundary or device battery drops below a level. These could include blood pressure, heart rate, temperature, ECG, EKG and other health-related information.

There is another issue in the major of patient monitoring requirements, which is how frequent monitoring of vital signals should be applied. The other related issue is the representation of data that needs to be transmitted and the frequency of information that needs to be send. For example, the vital signals should be transmit every few seconds for some of the patients. While for the others, the monitoring should be conducted in real time-base.

For all RPMS, the key challenges is to transmit the data as soon as indicating a major changes in the patient vital signs. In the wireless monitoring system it could be better to transmit differential changes since the last time of change to reduce the amount of information exchanging between the main server and the mobile.

The wearable, portable or under mattress sensors and Wireless Body Networks under many usability issues like the comfort and trust. The patients trust level is very important to make the patient monitoring success. For example, some patient with mental illnesses that are inclined to think that some controlling entity is monitoring them all the time (Varshney, 2006). Such patients are likely to be very difficult in agreeing to be monitored via wireless bases.

- **Network Related Requirements**

The patient monitoring system will require an inclusive and high-speed access to the wireless network. The reliability and scalability of wireless network is a key aspect in RPMS requirements. All this will be covered in the consideration for choosing WLAN part.

The increasing number of patients who are required to be monitored leads to new challenges which is the managements and authentication, as long as the patient

information will be in the public network. For this reason, the use of MikroTik Routing operating system will operate to solve all these concerns.

- **Health Care Provider Related Requirements**

The confidentiality and privacy are the most important issues in Remote Patient Monitoring Systems. Furthermore, The operation of operating large number of patient should not effect the reliability of information.

### 3.2.1 Taxonomy of HIT Interaction Environment

The health information technology includes the use of both computer hardware and software in the medical information process. It also includes the use of internet and telemedicine to data transitions. According to (Goodman et al. ,2005), the central part of health information technology is Electronic Health Record (EHR) or Electronic Care Record (ECR) as is shown in Figure 3.4

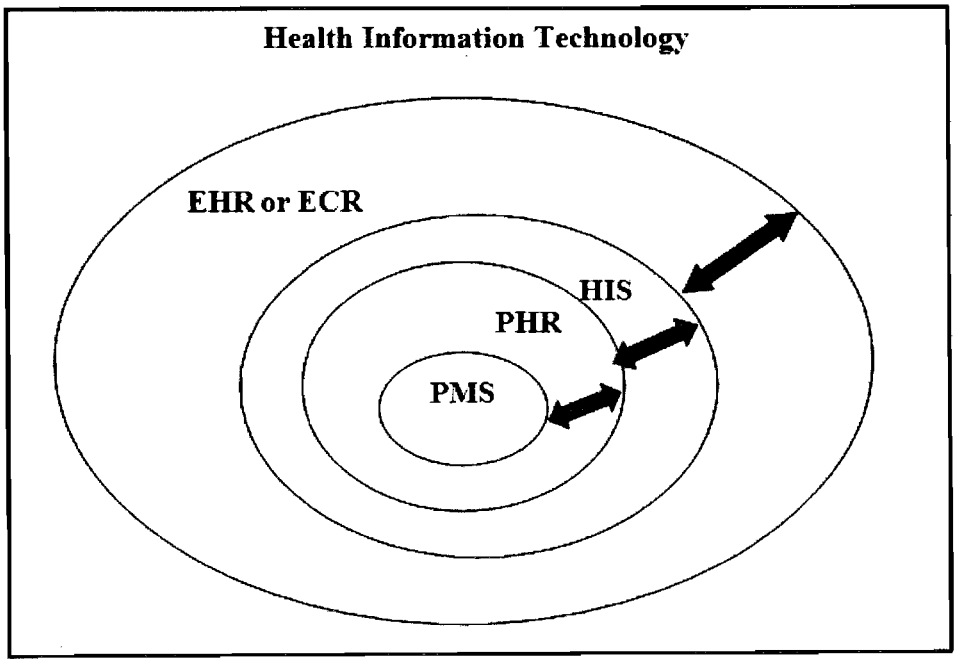


**Figure 3.4: Taxonomy module of HIT Interaction Environment**

As a part from E-Governments exchanges. Each person should have an Electronic Health Record (Kamar. N, 2007). The Hospital Information System (HIS) is about impacting Information System to manage the administration, financial and clinical aspect of hospital. Each patient in the hospital should have a Patient Health Record (PHR). The Patient Monitoring System is part from PHR. Eventually, the acquired data from PMS will be stored in the PMR and after that it will be stored in the EHR.

### 3.2.2 Consideration for Choosing WLAN IEEE 802.11b

WLAN technology is the only available and reliable network which is supported by Iraqi government in Tikrit city.

Since the way of acquiring internet is operated via Satellite connections. The destruction of services is through WLAN bridges. No Digital Subscriber Line (DSL) service are available. This is the primary consider of choosing WLAN as a way of data exchanging between the hospital servers and hospital staff. There are several technical consideration of choosing WLAN that can be listed below.

- **Easy of Setup**

To install a wireless LAN, the manager should install and configure Access Point (AP) and Personal Computer (PC) card. The place of AP is very important issue. Most site survey tools that provided by the vendors are very important in the measurement of signal strength.

- **Easy of Managements**

Since an 802.11 wireless LAN is very popular nowadays. Thus it is very easy to mange the connection between end user and internet.

- **Mobility**

The user has a freedom in the mobility as long as the WLAN coverage service available all around the city.

- **Security**

The 802.11 has a security protocol for wireless networks which is Wired Equivalent Privacy (WEP). The WEP encryption method was designed to provide wireless networks with the equivalent security available in wire line networks; however, WEP was more easily compromised than had been expected.

### 3.2.3 Text-based vital information requirements

The patient vital data can be classified into two types. The graphical data like electrocardiogram, which is a graphical recording of the electrical activity of the heart.

The graphical data output is usually in the form of a long scroll of paper displaying a printed graph of activity. Newer models output the data directly to a computer and screen, although a print-out may still be made.

The second type of patient vital data is the text-based information which will be used in this study. The requirements of that information are elaborated in chapter two.

## 3.3 Mobile-based Remote Patient Monitoring System Simulate

SafeBed IP software system is a firmware-base that is used when we have a fixed operating system to control a various electronic device like, mobile phone, digital camera and some medical device (Zimmer and Vincent, 2008).

The SQL DBMS which is part from the exists system can not work as web-based system. The assumption in this study will be in this way. The data is migrated out side the SQL server to our server (MySQL) which is acting as gateway between the hospital and the internet in the real world. The text-base vital information was retrieved from the existing system and stored in our server.

The server will include the web base system which is based on java platform by using Java Server Page to get an independent platform.

As the system will connected to the public network, the privacy of collected data must be protected. Thus, the system will be managed by another server that is MikroTik Routing OS server. That server will control and manage the administration and security access to the system. Furthermore, MikroTik will be used to simulate the DNS and WLAN access point with DHCP fetchers .

### 3.3.1 WLAN-based Remote Patient Monitoring System Design

Software Engineering Methodology (SEM) should be used in the system design process. We can found many SE methods that can be used like Structured Methodologies, Rapid Application Development (RAD) Methodologies and Agile Methodologies (Robert et al. , 2007).

In this study RAD will be applied to perform a system design process. RAD is Software Engineering Methodologies that emerged in the 1990s to adjust the Software Development Life Cycle (SDLC) phases to get some parts from

developed system quickly into the hands of the users. Most RAD-based methodologies use special techniques and computer tools to speed up the analysis design and implementation phases. Computer Aided Software Engineering (CASE) tools used to graph the system design module. Furthermore, Unified Modeling Language (UML) tolls used to design the system.

There are three types of methodology development–based RAD, prototyping-based throwaway prototyping-based and phased development. The methodology that will be used in developing the prototype for this study is prototyping .

- **Prototyping**

The prototyping-based methodologies perform the analysis, design, and implementation phases concurrently. All the phases are performed repeatedly in a cycle until the system is completed.

The basic analysis and design with this methodologies are performed immediately and work begins on a system prototype. The primary prototype is usually the first part of the system that the user will use. This will be shown to the users and the project manager who provide reaction and comments. This feedback is used to reanalyze, redesign, and reemployment a second prototype that provides a few more features.

This process continues in a cycle until the analysts, users, and project manager agree that the prototype provides enough functionality to be installed and used in the organization. After the prototype is installed, the refinement occurs until it is accepted as the new system.

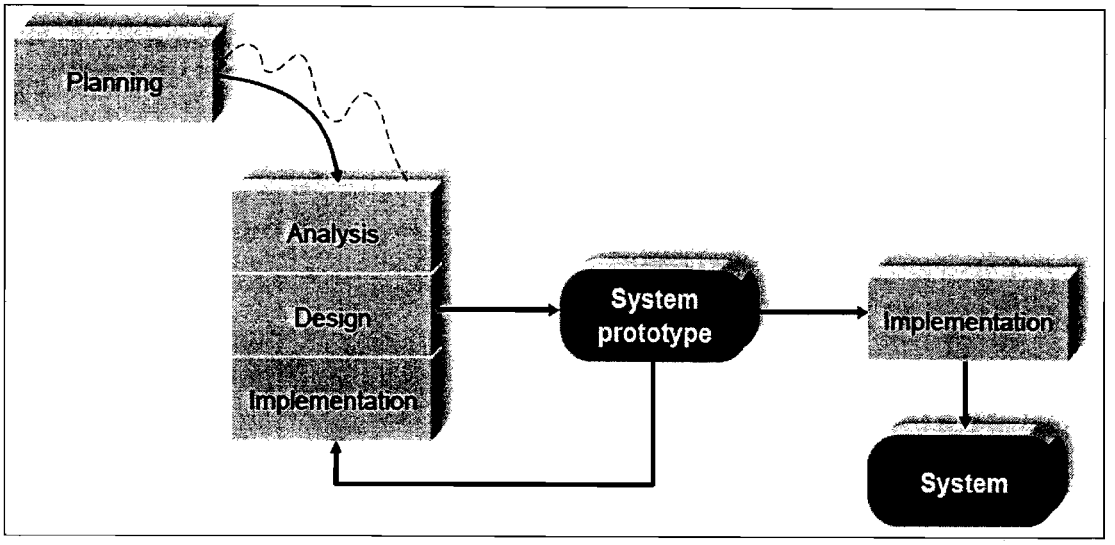


**Figure 3.5:Prototyping base methodology (Robert .A et al. , 2007)**

The key advantage of the prototyping-based methodology provides the system to the end users for the quickly interact, even if it is not initially ready for widespread organizational use.

### 3.3.2 RPMS prototype Development

To develop the proposed prototype for the Remote Patient Monitoring System. We should include the configuration and installation of MikroTik Routing Operating system and the development of the web-based system.

#### 3.3.2.1 Mikrotik Routing Operating System Phase

- **Mikrotik_Ltd**

It's known in the public terms as MikroTik. It is a company for manufacturer computer and wireless networking equipment. It sells wireless products and routers. The company was existed in 1995, with the aim to sell in the emerging wireless technology market. As of 2007, the company has more than 70 employees.

- **Mikrotik Routing OS**

The main product of MikroTik Ltd is MikroTik Routing OS, it is a Linux kernel - based operating system. In this study the fetchers of changing PC-based machine into a software router will be used.

The Router will allow firewall rules, Virtual Private Network (VPN), client-server architecture, bandwidth share and limitation. The system also able to serve as a captive-portal based hotspot technology which will be enabled in our system.

The user can access MikroTik in telnet mode or by Graphical User Interface (GUI) mode. MikroTik GUI can be access via Winbox which is a software that provides a GUI for the Router OS. The connections allows via File Transferee Protocol (FTP) and telnet protocols.

In our study the routing system will be used to determine the access authentication and users monitoring. The firewall will be enabled to prevent any hacking system possibility, as long as the database will be accessible via the public network (internet).

The system administrator manage the creation of accounts. Moreover, The administrator has the ability to cancel and rewrite the authentication roles to any authorized user

- **PC Requirements**

Mikrotik had been chosen because of many reasons. It is the cheapest solution, most reliable, effective, easy to deal with, and available solution. Its requirements are so simple:

- 233MHZ CPU and above (Pentium II and above).

- 64MB RAM and above.
- 500MB Disk space hard disk and above.
- 10-100 MBPS PCI network card.

#### 3.3.2.2 Mobile Web-based System

To develop the prototype, Wireless Markup Language (WML) and JSP will be used to perform the mobile web-based system. WML based on Extensible Markup Language (XML), the markup language which is intended for the devices that used the Wireless Application Protocol (WAP) specification such as mobile phones. WML document is known as a deck. Data in the deck structured into one or more cards (pages) – each of this card represents a single interaction with the user. In this study WML Card will be used to pass the variable (patient ID) to the JSP file (search.jsp). JSP file will is responsible for retrieving the data that related to the patient ID from the database and send it back to another WML cared to be view to the user. Java Server Pages (JSP) is part from Java technology which allows software developers to create dynamically-generated web sites with HTML-based, XML-based or other document types in response to a Web client request. The technology allows Java code and certain pre-defined actions to be embedded into static content. To emulate the web-base system Tomcat apache will be used. Tomcat is a servlet container founded by the Apache Software Foundation (ASF). Tomcat implements the Java Server Pages and Java Servlet specifications from Sun Microsystems. Tomcat provide a pure Java, HTTP and web server environment for Java code to run.

## 3.4 Chapter Summary

This chapter includes the research methodology that has been used in this study. The methodology customize to cover the system objective and sup objectives. It is divided into three phases. The first one concerns with study the existing system. The outcome of this process addresses the state of the existing system in the term of the scalability, data processing, data storing and data acquiring technique. The second process deals with the RPMS general requirements. The deliverable of this process is the formulation of the RPMS requirements. Finally, the explanation of the Software Engineering Methodology and the technique of developing the RPMS are elaborated and discussed in this chapter.

# CAHPTER FOUR

# ANALYSIS AND DESIGN

## 4.0 INTRODUCTION

This chapter cover the concepts of system analysis and design related to the system prototype. The chapter starts with the planning phase which is divided into project initiation and project management steps, the outcome of this face will be system development time scheduler (Gant chart). The requirement is listed in the analysis phase during the requirement gathering step. The system is designed by using UML (Unified Modeling Language) notation in the modeling. The final phase is the system snap shout that demonstrates the development and implementation of the prototype.

## 4.1 Planning

The planning phase is considered the primary process of understanding the reason behind building the information system. This phase determines, how the project developer acts through building a system. It has two steps:

### 4.1.1 Project Initiation

During project initiation the system's worth value to the organization or to the community should be identified, how it will lower the costs or increase the income? How it will make the life effortless?. Most the ideas for the new systems come from outside the IT area (from the marketing department, accounting department, hospital etc. ) in the form of a system request. This face also concern about the

usability issue. If the system is constructed ,would it been used?, all the above concerns are discussed in chapter one. The system will aid the hospital staff to monitor the patient remotely, they can be informed through this system in case of any critical situation may occur in some other place. Eventually, it will help to save patient life.

In our case, the hospital of Tikrit would get the most advantages due to the bad situation of the city where communication and transportation are always reach the extreme level of inflexibility that put an obstacle against direct medical monitoring and stuff availability. Furthermore, this system would be more usable and accessible since the satellite connection is available and cover the whole city through wireless LAN.

### 4.1.2 Project Management

The project plan is immediately executed upon the acceptances of the proposal. The deliverables of this phase are project time line in the form of Gant chart. Figure 4.1, describes how the project developer acts through building a system.

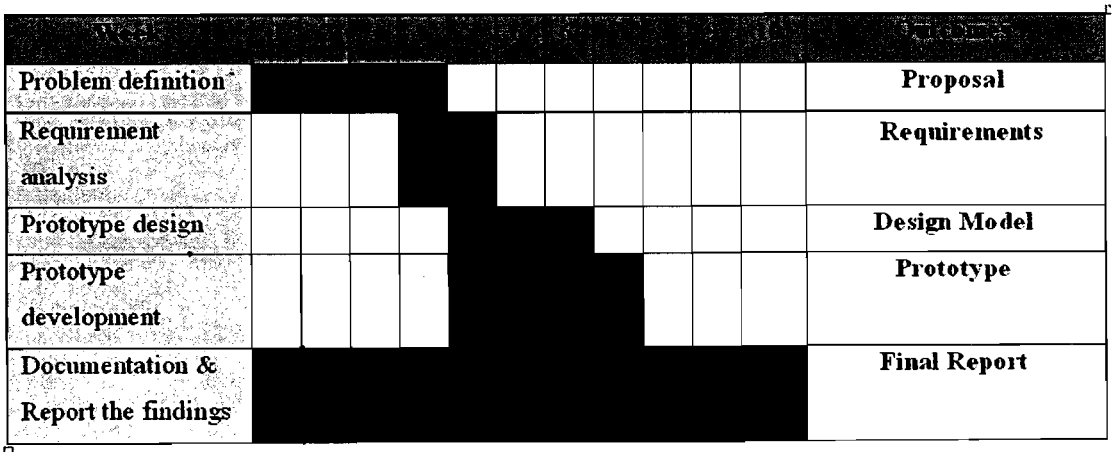


**Figure 4.1: Gant chart**

## 4.2 Requirement Analysis

The requirement and system functionality is very sensitive and critical steps in any system development. According to study conducted by (Tmbler, 2004) that investigates the software failure. The study found that 71% of system faults because of the function faults (requirements problems) , coding faults 6%, interface faults 23%. According to the result of the formal study we should choose and implement the right mechanism and trace the process step by step to gather the requirements and overcome any uncounted problem in this critical ladder.

In the requirement analysis we should answer the questions of who will use the system, what the system will do, and where and when it will be used. During this phase, the prototype developer investigates any current system(s), identifies improvement opportunities, and develops a concept for the new system. This phase has three steps:

### 4.2.1 Analysis Strategy

The analysis strategy is developed to guide the prototype development processes. Such a strategy usually includes an analysis of the current system (called the as-is system), which is in our study SafeBed IP (DVM 2008). This system is covered comprehensively in chapter three.

The end user system should be addressed during the analysis strategy the. The new system extends the accessibility to the vital information to the patient in TEH by developing a web-based system for the WLAN-enabled phones.

### 4.2.2 Requirements Gathering

There are many techniques to gather the system requirements. In this study the requirements gathering process made by the interview with MMC and IT staff in

TEH. The analysis of the information in conjunction with inputs from the Library reading leads to the development of a concept for a new system as shown in Table 4.1.

**Table 4.1: Requirements**

| NO. | REQ. Description | Info. criticality | Priority |
|---|---|---|---|
| 1 | System are accessible only by authorized parties (User name and password) | Confidentiality | Non functional |
| 2 | An assets can be modified only by authorized or only in authorized ways. | Integrity | Non functional |
| 3 | Transmission of vital information | Availability | Functional |
| 4 | Transition and network delay | Reliability | Functional |
| 5 | Acquiring Data | Usability | Functional |

The system requirements are used as bases to design a set of analysis and design models that describes how the system functionality will operate. The set of models typically includes models that represent the data and processes flow.

## 4.3 System Design

In the system design process, UML notations will be used. The design includes the use case module, list of specification and list of requirements for each use case. Sequence diagram will be used to model the object collaboration by using an interaction sequence diagrams. It will identify and transform the use case specification into sequence diagrams using UML notation.

### 4.3.1 UML Modeling Language

UML stands for Unified Modeling Language, it is a graphical language for specifying display, building and documenting artifacts of software intensive systems. UML represents the unification of efforts to build a series of shortcuts for the expression of patterns of object-oriented analysis and design (OOAD) under the auspices of the Object Management Group of matter (OMG). Currently, UML is the de facto standard for modeling objects (Ojo & Estevez, 2005). UML is a graphical notation for drawing diagrams of software concepts. It can be used to draw diagrams of a problem domain, a draft design of software or a software application already. In this study, use Case notation will be used to describe the system functionality and the interaction between the users (actors) and these functions. The Activity Diagram will be used to describe the flow of the system process. Finally, Class Diagram represents the classes and the objects within a model form.

#### 4.3.1.1 Use Case Diagram

A use case and measurable value of actor provide something that describes a series of actions that can be made as a horizontal ellipse (Ambler, 2004). The use of use

cases is to determine the best way to run a project. Common to two or more use cases should be applied only once and then can be reused. Use case defines the system functional requirements. Use cases address the question of how to interact with the actors of a system, and describe the actions that the system should do.

- **List of Requirements**

Listed below are the functional requirements and non-functional requirement of the system. In the priority column, the following short hands are used:

- M – mandatory requirements (something the system must do)
- D – desirable requirements (something the system preferably should do)
- O – optional requirements (something the system may do)

**A. FUNCTIONAL REQUIREMENTS**

**Table 4.2: Functional Requirements**

| No. | Requirement ID | Requirement Description | Priority |
|---|---|---|---|
| | **TMS_01** | **Mikrotik Authentication controller** | |
| 1. | TMS_01_01 | The administrator inter MikroTik local IP address on Winbox to enter the routing system. | M |
| 2. | TMS_01_02 | The system shall display MikroTik GUI. | M |
| 3. | TMS_01_03 | The administrator should be able to create new account to the users (username and password). | |
| 4. | TMS_01_04 | Administrator can limited the browsing bandwidth for each user. | D |
| 5. | TMS_01_05 | MikroTik Routing OS , should prevent any unauthorized access via custom firewall. | O |
| 6 | TMS_01_06 | The administrator may want to cancel the creation of account | O |
| | | | |
| | **TMS_02** | **Browsing RPMS** | |
| 7. | TMS_02_01 | The user can access the main page. | M |
| 8. | TMS_02_02 | The user enter the patient ID. | M |
| 9. | TMS_02_03 | The user can view the patient vital data if there is no **(E1)** | M |
| 10. | TMS_02_04 | If the patient ID not exits, the system will navigate to the main page automatically with in 3 seconds. | D |
| 11. | TMS_02_05 | The user can cancel the searching process. | |

| | | | |
|---|---|---|---|
| | **TMS_03** | **Authorized** | |
| 12. | TMS_03_01 | The user request TEH URL. | M |
| 13. | TMS_03_02 | The system shall display login page. | M |
| 14. | TMS_03_03 | The user should enter username and password and press login. | M |
| 15. | TMS_03_03 | The user can log to the system if there is no **(E1)** | |
| 16. | TMS_03_04 | The user can cancel the login process. | M |
| | | | |
| | **TMS_04** | **Data storage process** | |
| 17. | TMS_04_01 | Data can be stored to represent data migration process. | M |
| 18. | TMS_04_02 | Send the acquired data in the form of IP( TCP/IP, UDP, HTTP, all over IP). | M |

## B. NON-FUNCTIONAL REQUIREMENTS

**Table 4.3: Non-Functional Requirements**

| No. | Requirement ID | Requirement Description | Priority |
|---|---|---|---|
| | **TMS_05** | **Reliability issues** | |
| 1. | TMS_05_01 | Many user should be able to browse vital information. | M |
| 2. | TMS_05_02 | If the systems crash, it should behave perfectly normal when reloaded again. | M |
| 3. | TMS_05_03 | If the patient ID not exits, the system should inform the user. | |
| 4. | TMS_05_04 | The system can do the business process properly and handle of any errors or failures. | M |
| 5 | TMS_05_04 | If the username and password not valid the system should inform the user. | M |
| | | | |
| | **TMS_06** | **Usability issues** | |
| 6.. | TMS_06_01 | Hospital safe should be able to search and view for information within 10 seconds. | M |
| 7. | TMS_06_02 | The system should be easy to use with simple navigation from page to the others. | M |
| 8. | TMS_06_03 | If the patient ID not exits, the system will navigate to the main page automatically with in 3 seconds. | D |
| | | | |
| | **TMS_07** | **Security issues** | |
| 9. | TMS_07_01 | Password should be encrypted to ensure security. | M |

- **Use Case Model**

In this use Case diagram Figure 4.2, the system includes three main use cases. MikroTik Authentications Controller, Authentications and Browsing Patient Vital Data. Two actors are interacting with these functions. The users who interact with the function of Authentications and Browsing Patient Vital Data. The administrators who interact with the function of MikroTik Authentications Controller. To access the include function (authorized) should be valid, the users should be authorized by key-in the correct username and password.

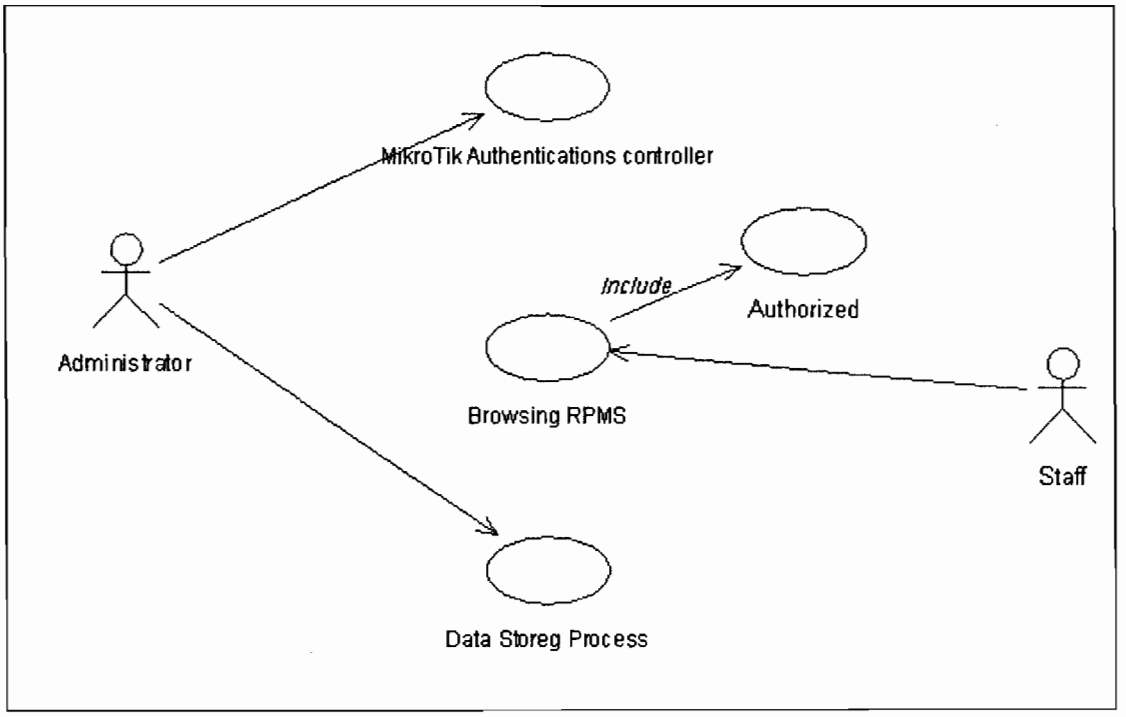


**Figure 4.2:Use Case diagram**

### 4.3.1.2 Sequence Diagram

The sequence diagram shows the interactions among the objects that participate in a use case, and the message that pass between them over time for one use case. It is a dynamic model that shown in a time sequence. Typically is used to represent the

detailed interaction among the objects of the classes, not among the classes themselves.

- **SEQUENCE: Mikrotik Authentication controller (VMS_01)**

This sequence diagram Figure 4.2 represents the interaction between the objects and MikroTik system administrator. The system administrators have to key-in MikroTik ip address, username and password in WinBox. There is an alternative event which is cancelling the operation when the admin enter the system. He can create new account for the users and freeze some of the user accounts. The administrator also able to limit the bandwidth for the users.

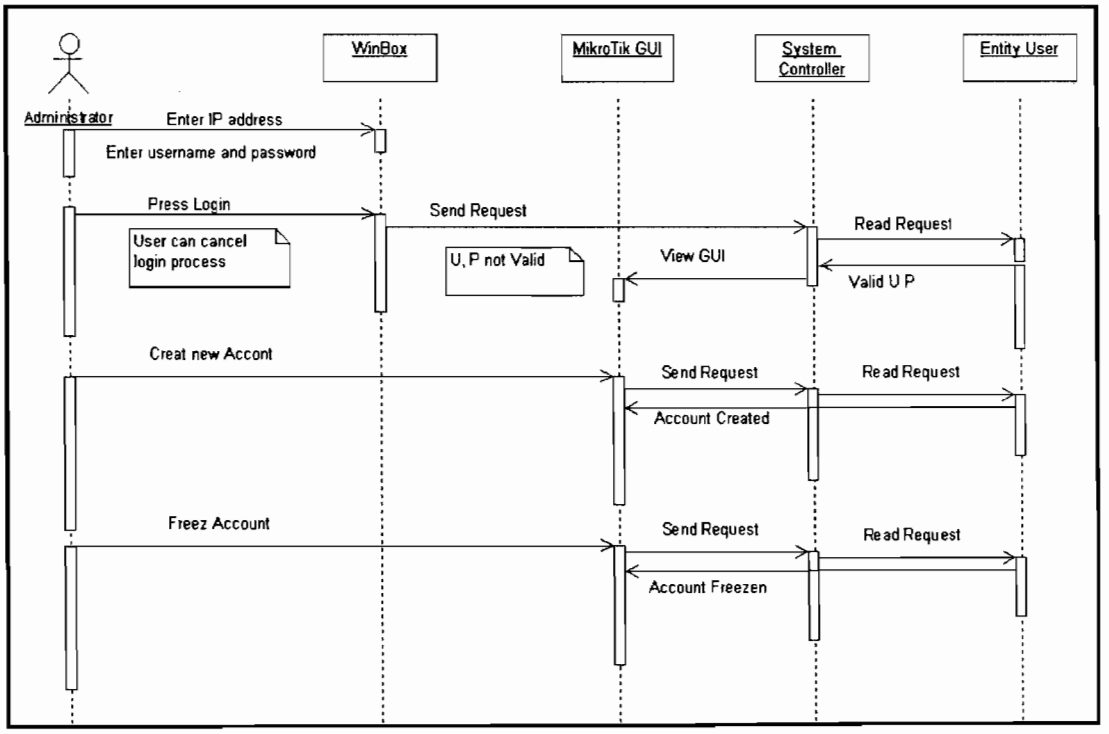


**Figure 4.3:SEQUENCE (VMS_01) diagram**

- **SEQUENCE: Authorized (VMS_02)**

This sequence diagram Figure 4.4 represents the interaction between the security objects and users (Hospital Staff). The interaction starts when the user key-in the

username and password. There is alternative process which is cancelling the login process. The system controller will check the username and password to check the validity of it, after receiving the request form the user. If the username and password are valid a welcome message would be displayed. If not, the system informs the user that the username and password are not valid.

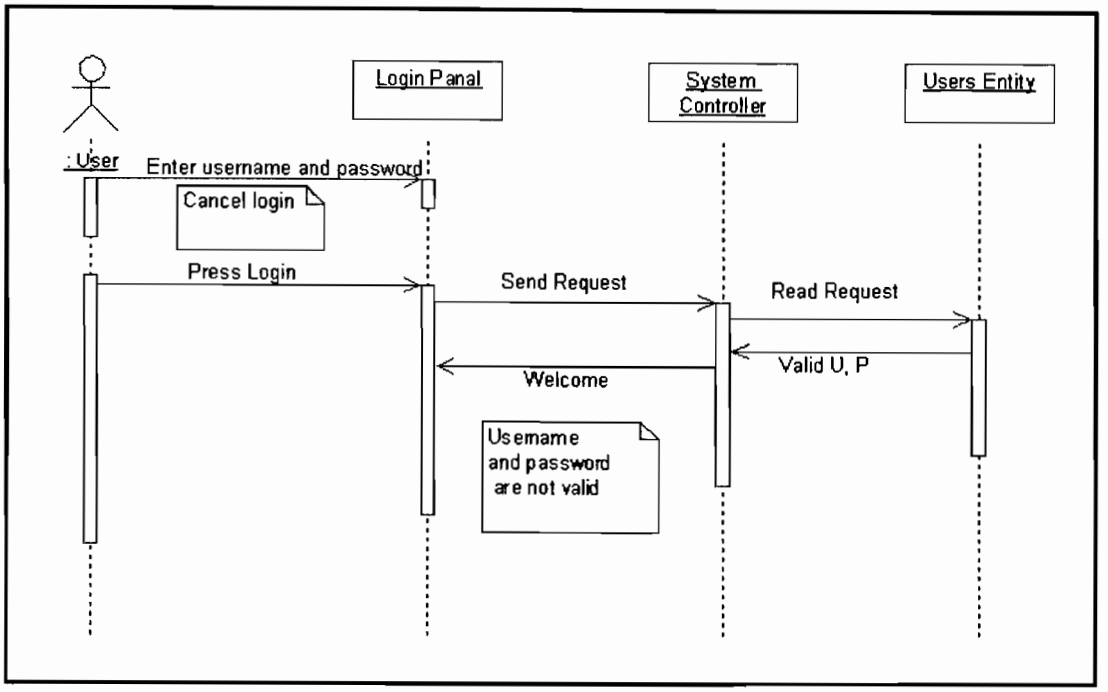


**Figure 4.4:SEQUENCE (VMS_02) diagram**

- **SEQUENCE: Browsing RPMS (VMS_03)**

This sequence diagram Figure 4.5 represents the interaction between the web-based system and users (Hospital Staff). The process starts when the users browse Tikrit Educational Hospital. The users enter patient ID in the main page filed. The request is sent to the system controller in order to check the database. If the patient ID exist, the patient related information would be viewed in the patient page. If the patient ID not exist, the system would inform the user, and it would navigate the user to the main page with in three seconds.

The user can reset the search filed as alternative process.

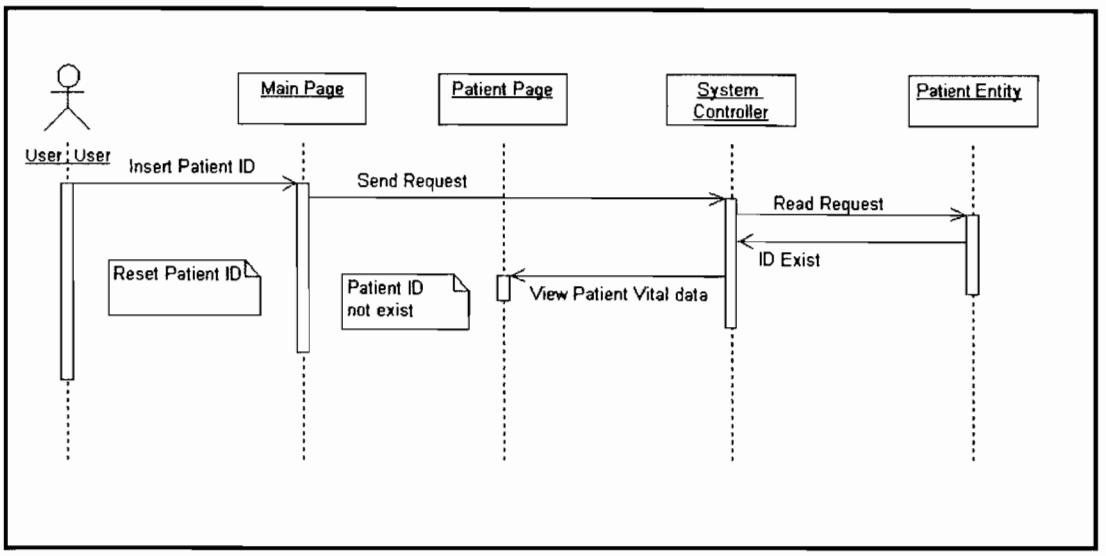


**Figure 4.5: Browsing RPMS (VMS_03)**

### 4.3.1.3 Class Diagram

Class diagrams are the basis for object-oriented analysis and design. The purpose of a class diagrams to represent the classes within a model. In an object-oriented application, classes have attributes (member variables), operations (member functions) and relationships with other classes. This diagram can represent all these things quite easily. Class diagrams show the classes of the system, their relationships (including inheritance, aggregation and association), and the operations and attributes of classes. Class diagrams are used for a wide range of uses, including conceptual / domain modeling and detailed design modeling (Martin, 1997). Figure 4.6 shows prototype class diagram.

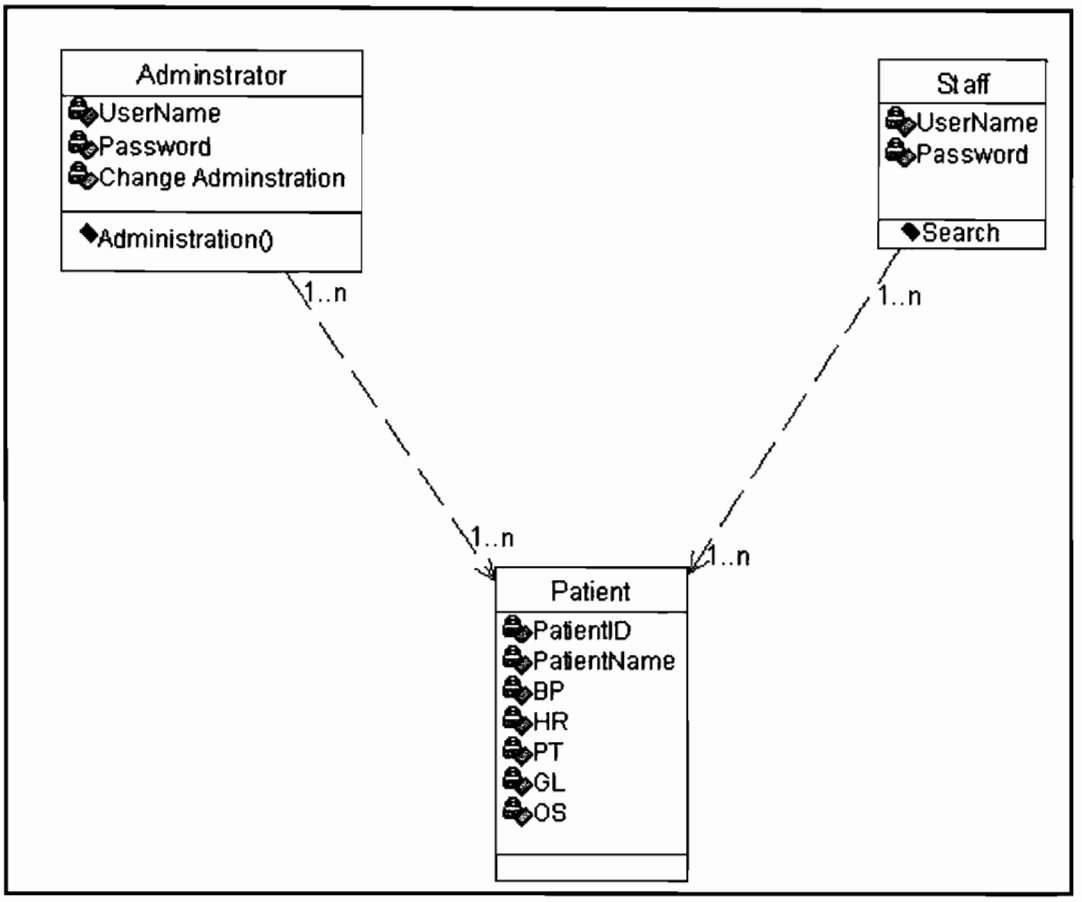


**Figure 4.6: Class Diagram**

## 4.4 System Prototype

The system prototype can be divided into three integrated parts. The configuration and installation of MikroTik Routing Operating System. The configuration of 3Com Access point. Finally, the mobile web-based system and database.

### 4.4.1 MikroTik Routing Operating System Configurations

The configuration of MikroTik R.O.S, includes setting the IP (Internet Protocol) address of each interface and setting the routing module. The routing module might be static routing, dynamic or might be default Routing. Then, setting the Dynamic Host Configuration Protocol. Finally, the users access method should be specified.

#### 4.4.1.1 Installing MikroTik Router OS

Setting up MikroTik Router OS is not a complicated issue, it is exist at the following site http://www.mikrotik.com/docs/ros/2.9/guide/basic. There are three installation ways that is from floppy disk, network or CD ROM. Here is the review of setting up Midrotik from a CD. After parching and downloading the licensed copy from MikroTik web site www.mikrotik.com and burn it a CD, it should make that CD as bootable CD using Nero or any burning software's. After accomplish this tasks, we have to put the Compact Disc in the CD-ROM drive. Finally, booting up the computer that wanted to be used as a Routing Server. The following window in Figure 4.7 will request for the necessary packages to be installed.

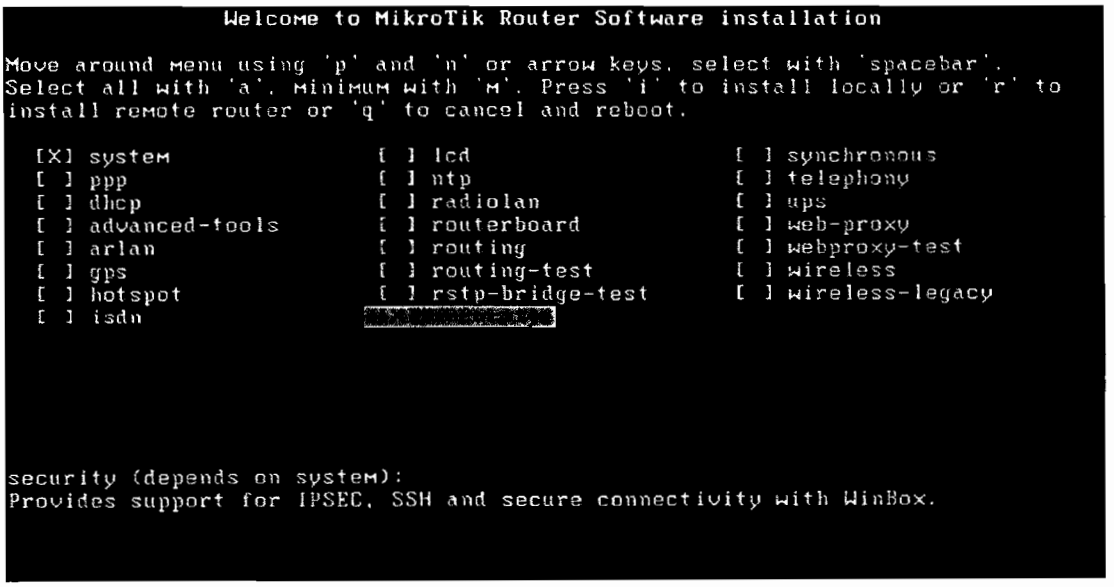


**Figure 4.7: Mikrtik Routing OS installation window**

By choosing (a) to select all the packages and pressing (i) to install the routing system, the installing process will be started. To access the server After installing Mikrotik OS, IP address should be configure in one of the server NIC (Networking Interfaces Cards).

To set an IP address for the NIC it should use MikroTik default user name which is (admin) and for the password filed should be leaved empty.

#### 4.4.1.2 Accessing Server and Setting up IP address to NIC

In MikroTik OS, NIC can be configured using one of two methods. By using command line (/setup ) and follow the instructions on the screen and menu command /ip. In this case the second method will be used to set up the IP address to the NIC by using the following command.

/ip address add address=192.168.0.1/24 interface=ether1.

After setting up the IP address to the NIC. The Routing server Can be accessed form a client PC. For the PC client, the NIC IP address should be the same as the network IP. by using WinBox Loader. Figure 4.8, we can enter to MikroTik.

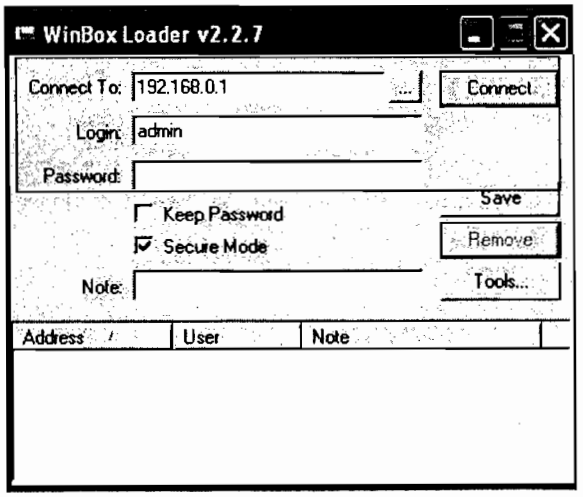


**Figure 4.8:WinBox loader to access the server via UTP connection**

WinBox Loader is a attached software with Mikrotik server used to enable the administrator to access and configure the server by suing connected client pc.

In the field 'connect To', we have to write the server NIC IP. Moreover, we have to write the default username and password.

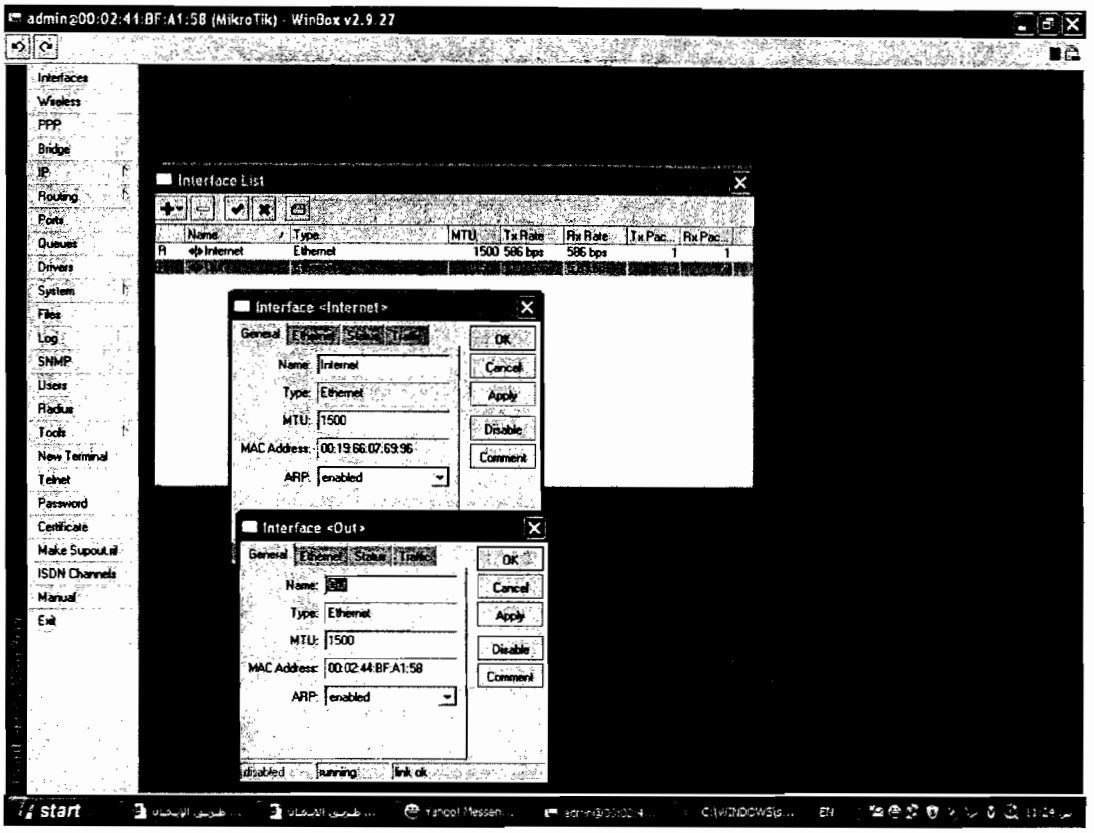


**Figure 4.9: List and Rename Server NIC**

After connecting to Mikrotik server via client pc. The interface in Figure 4.8 shown how to configure the second NIC. To list and rename the server interfaces, 'interfaces' must be chosen. In this study we used two interfaces, 'internet' which is from the internet side and 'Out' which is to the client side.

Each interface in the router should be in different network domain. By choosing 'IP' menu and choosing Addresses, two network ID will be used which is 10.0.0.1/24 to the client and 192.168.0.1/24 to connect with the mobile web-based system. The subnet mask will be 255.255.255.0 which is the same (/24)in both interfaces to reduce the broadcasting. Because the first network is class A network and the

subnet mask should be 255.0.0.0, but the subnet mask will customize to 255.255.255.0 to avoid wasting bandwidth. Figure 4.10 shows setting a new IP for the second interface.

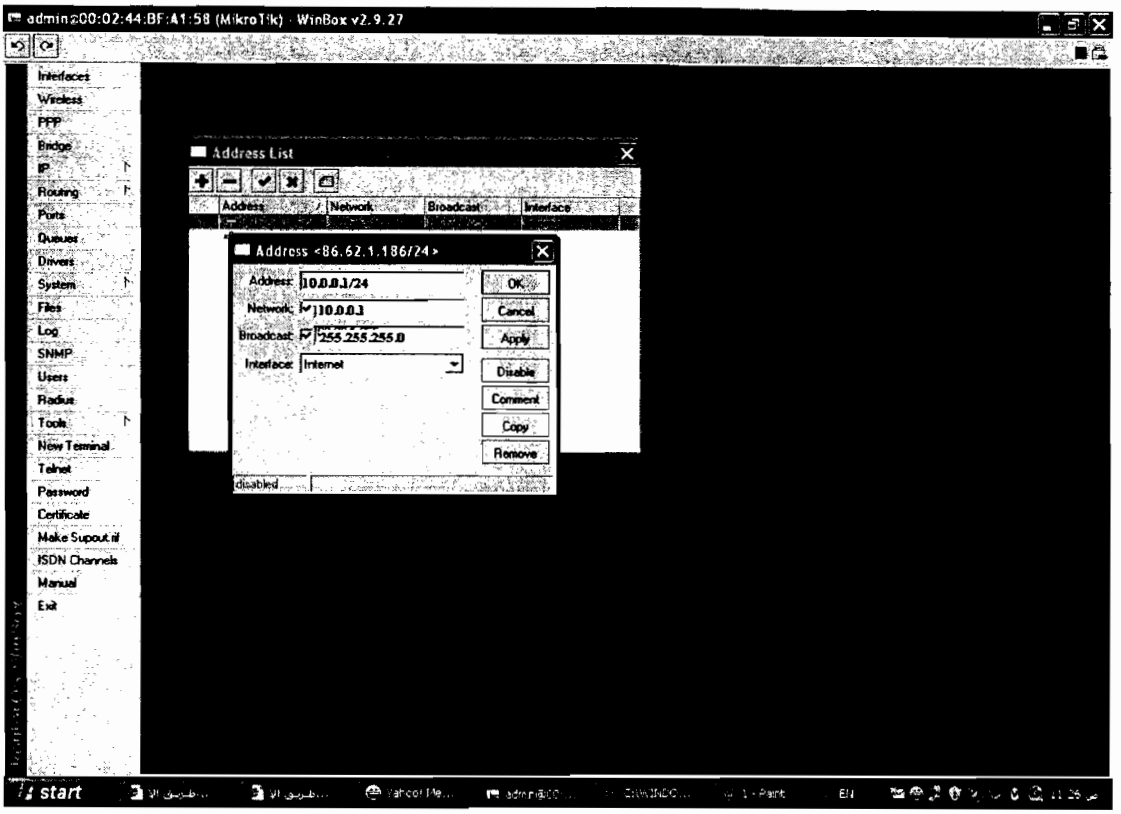


**Figure 4.10: Setting IP address using GUI**

### 4.4.1.3 Setting Routing Table and DHCP fetcher

The next step will be enabling DHCP (Dynamic Host Configuration Protocol) by choosing the Routing list from the menu as shown in the next figure. The protocol will assign an automatically IP for each user when he/she try to connect to the system. Figure 4.11.

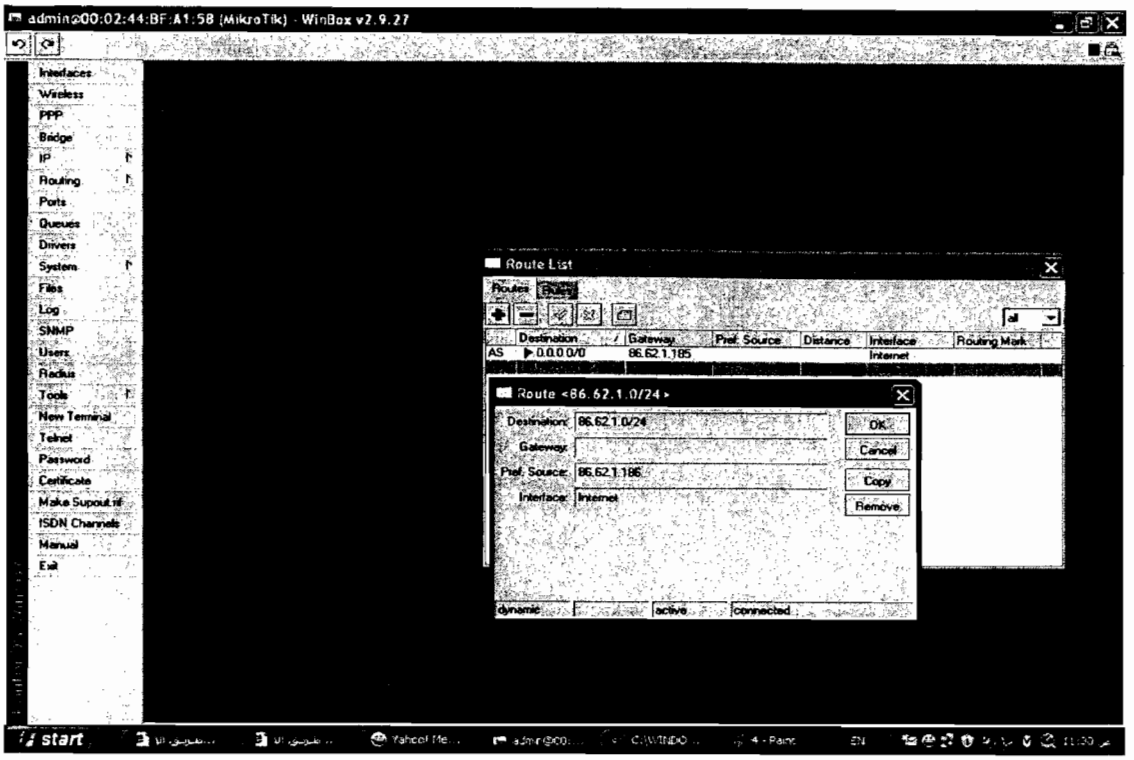


**Figure 4.11: Setting Routing table and DHCP**

### 4.4.1.3 Setting Firewall Roll

In order to prevent unauthorized access and allow the users using the Internet, their local IP addresses at the external interface of the router should be translated to the external IP address by writing the flows command.

```
/ip firewall nat add chain=srcnat src-address=192.168.1.0/24 \
\... out-interface=ether1 action=src-nat to-addresses=10.0.0.1
```

After setting up translation of IP addresses, every computer on the local network is allowed to access the Internet in a secure way. To manage the users access should add the following rules to the forward chain of the firewall.

```
> /ip firewall filter add chain=forward action=jump jump-target=utm5_forward
> /ip firewall filter add chain=forward action=drop
```

#### 4.4.1.5 Setting Hotspot Server

After choosing the hotspot submenu from 'IP' menu and choosing the Interface that will be used to manage the users. The user now can access the internet or intranet. The hotspot page in Figure 4.12, ask the users to key-in the correct username and password to access the system.

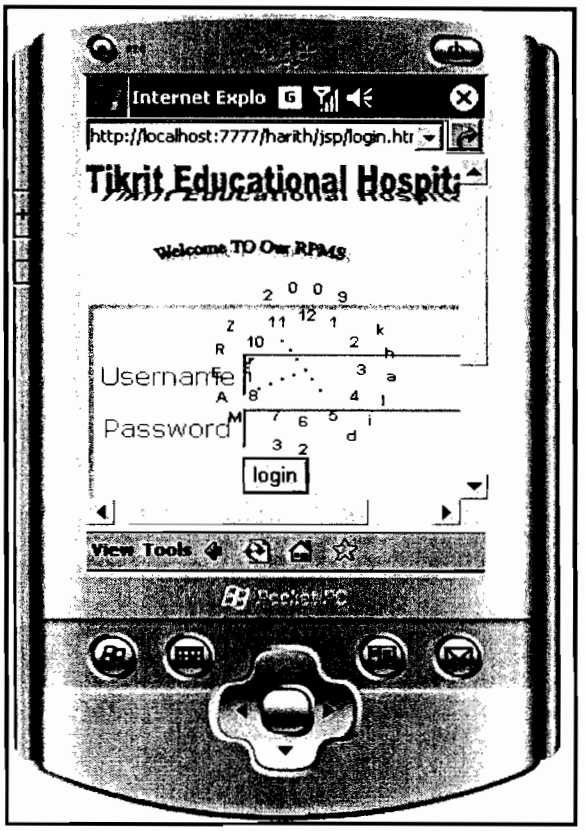


**Figure 4.12: User name and password to access the system**

The user should key-in a valid username and password, assigned by the system administrator to access the RPMS vital signal database.

### 4.4.2 Wireless Access Point

The Wireless Access Point (WAP or AP) is a device that enable the wireless communication devices to connect to a wireless network using Wi-Fi or related

standards. In this study, AP used to exchange data between the WLAN devices and wired devices on the network, which is the server. The used access point is 3COM office Connect 11 Mbps Wireless Access Point, as shown in Figure 4.13.

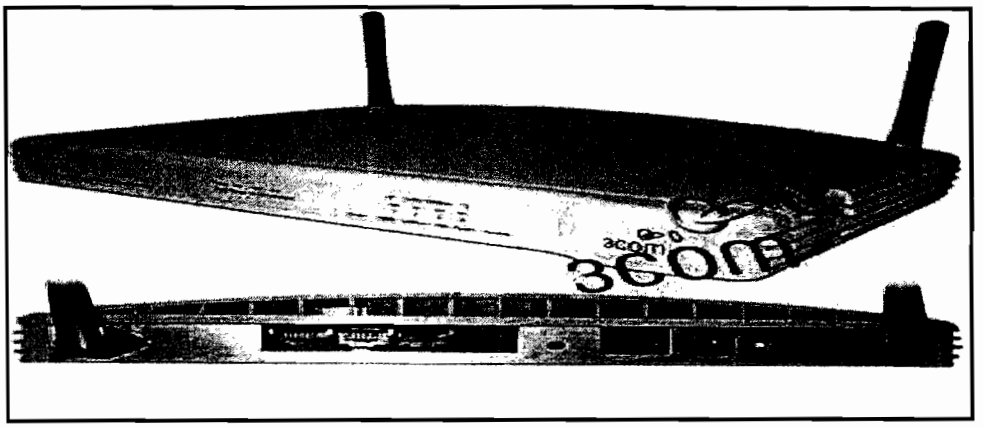


**Figure 4.13: 3COM office Connect 11 Mbps Wireless Access Point**

The user can access the Access Point system by using the attached tolls. The SSID will be TEH, which is stand for Tikrit Educational Hospital, Figure 4.13.

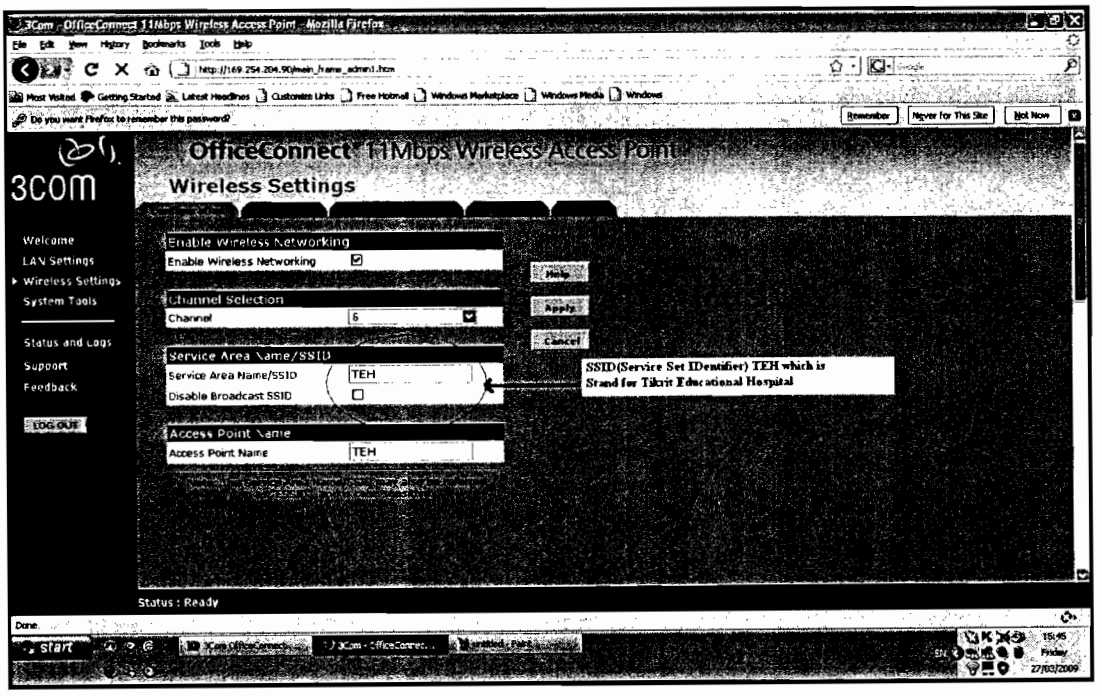


**Figure 4.14: 3COM AP configuration**

The dynamic host configuration in the LAN setting was enabled because Mikrotik will manage the operation of assigning IP to the clients.

### 4.4.3 Mobile Web-based system

#### 4.4.3.1 MySQL Server DBMS

After installing MySQL server system version v5.0 in the Web server. the administrator can access to the database by two ways, by command-line and Graphical User Interface (GUI) tolls. In this study a commercial GUI administration tool will be used, which is NAVICAT. Shown in Figure 4.14.

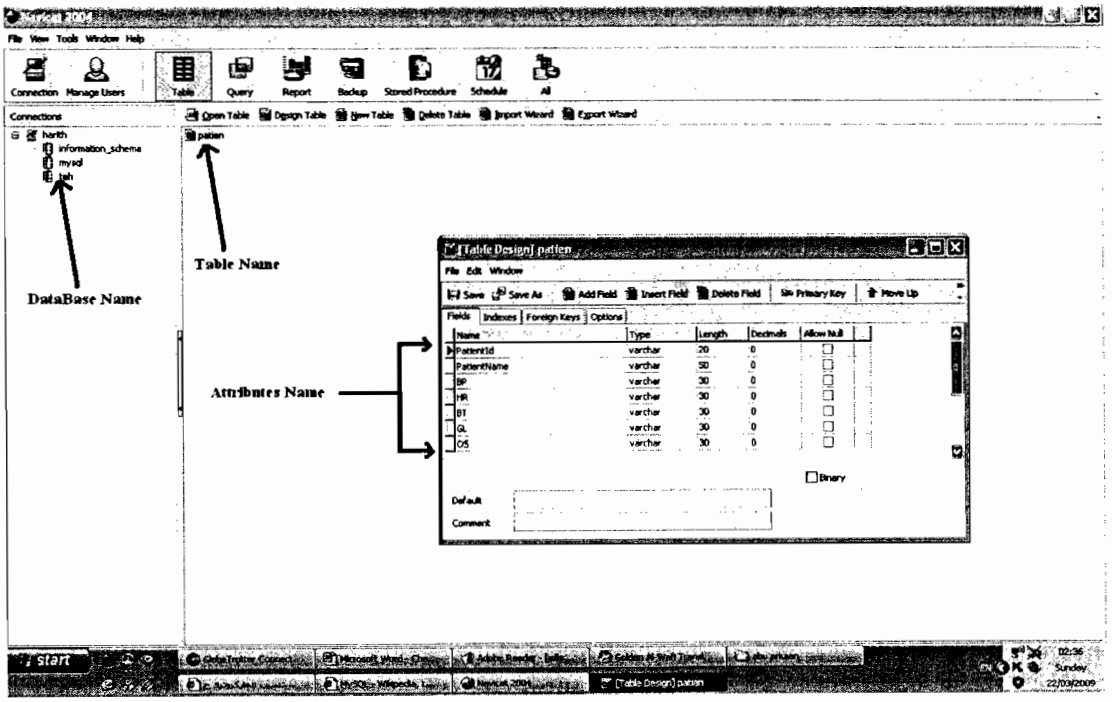


**Figure 4.15: MySQL GUI administration**

The first step is make a connection between NAVICAT and MySQL DBMS, a new database should be created. In this study the database name is (teh) which is stand for Tikrit Educational Hospital, its include one table 'patient'.

The patient table include seven attributes Patient id, Patient name, Blood Pressure (BP), Heart Rate (HR), Body Temperature (BT), Glucose Level (GL) and Oxygen Saturation (OS). All the attribute in the type Varchar and the primary key in this table is Patient ID.

#### 4.4.3.2 WML and JSP file using Tomcat Application Server

To develop the prototype, Wireless Markup Language (WML) and JSP will be used to perform the mobile web-based system. WML based on Extensible Markup Language (XML), the markup language which is intended for the devices that used the Wireless Application Protocol (WAP) specification such as mobile phones. WML document is known as a deck. Data in the deck structured into one or more cards (pages) – each of this card represents a single interaction with the user. In this study WML Card will be used to pass the variable (patient ID) to the JSP file (search.jsp). JSP file will is responsible for retrieving the data that related to the patient ID from the database and send it back to another WML cared to be view to the user. Java Server Pages (JSP) is part from Java technology which allows software developers to create dynamically-generated web sites with HTML-based, XML-based or other document types in response to a Web client request. The technology allows Java code and certain pre-defined actions to be embedded into static content. To emulate the web-base system Tomcat apache will be used. Tomcat is a servlet container founded by the Apache Software Foundation (ASF). Tomcat implements the Java Server Pages and Java Servlet specifications from Sun Microsystems. Tomcat provide a pure Java, HTTP and web server environment for Java code to run.

## 4.5 Browsing Scenario

After setting and connecting the pc-client to connect to (TEH) Wireless Access Point. The user can start the browsing by key-in TEH URL. The system main page will request the user to enter valid username and password as shown in Figure 4.12,. If the username and password are not valid, an error message will inform the user that the username and password are not valid.

After key-in the correct username and password the user will be able to access the patient vital data as shown in Figure 4.17. The page in Figure 4.16, ask the users to enter the patient ID, if the patient ID is not exist an error message inform the user that the Patient ID, is not exist. The system will navigate the user to the main page within three seconds.

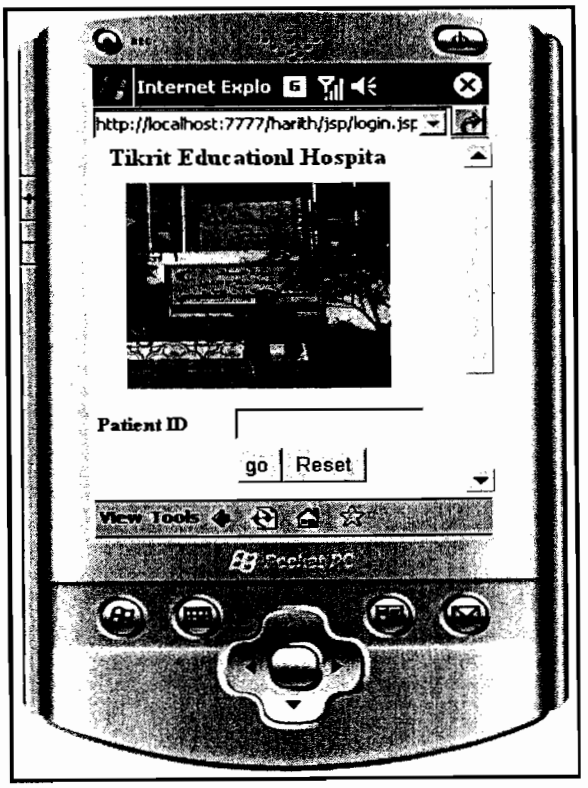


**Figure 4.16:Browsing patient vital data by his ID**

For example, let the patient ID is 1. Then, we check the patient id if it is valid or not. If its valid, the next page will include all the patient vital data and his name. Figure 4.17.

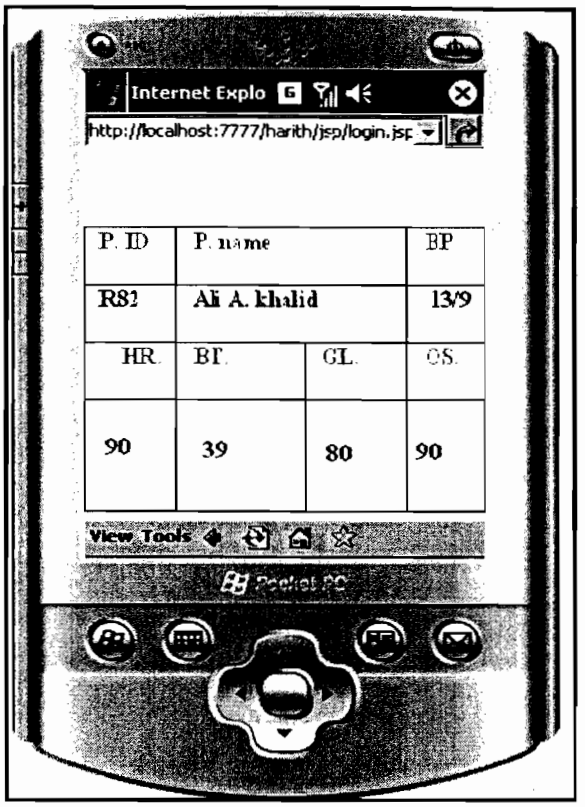


**Figure 4.17:Patient vital data**

The patient data include seven attributes are: Patient id, Patient name, Blood Pressure (BP), Heart Rate (HR), Body Temperature (BT), Glucose Level (GL) and Oxygen Saturation (OS).

## 4.6 Chapter Summary

This chapter clarifies the Software Engineering Methodology that is used in the prototype development process. The prototype-based methodology has been used in the prototype development. The chapter covers the software development life cycle phases, which include planning, requirement analysis, system design and system development. The system vital value and project timing schedule are the outcomes of the planning phase. Furthermore, the outcomes of the requirements analysis are the formulation of the system requirements that are used in the system design. UML notations are used to shown the system functionality and to list the requirements and specifications for each function. Finally, the chapter explains the system snap shoot and MikroTik Routing Operating System configurations.

# CHAPTER FIVE

# CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

## 5.0 Introduction

This chapter highlights the significant concerns and limitations in this study. The limitations are alienated to Graphical user interface as well as the way of saving or representing data. The Recommendations and Future works are elaborated to cover most of these limitations and concerns in this study. Finally, this chapter covers the conclusion of this study.

## 5.1 Limitations

The limitations can be divided into three parts.

### 5.1.1 Graphical User Interface Enhancement

The system interfaces need to some enhancement like using Mobile Flash Player (MFP). The interface should be enhanced to be more friendly, some picture should be used.

### 5.1.2 Data Migrations

The system works on the assumption that the data is migrated from SQL server, (DBMS for SaefBed DVM 2008) to MySQL server DBMS (our server). The data migration is not real that might be one of the limitations of this study. The data migrations can be applied in two ways. The first way: by connecting MySQL server

to (SaefBed DVM 2008) and use the migrations feature that is existed in that system. The second way: by using simulation software like Matlab.

### 5.1.3 Real-Time Monitoring

To gain the full usefulness of Remote Patient Monitoring system, it is preferred to be Real-time based monitoring. As it is mentioned in the in chapter three, the frequency of patients monitoring is manageable. That is to say, the monitoring could be in Real-time base for some patient who are in special emergence cases. Furthermore, the monitoring for other patients can be done within 5 or 10 seconds.

## 5.2 Recommendations and Future Work

The recommendations can be classified in two parts. The first one is migration the data automatically, that can be done by using simulation software. The second part by applying the concept of real monitoring.

### 5.2.1 Using SQL* loader and Matlab to immigrate the data

Database package in Matlab will be used to generate the data and save it in text file. After that, that data will be sent to the database by using one of Oracle tools (SQL*).

#### 5.2.1.1 Matlab to Simulate the Data

Matlab is a numerical computing environment and programming language. The software includes so many Packages, like math package, image processing package, signal processing package, neural network package and database package. we recommend to user database package to gain the simulation of data. The database

package will be used to expedite the process of data migration. The imported data will be converged by Matlab to text format (Text file), then textual data will be loaded to new Oracle database by using SQL* loader.

#### 5.2.1.2 SQL* Loader to Store the Data

According to Oracle, SQL* "loader is a bulk loader utility used for moving data from external files into the Oracle database". The main function of SQL* loader is to load and convert external textual data into Oracle database form.

### 5.2.2 Appling the Concept of Real-Time Monitoring

To apply the concept of real time monitoring , Java Bean passing functions should be used. That function well be sensitive to any change in the data in the database. It will send the change in data exactly at the same time of changing. By doing that both of the concepts, Real-time monitoring and data migrations will be applied.

## 5.3 Conclusion

There is an extensive attention and interest of using internet and mobile technologies in patient monitoring field under various environments using wireless LAN to perform data transferring in and out of the hospital. This study presents the principle requirements to develop the exist patient monitoring system in Tikrit Educational Hospital under the coverage of WLAN and gives access to the medical staff to monitor the patient who are in emergence cases. The processed data monitored by the staff in the MMC room. By using this system, all the information can be access when transferred outside the hospital via LAN and WLAN interface technology.

In order to make the data accessible through the internet, the server works as a gateway between the hospital and the internet. The system is assumed to simulate the data and to make a web base system. The web base system developed by using Java technology (JSP) and Wireless Markup Language (WML) to perform mobile platform. Since the RPMS information are transmitted in the internet, then the privacy of the transmitted data should be kept and protected. Because of that we used another server that is the MikroTik Routing Operating System. The intended server controls and manages the administration and security access to the system.

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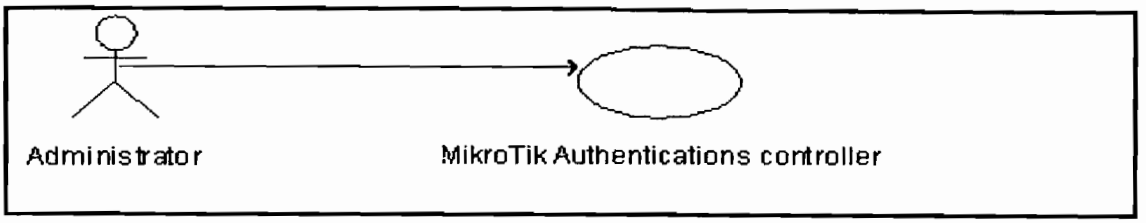
# APPENDIX A

## Use Case Specification

# APPENDIX A USE CASE SPECIFICATIONS

# 1- USE CASE : MIKROTIK AUTHENTICATION CONTROLLER (VMS_01)




## 1.1 BRIEF DESCRIPTION

This use case is initiated by the System Administrator. This use case will enable the administrator to create new account to the hospital staff who want entering RPMS. Furthermore, it will enable the system to prevent unauthorized access to the system, It will work as firewall between hospital intranet and public network (internet).

## 1.2 PRE-CONDITIONS

The administrator should have correct username and password that connecting him to MikroTik management Server. The administrator should have WinBox, which is the connection software.

## 1.3 CHARACTERISTIC OF ACTIVATION

Event Driven (on staff request to the administrator)

## 1.4 FLOW OF EVENTS

### 1.4.1 Basic Flow (VMS_01_01)

- This use case begins when the administrator inter MikroTik local IP address on Winbox.
- The system shall display MikroTik GUI.
- The administrator will select user profile management to create new user account.
- The administrator will update the user profile. **(E-1:change password).**
- The administrator shall cancel the new account creations. **(E-2: Cancellation).**
- The administrator can monitor users activities **(E-3: Freeze account).**

### 1.4.2 Alternative Flow

Not Applicable.

### 1.4.3 Exceptional Flow

**E-1: Change password.(VMS_01_02)**
The administrator may want to change the user name or password only due to unknown threats.
**E-2: Cancellation. (VMS_01_03)**
The administrator may want to cancel new account creation process.

**E-3: Freeze account. (VMS_01_04)**
The administrator may discover that the user PC is infected, it should freeze that account.

## 1.5 POST-CONDITIONS

- The administrator managed by MikroTik local IP address.

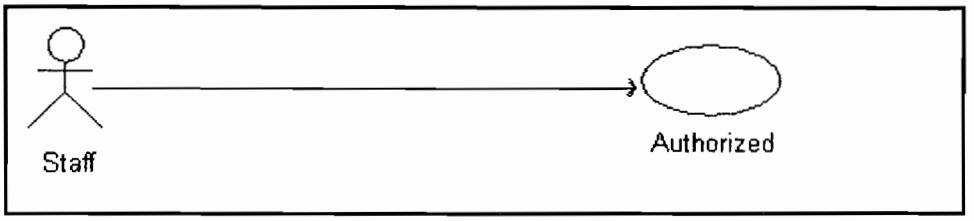
## 1.6 RULE(S)

Not applicable.

## 1.7 CONSTRAINT(S)

MikroTik routing system accept only 10 administrators with full authentications. Furthermore, each user should have only one username and password.

# 2- USE CASE : AUTHORIZED (VMS_02)




## 2.1 BRIEF DESCRIPTION

This use case is initiated by the hospital Staff (System users). The use should have a valid user name and password assigned by system administrator. This use case will enable the use to inter to Tikrit Remote Patient Monitoring System.

## 2.2 PRE-CONDITIONS

The use should have a valid username and password to use the system.

## 2.3 CHARACTERISTIC OF ACTIVATION

Event Driven (on user request to the system)

## 2.4 FLOW OF EVENTS

### 2.4.1 Basic Flow (VMS_02_01)

- This use case begins when the user request Tikrit RPMS URL.
- The system shall display login page.
- The user should enter username and password, then he have to press login.
- The user will enter to Tikrit RPMS if there is no (E1- username and password are not correct).
- The user can cancel the login process (E2-Cancle login).

### 2.4.2 Alternative Flow

Not Applicable.

### 2.4.3 Exceptional Flow

**E-1: Username and password not valid.(VMS_02_02)**
The username and password are not correct, the user have to contact the administrator.
**E-2: Cancellation. (VMS_02_03)**
The user can cancel the login process.

## 2.5 POST-CONDITIONS

- The administrator managed by MikroTik local IP address.

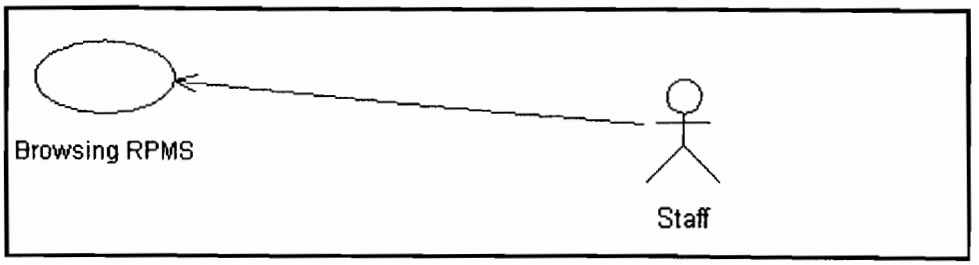
## 2.6 RULE(S)

Not applicable.

## 2.7 ONSTRAINT(S)

Each user should have only one username and password to enter the system.

# 3- Use CASE : Browsing RPMS (VMS_03)




## 3.1 BRIEF DESCRIPTION

This use case is initiated by the hospital Staff (Systems users). It will enable the user to monitor the patient vital data.

## 3.2 PRE-CONDITIONS

The user should have a valid username and password, assigned by the system administrator.

## 3.3 CHARACTERISTIC OF ACTIVATION

Event Driven (on staff request to the system)

## 3.4 FLOW OF EVENTS

### 3.4.1 Basic Flow (VMS_03_01)

- This use case begins when the user enter the patient Id.
- The user can see the patient vital data if there is no **(E-1:patient Id is not exist).**
- If there is (E1), the system will inform the user that patient Id is not valid, then it will let the user back to the main page with in 3 second **(E-2: Back to the main page).**
- The user can reset Patient ID search field.

### 3.4.2 Alternative Flow

Not Applicable.

### 3.4.3 Exceptional Flow

**E-1: Patient ID not valid.(VMS_03_02)**

The patient ID is not valid or its not listed in the patient database.

**E-2: Back to the main page. (VMS_03_03)**

If the patient ID not exist, the system will let the user back to the main page with in three seconds.

## 3.5 POST-CONDITIONS

- The user should write correct Patient ID.

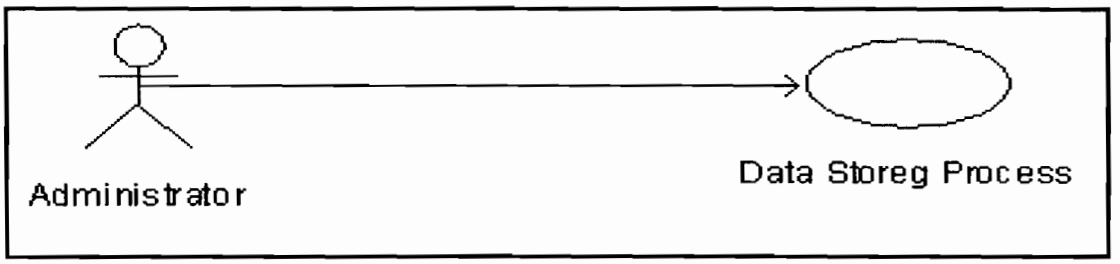
## 3.6 RULE(S)

Not applicable.

## 3.7 CONSTRAINT(S)

The user should be able to remember the patient ID, else he have to try enter it so many times.

# 4- Use CASE : Data storage process (VMS_04)




## 4.1 BRIEF DESCRIPTION

This use case is initiated by immigration the data from the existing systems server (SQL) to our server (MySQL). (Study assumptions).

## 4.2 PRE-CONDITIONS

The data is already stored in the database.

## 4.3 CHARACTERISTIC OF ACTIVATION

Event Driven (by immigrating the data from SQL server to MySql server).

## 4.4 FLOW OF EVENTS

### 4.4.1 Basic Flow (VMS_04_01)

- This user case begins when the data immigrated to Mysql server, But in our system, the data is entered manually by the system administrator.
- The data type of each data should be justified.

## 4.5 POST-CONDITIONS

- The data are reliable.

## 4.6 RULE(S)

Not applicable.

## 4.7 CONSTRAINT(S)

The is immigrated virtually, in this study, the data is entered manually.

# APPENDIX B

## Tikrit Educational Hospital interview

# APPENDIX B: Tikrit Educational Hospital Staff Interview

**First Interview:**

The first interview was to address the existing system functionality and scalability. It conduct with IT manager, Mr. Khaldon A. Al-Rays.

1- How is the data acquired from the patients?

2- How many patients can be monitored in the same time?

3- What is the frequency of data acquiring?

4- Can you monitor the patients on Real-Time based?

5- What is the data that can be acquired from the patients?

**Second Interview:**

The second interview conducted with some of TEH staff who are using the PMS. Dr. Abdulla A. Hussein, Dr. Rsheed Osman and Mr. ALI Kamil. The questions asked are listed below.

1- To what extent are you familiar with internet technology?

2- Are you able to use Wireless LAN technology?

3- Do you think that the use of WLAN is easy?

4- What are the problems expected in the RPMS?

5- What are the worries that you expect concerning the use of RPMS?

6- What is the limitations that you expect in using the RPMS?

7- What is the most important patients data that the staff should monitor?

8- What is the benefits that you expect from the use of RPMS?