CHAPTER 1

INTRODUCTION

1.1 PATIENT MONITORING SYSTEM

Patient Monitoring systems are the most important diagnostic systems in the critical care units (CCUs) of hospitals, providing continuous display and interpretation of the patient’s vital functions. The patient monitoring system utilizes telecommunication technology for medical diagnosis, treatment and patient care. It can be divided into two modes of operations: the real-time mode, in which patient data are available at the remote terminal immediately after acquisition, and the store-and-forward mode, which involves accessing the data at a later time. Patient monitoring systems in the past dealt mainly with various measurement techniques and low level signal processing algorithms (Himmelstein and Scheiner 1952). However, the quality of such real-time systems is determined by many other factors, too. They are: applied software technology, communication technology, data representation methods, high level signal processing algorithms and the automation of signal representation for helping human diagnosis.

There are at least four categories of patients who need continuous monitoring:

1. Patients at high risk of developing a life-threatening condition; for example, patients immediately after open-heart surgery, or a premature infant whose heart and lungs are not fully developed.
2. Patients with unstable physiological regulatory systems; for example, a patient whose respiratory system is suppressed by a drug overdose or anesthesia.

3. Patients with a suspected life-threatening condition; for example, a patient who has findings indicating an acute myocardial infarction (heart attack).

4. Patients in a critical physiological state; for example, patients with multiple trauma or septic shock.

A patient monitoring system usually consists of many bedside monitors and a central station (Varady et al 2002; Edwards and Donald 2004; Healy et al 1977). Bedside monitors measure and process different kinds of physiological signals such as ECG, blood pressure, body temperature etc. for the continuous surveillance of patient status (Van Der Kouwe and Burgess 2003). The Central station provides a centralized monitoring of many patients utilizing various computer networking technologies (Zatari 2005). Patient monitoring systems are installed in a certain location like the ICU (intensive care unit) or CCU (coronary care unit). Therefore, for a physician to access patient data, he or she must be in a place where the system is running. Lately, clinical workstations that are connected to the computer network of a patient monitoring system are being used for the review of patient data in a place other than the ICU or CCU.

Patient monitoring is a major part of many healthcare services. It can reduce the number of unnecessary hospitalizations, while increasing the access to healthcare for those who really need these services (Rasid and Woodward 2005; Gallego et al 2005). A patient monitoring system is used to collect health data at home and, in some cases, in outdoor scenarios, facilitate disease management, diagnosis, prediction and follow-up. Recent advances in the development of smaller and more precise sensors, which do not require
gels, have made it possible to apply a wide range of wireless remote patient monitoring systems in natural environments (Talbot et al 2007).

1.2 REMOTE PATIENT MONITORING SYSTEM

Remote physiological monitoring (Remote Patient Monitoring) is a form of telemedicine that uses computerized technology to track patients’ vital signs and health status without face-to-face contact (Choi et al 2003; Virone et al 2002). Physiological parameters, such as heart rate, body temperature, blood pressure, Electrocardiogram, oxygen saturation and/or glucose levels, are measured (Hernandez et al 2001). The data are then transmitted to physicians. The physicians conduct further analysis using intelligence tools and follow-up with patients as needed (William Hanson and Marshall 2001; Becker et al 1994; Puers and Sansen 1989). By monitoring patients’ parameters remotely, the remote patient monitoring system allows physicians to intervene before an emergency room utilization or hospitalization, preempting unnecessary costs (Mora et al 1993; Bao et al 2005; Warner and Adrian 2007). The remote patient monitoring system has the potential to serve both patients and physicians; allowing patients to stay in their homes and enabling physicians and nurses to use their time and resources more efficiently and effectively (Shin et al 2000). The typical remote patient monitoring system is shown in Figure 1.1.

![Figure 1.1 Remote Patient Monitoring System](image-url)
A remote patient monitoring system varies in terms of the clinical conditions being monitored, the frequency with which physiological variables are monitored, the data collection technique and whether data are monitored on a ‘real-time’ or periodic basis (Wu Shuicai et al 2007). The remote patient monitoring system enables a physician or specialist at one site to deliver health care, diagnose patients, give intra-operative assistance, provide therapy, or consult another physician or paramedical personnel at a remote site (Qingshan Shan and David Brown 2004; Seung-Hun Park et al 1998). The remote patient monitoring system consists of customized medical software integrated with computer hardware, along with medical diagnostic instruments at each location. These techniques promise to greatly improve the cost and convenience associated with long-term outpatient monitoring, and could potentially extend monitoring to the broader healthy population for preventive diagnostics and alerts (Manwaring et al 2001; Wang and Istepanian 2003). The remote patient monitoring system also enables medical physicians to watch their patients’ real time health status from a remote site, and to give them some advice for first-aid treatments through the Internet (Bielli et al 2004; Hung and Yuan-Ting Zhang 2003; Jaesoon Choi et al 2005).

The traditional way of providing telemedicine services is to transmit biomedical signals from a patient to a hospital using “landlines,” such as the public switched telephony network and the integrated services digital network (Yuan-Hsiang Lin et al 2004; Sapal Tachakra et al 2003). Most current telemedicine applications are limited to communications between fixed locations, often with conventional handsets (De Azevedo et al 2003; Oliver and Flores-Mangas 2006). The adoption of mobile technology has led to new m-health applications in health-care provision. Although face-to-face consultations between a clinician and a patient will never be replaced, there are medical cases that can be managed more efficiently by adopting

1.2.1 Applications of Remote Patient Monitoring System

The following are the significant applications of Remote patient monitoring system (Golmie et al 2004):

1. **Home Health Care:** In the home health arena, a remote patient monitoring system can be used (1) as a substitute for home care visits, (2) as a means of maximizing limited nursing resources and (3) as a strategy for better managing high risk, high cost patients, such as those with congestive heart failure.

2. **Disease Management:** As part of a disease management program, the remote patient monitoring system has the potential to help limit patient costs by (1) equipping caregivers with the information they need to detect health management problems at the earliest possible stage, and (2) providing patients with the feedback needed for informed self-management.

3. **Hospitals:** In addition to the two applications mentioned above, pilot studies suggest that a remote patient monitoring system can be used to provide continuous intensive care unit (ICU) patient management. Also, hospitals may use the remote patient monitoring system to automate the process of measuring vital signals.
1.3 WIRELESS SENSOR NETWORKS

In recent years, wireless communications and electronics have encountered many breakthroughs. Advances in digital signal processing, miniaturization of electronic circuitry, low-cost and low-power sensors have prompted the emergence of wireless sensor networks (Akyildiz et al 2001). A wireless sensor network (WSN) is a collection of wireless sensors (called motes) that form a certain network topology (Chee-Yee Chong and Kumar 2003). Sensor nodes are densely deployed inside the phenomenon (or very close to it) we want to analyze. They consist of base stations and a number of wireless sensors. Each sensor has the capacity to collect data and route it to the sink and the end user. Data are routed back by a multihop infrastructure to the base station that can communicate with the central server for storage and for further analysis, as shown in Figure 1.2.

Wireless Sensor Networks are designed to perform a set of high-level information processing tasks such as detection, tracking and classification. Measures of performance for these tasks are well defined, including detection of false alarms or misses, classification of errors, and tracking quality. Wireless sensor networks are widely used for industrial, military and environmental measurements and monitoring purposes (Archana Bharathidasan and Vijay Sai Ponduru 2000). Wireless sensor networks remain very reliable even under extreme conditions because they use distributed routing algorithms and they have multiple routing paths and self-healing capability (Hadim and Mohamed 2006).
Figure 1.2 Wireless Sensor Node Scattered in Sensor Field

1.3.1 Advantages and disadvantages of WSNs

Wireless sensor networks play an important role in everyday life, and in industrial and military applications. It is a rapidly growing area since new technologies are emerging and new applications are developed. Some advantages of wireless sensor networks are:

1. **Self-configuration and self-maintenance**

   Network nodes are usually programmed to have ad hoc capability that gives them the ability to detect the presence of neighboring nodes and organize themselves into a structured network. They are also able to detect and recover from faults occurring in the network or in the communication link without any human intervention.
2. **Low running cost**

Human intervention to maintain the wireless sensor networks is minimum; thus the administration and maintenance costs are significantly reduced.

3. **Miniature size**

Transceivers and sensors are usually integrated onto the same board and referred to as mote. A mote means a small particle but technically it is a small device that can sense and transmit information. Due to their small size, motes can be deployed in confined and inhospitable environments.

Wireless Sensor Networks (WSN) can be deployed where the measurement of environment parameters is dangerous or difficult to access. For example, applications such as sensing a building integrity or structural vibrations during an earthquake, the stress of an airplane’s wings, are some of the applications where WSN promise to change how researchers gather their data.

A Wireless Sensor Network is composed of various sensor modules attached to radio modules (motes). They can be deployed in areas where the parameters of interest need to be measured. Their computational capability is limited, so the data is transmitted at low speeds; few bytes per hour at most (Estrin et al 2001). Motes transmit the data from mote to mote in an adhoc way back to a base station where the data is stored, processed and displayed. The radio motes require minimal attention if they are setup in appropriate locations and with the appropriate housings which protect the electronic components. Their power source, a pair of AA batteries, lasts an average of one year, assuming transmission is not constant. The versatility with which
WSN can be applied to any system(s) and their flexibility require extensive research and development (Puccinelli and Haenggi 2005).

1.3.2 WSN and traditional ad-hoc networks

Wireless sensor networks and traditional wireless ad hoc networks are similar if we consider that communication occurs in a shared wireless medium and there is a lack of networking infrastructure (Lewis 2004). However, communication protocols and algorithms proposed for traditional wireless ad hoc networks may not be adequate to address the sensor network paradigm. In fact, sensor networks are deployed to achieve a specific application objective, via a collaborative effort of numerous sensor nodes; furthermore sensor nodes have much tighter energy-constraints, and hence, limited processing capabilities (Polajnar et al 2005).

The major differences between sensor networks and ad hoc networks are given below:

1. Sensor networks are deployed with a specific sensing application in mind, whereas ad-hoc networks are mostly constructed for communication purposes
2. Sensor nodes are densely deployed
3. The number of sensor nodes in a sensor network can be several orders of magnitude higher than the nodes in an ad-hoc network.
4. Sensor nodes are prone to failures
5. Sensor nodes are limited in power, computational capacities and memory
1.3.3 Applications of Wireless Sensor Networks

Wireless Sensor Networks are an active field of research and they can be used in many different areas, such as habitat, environmental, military, healthcare, home and commercial applications (Akyildiz et al 2002; Culler et al 2004).

i. Habitat monitoring applications

In monitoring scenarios sensors observe local phenomena and report these observations to some external user. Researchers are becoming increasingly concerned about the potential impact of human presence in monitoring plants and animals in field conditions. Sensors can be deployed prior to the onset of the breeding season or other sensitive periods (in the case of animals) or while plants are dormant or the ground is frozen (in the case of botanical studies). Sensors can be deployed on small islands where it would be unsafe or unwise to repeatedly attempt field studies. These nodes monitor the microclimates in and around nesting burrows (Alan Mainwaring et al 2002).

ii. Tracking applications

In a tracking scenario, sensors are placed over some space coordinate to track one or more moving objects in their midst. So the goal is to track the object as accurately as possible. Current inventory control systems attempt to track objects by recording the last checkpoint that an object passed through. However, with these systems, it is not possible to determine the current location of an object. The system breaks down when objects do not flow from checkpoint to checkpoint. With wireless sensor networks, objects can be tracked by simply tagging them with a small sensor node. The sensor
node will be tracked as it moves through a field of sensor nodes that are deployed in the environment at known locations. Instead of sensing environmental data, these nodes will be deployed to sense the RF messages of the nodes attached to various objects. The nodes can be used as active tags that announce the presence of a device. With this system, it becomes possible to ask where an object is currently, instead of simply asking where it was last scanned.

iii. **Military applications**

Wireless sensor networks can be an integral part of military command, control, communications, computing, intelligence, surveillance, reconnaissance and targeting systems. The rapid deployment, self-organization and fault tolerance characteristics of sensor networks make them a very promising sensing technique for the military. Since sensor networks are based on the dense deployment of disposable and low-cost sensor nodes, the destruction of some nodes by hostile actions does not affect a military operation as much as the destruction of a traditional sensor, which makes sensor networks a better concept for battlefields. Some of the military applications of sensor networks are monitoring friendly forces, equipment and ammunition; battlefield surveillance; reconnaissance of opposing forces and terrain; targeting; battle damage assessment; and nuclear, biological and chemical attack detection and reconnaissance.

iv. **Health applications**

Some of the health applications of sensor networks are, providing interfaces for the disabled; integrated patient monitoring; drug administration in hospitals; monitoring the movements and internal processes of insects or other small animals; telemonitoring of human physiological data; and tracking

v. **Home applications**

Sensors can be used for home automation fixed in appliances such as vacuum cleaners, micro-wave ovens, refrigerators and VCRs. In other words, sensors are put in domestic devices; they interact with each other and communicate with external networks via the Internet or Satellite.

vi. **Commercial applications**

Commercial applications include monitoring material fatigue; managing inventory, monitoring product quality, robot control and guidance in automatic manufacturing environments, interactive toys, factory process control and automation, smart structures with sensor nodes embedded inside, machine diagnosis, transportation, factory instrumentation, local control of actuators, vehicle tracking and detection and weather station monitoring (Negoslav Daja et al 2001; Martinez et al 2005). Some other examples of this kind of applications are: environmental control in office buildings, interactive museums, detecting and monitoring car thefts, and managing inventory control (Arms et al 2004).

1.3.4 **Wireless Sensor Networks For Patient Monitoring**

Recent technological advances in sensors, low-power integrated circuits, and wireless communications have enabled the design of low-cost, miniature, lightweight wireless sensor nodes. Wireless Sensor Networks research is originally motivated by military applications such as battlefield
surveillance. As the field slowly matured and technology rapidly advanced, it has found itself merging into many of the civilian applications as well, such as environment and habitat monitoring, home automation, traffic control, and more recently healthcare applications (Krco 2003).

Wireless Sensor Networks promise to revolutionize healthcare by allowing inexpensive, non-invasive, continuous monitoring with almost real-time updates of medical records (Lamprinos at al 2001). These nodes are capable of sensing, processing, and communicating one or more vital signs into wireless personal or body networks for health monitoring (Benny et al 2005; Taylor and Sharif 2006; Jovanov et al 2006; Keoh et al 2007). This technology helps in giving physicians, emergency department personnel and caregivers, real-time access to accurate patient data, clinical histories, treatments, medications, tests, lab results, etc. Wireless Sensor Networks, unlike wired monitoring systems, can be used for long-term, continuous monitoring and real-time analysis, even when people are involved in their normal activities (Baker et al 2007). In addition, higher level medical tasks can be carried out because of the coordination of networked nodes.

Wireless sensors are used to monitor the status of patients, logging information about the patients’ whereabouts and normal duties. With the logged information the central server monitors their health status while they live normally in their own place. Once it detects an abnormal situation, the central server alerts their family or medical personnel immediately (Ryan Burchfield and Venkatesan 2007).

Most of the patients monitoring systems are wired systems that are linked to a central monitoring system. Since these systems are hard-wired, they are non-portable and the cost of upgrading or adding devices to the system is significantly high. Hence, there is a need for a portable, low-cost
and reliable system for monitoring and data logging (Wenfeng Li and Onching Yue 2005). This system also needs to accommodate new devices with the least configurations required. Unlike most existing systems, the wireless sensor network will provide more flexibility at an affordable cost.

This thesis outlines the development and implementation of a wireless sensor network-based remote patient monitoring system which is used for monitoring the patient in a hospital, at home and in ambulatory environments.

1.4 CONTRIBUTIONS OF THE THESIS

This thesis evaluated the suitability of a wireless sensor networks for i) remote monitoring of post-operative patients in a hospital ii) remote monitoring of elderly patients at home and iii) remote monitoring of patients affected by COPD and PD in ambulatory environments. Wireless sensor networks are found to be a single technology in a complete scenario for monitoring multiple patients. The system implemented is a real-time patient monitoring system, which enables physicians to watch their patients’ health conditions from a remote site, and to give them some advice for first-aid treatments.

1. Remote Monitoring of Post-Operative Patients using Wireless Sensor Networks

Patients recovering from surgery are at risk of complications due to mobility as a result of post-operative pain. WSN can monitor post-operative patients' physiological signals (Heart rate, Body temperature, ECG, and blood pressure) through an individual node that is carried by the patients. It then alerts the healthcare professionals to abnormal changes in the patient's
physiological condition while delivering the data to the patient’s database system for long term analysis and prediction. This thesis explains in detail, the implementation of architecture for monitoring post-operative patients using wireless sensor networks. In this thesis, the following novel techniques are embedded into the architecture for monitoring post-operative patients in a hospital to facilitate communication among patients, medical professionals at local hospitals and specialists available for consultation from distant places.

1. Designed and tested the wireless sensor network architecture for remote monitoring of post-operative Patients in hospitals.

2. The system was designed to provide access to long term physiological data through the web server by healthcare professionals and patients with an authorized ID and password.

3. The system was also designed to automatically generate the alert through mail and short message services to medical specialists in a hospital and caretakers nearby, when any anomaly is detected.

2. Remote monitoring of elderly patients at home using Wireless Sensor Networks

With the increasing number of elders relying on home care, better monitoring and analysis systems are crucial for maintaining and improving the quality of life of the elderly patients. Growing medical expenditure is a serious problem as the population ages, and early treatment should decrease medical expenditure. To provide timely treatment, early signs of disease must be detected before subjective symptoms appear, and thus health monitoring at home can be a possible method. In homecare, the WSN collects data
according to a physician's specifications, removing some of the cognitive burden from the patient (who may suffer age-related memory decline) and provides a continuous record to assist diagnosis. In this thesis, the following advantages have been added into the architecture for monitoring elderly patients at home to improve patient care without affecting their daily activities.

1. Designed and tested the wireless sensor network architecture for elderly patient monitoring in home environments.

2. Implemented In-Network data aggregation technique using OMNET++ (Castalia).

3. Implemented the fall detection algorithm based on acceleration and orientation.

4. Designed Software interface for generating alerts over e-mail and Short Message Service (SMS) to emergency departments, medical specialists and caretakers nearby when any anomaly is detected.

3. Monitoring of Patients Affected By Chronic Obstructive Pulmonary Disease (COPD) And Parkinson’s Disease (PD) in Ambulatory environment Using Wireless Sensor Networks

Today, a lot of attention is given to the development of wearable ambulatory systems to monitor the physiopathological parameters of individuals during their daily activities (Rajiv Ranjan Singh and Rahul Banerjee 2005). The number of patients with Chronic Obstructive Pulmonary Disease (COPD) and Parkinson’s disease (PD) has continued to increase as cigarette smoking and environmental toxins, the primary cause of these disorders, remains common, despite aggressive public health initiatives to reduce tobacco and toxin consumption. It is thus anticipated that COPD and PD will remain a major public health problems. Physical exercise is a crucial
component of the medical treatment of COPD and PD to prevent
deconditioning, to improve the patient’s Health Related Quality of Life
(HRQL), and to optimize the response to potential surgical interventions.
Long-term health monitoring of patients with COPD and PD can capture the
diurnal and circadian variations in physiological signals during their
rehabilitation period. In this thesis, the following techniques have been added
into the architecture for monitoring ambulatory patients who are affected by
COPD, patients with PD during their rehabilitation period.

1. Designed a smart ground for remote monitoring of Patients
affected by Chronic Obstructive Pulmonary Disease (COPD)
and Parkinson’s disease (PD) in ambulatory environments.

2. The smart ground has been designed in such a way that
physicians can monitor a group of patients’ physiological
parameters during their exercise training during their
rehabilitation period.

3. The simple data compression algorithm is implemented at
the node level to transit the acquired data to the central
server in an energy efficient manner.

4. The algorithm is developed for analyzing ECG signals for
detecting similar sequential patterns from a set of time series
data.

4. **Sensor Grid Architecture for Monitoring Different Groups of
   Patients’ Health Status**

   Wireless Sensor Network (WSN) is finding an important role in
patient monitoring in diverse environments including remote monitoring of
post-operative patients in a hospital, monitoring of elderly patients at home
and during the rehabilitation period of patients affected by COPD and PD in an ambulatory environment. The emerging domain of wireless sensor network with grid extends the grid computing paradigm to the sharing of sensor resources in Wireless Sensor Networks. The ultimate goal of our system is to increase the availability of medical care in order to reduce the demands on hospital services and to improve the long-term care and recovery of patients. Our architecture framework is a hybrid architecture that combines Wireless Sensor Networks and Grid-enabled software tools that support the storage, processing and information-sharing tasks. The Alchemi toolkit is chosen to implement Grid middleware functions. Condor is used for job queuing, job scheduling and providing high throughput computing. In this thesis, the following techniques have been added to the sensor grid architecture for monitoring different groups of patients’ health status which reduces the time of routine check-ups; its real time monitoring also allows emergency situations to be handled immediately.

1. Designed and tested the sensor grid architecture for remote monitoring of post-operative patients at hospitals, monitoring of elderly patients at home and during the rehabilitation period of patients affected by COPD and PD in an ambulatory environment. This provides a platform for physicians and researchers to share information with distributed database and computational resources to facilitate analysis, diagnosis and alert, when a life-threatening event occurs.

2. The developed sensor grid provides a platform for clinicians and researchers within the Consortium to share information in distributed bioprofile databases and computational resources to facilitate storage, analysis and alert the physicians, emergency departments and caretakers through e-mail and SMS services for further follow-up of the patients.
1.5 ORGANIZATION OF THE THESIS

The thesis is organized in seven chapters.

Chapter 1, “Introduction”, provides the required introductory concepts of patient monitoring systems and remote patient monitoring systems. The drawbacks of current patient monitoring techniques were discussed in detail. This chapter concludes with the outline and applications of wireless sensor networks and its suitability for remote patient monitoring in all diverse environments.

Chapter 2, “Literature Survey”, describes the technical background and review of the existing technologies for remote patient monitoring systems in hospitals, home settings and in ambulatory environment. It then focuses in detail, on Wireless Sensor Networks and their applications. It reviews the application of a wireless sensor grid in patient monitoring systems. It also discusses the motivation and objectives of the thesis.

Chapter 3, “Remote Monitoring of Post-Operative Patients Using Wireless Sensor Networks”, presents the need for monitoring patients recovering from surgery for post-operative pain, and how wireless sensor networks is used in monitoring important physiological signals of post-operative patients in a hospital environment. The architecture for monitoring post-operative patients in a hospital environment is presented. This Chapter describes all the hardware for the implementation of the architecture. The main characteristics of the elements in the architecture i.e., Front-End Module, Patient Station and Server, are discussed in detail. This chapter explains how the physiological signal is transferred from the respective sensors to the central server through the base station for storage and analysis. It also demonstrates the ability to connect two disparate systems, that is, the patient
record database and the web portal, through the use of well-defined web services and make real-time patient information accessible to users through internet browsers. It also explains how a web-based information portal allows different types of users i.e., Emergency department personnel, doctors, and medical specialists to access patient information in real time. This chapter explains in detail the effectiveness of generating alerts through E-mail and short message service (SMS) when any abnormal event occurs. The field test results recommend that the system implemented has great potential in improving the solutions to the problems in today's emergency response system, especially patients recovering from surgery. This chapter demonstrated the concept of `care at the point of need' in cooperative environments to provide the continuity of patient care through the simple web and ensure the privacy and confidentiality of the patients. The most valued features of this system are to prevent the patient from re-hospitalization and avoid possible critical events, thus reducing global healthcare costs.

Chapter 4, “Elderly Patient Monitoring System Using Wireless Sensor Networks in Home Environment”, presents in detail, the demography of elderly patients in the western world and the shortage of caretakers for elderly people and how wireless sensor networks helps in monitoring the elderly patients’ physiological signals as well as activities at home without disturbing their daily routine. The architectural design for monitoring elderly patients was discussed in detail. The principle of design and methodology for monitoring elderly patients has been discussed in detail. This chapter explains how the physiological and activity signals of the elderly patient’s are transferred to the central server through the base station for storage and analysis. Chapter 4 explains in detail the implementation of In-Network Data Aggregation using OMNET++ (Castalia) at the sensor node for making decisions as to whether the information should be stored for future use or relayed as it is or modified by applying computation. It also describes the
algorithms for detecting abnormalities in both physiological signals and activity monitoring for identifying a fall of elderly patients from the accelerator output during their daily routine activities. This chapter describes the use of web services for publishing the real time data of elderly patients to a community of authorized users i.e., emergency department personnel, caretakers, and physicians. The field test results recommend wireless sensor network technologies for monitoring the healthcare of the increasing number of elderly population especially those in homes. The demonstrated technology will enable us to improve the quality of life through continuous monitoring of those needing ‘Assisted Living and Residential Monitoring Network’.

Chapter 5, “Ambulatory Monitoring of Free Living Patients Affected by COPD and PD Using Wireless Sensor Networks”, presents the importance of ambulatory investigations in real situations of daily activities and how wireless sensor network technologies have been used for monitoring the patients affected by COPD and PD in ambulatory environment. This chapter explains in detail, the targeted exercise plan for patients affected by COPD and PD. The “smart ground” architecture with wireless sensor nodes deployed all over the ground for monitoring patients affected by COPD and PD during their rehabilitation period has been elaborately discussed. It describes the time series analysis method to determine whether a stream of real time sensor data of the patients contains any anomalies. The field test result recommends the use of wireless sensor networks which has the potential to provide a better and less expensive alternative for rehabilitation healthcare and may benefit COPD and PD patients, physicians, and society at large through continuous monitoring in the ambulatory setting, early detection of abnormal conditions, supervised rehabilitation, and potential knowledge discovery through data-mining of all gathered information. This chapter also demonstrates the monitoring capabilities of our system, which has a positive impact on time saving, and its cost effectiveness by preventing the patients
from re-hospitalization, and monitoring multiple patients’ health status simultaneously.

Chapter 6, “Sensor Grid Applications in Patient Monitoring”, presents wireless sensor grid architecture for monitoring different groups of patients’ health status to provide a platform for physicians and researchers to share information with a distributed database and computational resources to facilitate analysis, and diagnosis. The design of the sensor grid architecture for monitoring of post-operative patients in a hospital environment, elderly patient monitoring system in a home environment and monitoring of patients affected by COPD and PD during their rehabilitation period in an ambulatory environment is discussed in detail. This chapter provides a grid-enabled network that facilitates secure and seamless sharing of different groups of patients’ physiological information and supports the acquisition and analysis of patients to combat major diseases on an individual basis. It also explains how our architecture combines the wireless sensor networks and grid-enabled software tools to support the storage, and processing of shared information. It also shows how a sensor grid allows physiological data to connect to a database for signal analysis and diagnosis, and generates an alert to the doctors and caretakers via e-mail, through web services and SMS through cell phones. The field test results recommend a wireless sensor grid architecture for monitoring different groups of patients’ health status from which high-value computations like analysis, and prediction of diseases can take place, give effective early alerts to the specialists, researchers and caretakers about their patient’s health status.

Chapter 7, “Conclusion and Future work”, summarizes the outcomes of the research work and outlines possible directions for future research.