ABSTRACT

In recent days, some severe diseases and disorders need close and continual monitoring in order to prevent further damage and/or death. The urgent problem in society today is the increase of patients recovering from surgery, the elderly population with a shortage of caregivers and ambulatory patients’ status. The existing patient-monitoring systems are designed to be used by highly trained operators, with a number of hampering wires from the sensors to the data acquisition system; thus, such instruments are hardly suitable for monitoring during the patients’ routine activities. This problem must be solved in a way, which is acceptable from a patient’s perspective, and at the same time increase the efficiency of the personnel working in healthcare centers during the patients’ routine activities. One of the primary challenges faced by healthcare authorities is to maximize the quality and breadth of healthcare services while controlling the costs. One possible solution is the use of modern information and communication technology to enable the healthcare personnel to work more efficiently.

Wireless Sensor Networks are rapidly emerging as an important area in mobile computing. Wireless sensor networks research has recently gained unprecedented momentum in both industries and academia, especially for its potential applications in the medical field. Therefore, there is a strong need for investigating the possibility of a design and implementation of an architecture for remote monitoring of patients in a hospital, home and
ambulatory environments using wireless sensor networks. This dissertation focuses on three important areas of remote patient monitoring system, viz., i) remote monitoring of post-operative patients, ii) remote monitoring of elderly patients and iii) remote monitoring of ambulatory patients.

Patients recovering from surgery are at risk of complications due to mobility as a result of post-operative pain. The proposed architecture for remote monitoring of post-operative patients using wireless sensor networks in a hospital environment is to alert doctors and emergency departments when life-threatening events occur. This system consists of front-end, which is composed of different sensors for recording the vital signals that are demanded by the applications. The patient station consists of a mote device that receives information from the sensor and transmits the same to the central server for analysis through a base station. When any anomaly is detected, our system will facilitate communication among patients, medical professionals at local hospitals and specialists available for consultation from distant places through a secured web server and alert medical professionals through e-mail and short message services.

With the increasing number of elderly people relying on home care, better monitoring and analysis systems are crucial for maintaining and improving their quality of life. The architecture using wireless sensor networks designed to monitor elderly patients in home environment without disturbing their daily activities provides them improved quality of life at lower cost. The wearable sensor platform makes the detection of physiological signals relevant to the motion pattern of the elderly patients.
The patient station is used to transmit both physiological and motion signals to the central server through aggregation nodes, which are programmed to identify the most critical data from the sensors and transmit it to the central server via the base station for analysis. The central server is programmed with two algorithms to detect abnormalities in both physiological and routine activities of elderly patients and alert the physicians, emergency department personnel and caretakers through e-mail and short message services.

Ambulatory Investigations have become more and more important as many physiological investigations can be performed in real situations of daily life. The ambulatory patient may be a person having a specific medical condition monitored or patients with Chronic Obstructive Pulmonary Disease (COPD) or patients with Parkinson’s disease (PD) during their rehabilitation period. Physical exercise is a crucial component of the medical treatment of COPD and PD during the rehabilitation period to prevent deconditioning, and to improve the patient’s Health Related Quality of Life. The proposed architecture is used for monitoring ambulatory patients affected by COPD and PD during their rehabilitation period in “Smart ground” developed inside the hospital. In addition to the physiological monitoring, tracking of body motions and positions provides useful information for activity classification and interpretation of the physiological status of the patients during their rehabilitation period. The sensor node compresses the measured data using a simple data compression technique and transmits it to the data collector node in an energy-efficient manner, which in turn transmits it to the central server. The anomaly detection scheme is based on a time series analysis that will allow the server to determine whether a stream of real time sensor data
contains any abnormality. When an anomaly is detected, the central server alerts the physician via a short message service and e-mail.

A trend in modern medicine is the tendency towards individualization of healthcare and, potentially, grid computing can play an important role by allowing the sharing of resources and expertise to improve the quality of healthcare. The wireless sensor grid architecture proposed for monitoring post-operative patients in hospitals, elderly patients at home and patients affected by COPD and PD in an ambulatory environment, provides a platform for physicians and researchers to share information with a distributed database and computational resources to facilitate analysis and diagnosis. The data acquired from heterogeneous sources are stored in a medical server to perform complex on-line and off-line analysis, and prediction with the information databases, and alert the physicians, emergency departments and caretakers. Authenticated users can access the patient’s information through a secured web server.

The scope of this thesis is to suggest a solution that would help to reduce response time in emergency situations by utilizing wireless sensor networks technology to monitor post-operative patients in a hospital environment, elderly patients in a home environment and patients affected by COPD and PD in an ambulatory environment and prevent them from re-hospitalization, and avoid possible critical events, thus reducing global healthcare cost. It also addresses a grid-enabled network that facilitates secure and seamless sharing of distributed databases by physicians, and emergency department personnel, to support the acquisition and analysis of databases to combat major diseases on an individual basis.