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Wireless Sensor Based Health Monitoring System

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Abstract: This study presents a healthcare monitoring system with wearable sensors. The sensors are very tiny devices which when attached to patient body eliminates the need for continuously monitoring by a doctor or nurse. The wearable sensor system is built in to a fabric belt which consists of various medical sensors that collects information about patients and conveys the status of patient through low energy wireless communication such as smart phones, PDA or palm device to their respective doctors. This study also presents the results of Wireless Sensor Mesh Network (WSMN) in terms of parameters such as delay, throughput when the number of doctors and patients are increased.

Key Terms: Wireless Sensor Network (WSN), Wearable Sensor Systems (WSS), Personal Digital Assistance (PDA)

I. INTRODUCTION

Various economic and technological factors have brought sophisticated electronics within the reach of average users. These technologies, when complimented with wireless sensor networks, [10] promise to add a truly ambient intelligent component to our daily lives. Today, these technologies may be integrated into existing consumer electronic and infrastructure already found.

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants [6]. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance and is now used in many industrial and civilian application areas, including industrial process monitoring and control, machine health monitoring, environment and habitat monitoring, healthcare applications, home automation and traffic control. In addition to one or more sensors, each node in a sensor network is typically equipped with a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, usually a battery.

II. WIRELESS SENSORS IN HEALTH MONITORING

One promising application is the area of health care and patient monitoring. The integration of sensing and consumer electronics technologies would allow people to be constantly monitored. One important benefit is to help stem rising health care costs by increasing health observability and doctor-to patient efficiency. Moreover, constant monitoring will increase early detection of adverse conditions and diseases for at risk Patients, potentially saving more lives. This ability is right around the angle and its beginning will be ushered in with Incremental integration of wireless sensor networks and consumer electronics [10].

Recent advances in WSN technology enable more ubiquitous Healthcare systems that simplify the monitoring and treatment of patients. By using wireless sensor physiological monitoring hardware and software systems, continuous monitoring of patients becomes convenient to assure timely intervention by a doctor [6]. These healthcare monitoring sensors are to be connected directly or indirectly to the internet. Due to the rapid progress in sensing techniques, sensors have been adapted in all shapes and sizes, accommodating human body parts with various degrees of functionality. Wearable sensor devices are designed for physical contact with the object or human body being measured to record physiology such as blood pressure, heart rate, ECG, weight, body temperature, etc. Ring sensors, Nose-on-a chip sensor and baby glove are discussed.

Figure 1. Ring Sensor

Ring sensor in the above figure is a miniaturized wearable sensor very convenient for the patients to wear. To monitor a patient twenty-four hours a day continually ring sensors are used. It is implemented for blood oxygen saturation monitoring. Ring sensor monitors the physiological status of the wearer and transmits the information to the medical professional over the Internet.

Figure 2. Nose-on-a-chip sensor

Nose-on-a-chip is a Micro Electro-Mechanical Systems (MEMS)-based sensor .It can detect 400 species of gases and transmit a signal indicating the level to a central control station. Most of the patients with respiratory problems use this type of sensors.

Figure 3. Baby glove swaddle

Owing to their petite nature, premature infants are vulnerable to a diversity of health problems based on the lack of proper thermal regulation. Their immature state and low body mass limits their ability to sweat which makes them vulnerable to hypo- or hyperthermia, at which point they become all the time more liable to sickness. Integrated health monitoring device, contained within a swaddling baby wrap called Baby Glove. The wrap design provides a comfortable method of securing the child, with strategically placed sensors that monitor their temperature, hydration and pulse rate, three main health considerations important to development.

III. RELATED WORK

In [1] A fabric belt built with wearable sensor system consists of various medical sensors. These sensors collect set of physiological health indicators and are transmitted through low energy wireless communication to mobile computing devices. For this purpose two types of sensor systems are designed. One sensor system for capturing patient's vital signals and the other for capturing the environmental physical parameters in their residence. A fabric belt is installed with wearable sensor systems (WSS) using Bluetooth wireless transmission. For capturing their physiological data the WSS is customized comfortably to the patient's body. For capturing the environmental parameters that are transmitted through a wired or wireless network, Wireless sensor motes (WSM) are placed inside buildings and Zigbee wireless technology is used for communication. A number of mobile computing devices (MCD) such as the PDA and laptop are organized using an ad hoc network. When one medical person in ambulance who is in motion wants to deliver monitored WSS or WSM data to another medical person who is also in motion ad hoc mode is required.

In [2] architecture is proposed in which a hospital contains many buildings. Each hospital building contains mesh nodes and these building contain many wards with many in-patients. Here the sensed information from each of these wards has to be transmitted to the administrative building which may result in overloading the mesh node in the building. This causes failure of mesh nodes. So failure of a mesh node in one building would result in total collapse of the patient health monitoring system, so in order to overcome the problem we go for decentralization scheme in the architecture. This scheme employs agents at ward level .Here the agent interpret the sensed information from sensors and sends to the doctor's PDA through mobile agent.

IV. METHODOLOGY

One of the major challenges of continuous in vivo sensing is the determination of the context with which the physiological signals are sampled. This includes different patient activities, as well as environment factors that trigger the physiological response. Combining the sampled clinical data with the associated context could provide further insight to the natural cause and progression of the disease. For instance, with arrhythmic heart disease monitoring, the underlying cause of the altered ECG signals can be attributed to the intrinsic cardiac condition as well as a number of other factors including the physical and mental stress of the patient. By integrating ancillary sensory readings with the primary ECG information we can provide a more complete picture of the physiological status of the patient.

The remote sensing units consist of physiological sensors which are placed on the subject, and are capable of delivering real-time data to a local processing unit via wireless RF link. The local processing unit then processes the incoming data streams in preparation for sending over the wireless networks. The central server receives the real-time multi-sensory data and stores it to the database, with which long-term trend analysis on historical data can be conducted.

This allows the prediction and identification of potential life-threatening conditions. The patient database is optimally designed for coping with multiple continuous data streams, as well as queries from client applications. To ensure security, the database is only reachable through the central server after authentication [5]. Workstations are generally used by the clinicians to view and interrogate subject data for detailed examination of significant cardiac events.

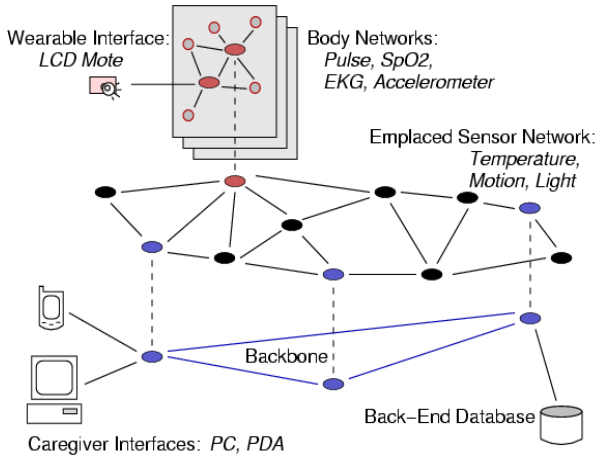

Figure 4. Architecture Diagram

The medical sensor network system integrates heterogeneous devices, some wearable on the patient and some placed inside the living space. Together they inform the healthcare provider about the health status of the resident. Data is collected, aggregated, pre-processed, stored, and acted upon using a variety of sensors and devices. Multiple body networks may be present in a single

system. Usually healthcare provider networks may connect to the system by a gateway, or directly to its database. Some elements of the network are mobile, while others are stationary. Some can use line power, but others depend on batteries. The architecture in figure.4 contains multiple tiers.

A. Body Network and Subsystems:

This network comprises tiny portable devices equipped with a variety of sensors (such as heart-rate, heart-rhythm, temperature, oximeter, accelerometer), and performs biophysical monitoring, patient identification, location detection, and other desired tasks [2]. These devices are small enough to be worn comfortably for a long time.

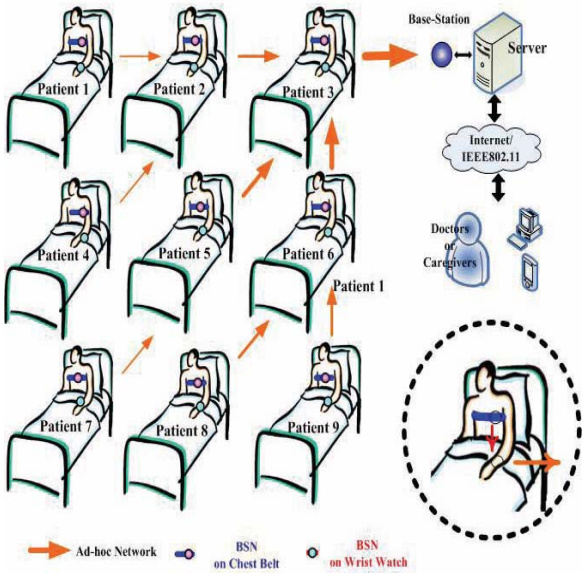

Figure: 5 Patients with wearable sensors

B. Emplaced Sensor Network:

This network includes sensor devices deployed in the environment (rooms,hallways, furniture) to support sensing and monitoring, including: temperature, humidity, motion, acoustic, camera, etc. It also provides a spatial context for data association and analysis. All devices are connected to a more resourceful backbone. Sensors communicate wirelessly using multi-hop routing and may use either wired or battery power.

C. Backbone:

A backbone network connects traditional systems, such as PDAs, PCs, and databases, to the emplaced sensor network.

D. Back-end Databases:

One or more nodes connected to the backbone are dedicated databases for long-term archiving and data mining. If unavailable, nodes on the backbone may serve as in-network databases.

E. Human Interfaces:

Patients and caregivers interface with the network using PDAs, PCs, or wearable devices. These are used for data management, querying, object location, memory aids, and configuration, depending on who is accessing the system and for what purpose. Limited interactions are supported with the on-body sensors and control aids. These may provide memory aids, alerts, and an emergency communication channel. PDAs and PCs provide richer interfaces to real-time and historical data.

The architecture can be explained with patients wearing chest belts in hospital and new born babies in incubators. Chest belts and incubator contains tiny sensors embedded in them.

In the following figure.5 chest belts and wrist watches are used by patients. The chest belts are for measuring the heart beat rates and the wrist watches are for measuring the pulse rates of the patients in hospitals.

Chest belts and wrist watches contains sensors in them which senses and then sends the sensed data to the server or the base station. The doctor or the nurse can access the patient's details from their cabins. Some patients need to be monitored continuously where these types of wearable sensors can be used in efficient manner. By using such wearable sensors number of nurses for monitoring patients can be reduced in large numbers.

For capturing their physiological data the chest belts or the wrist watches are customized comfortably to the patient's body. For capturing these parameters that are transmitted through a wired or wireless network, Wireless sensor motes (WSM) are placed inside buildings and Zigbee wireless technology is used for communication. A number of mobile computing devices (MCD) such as the PDA and laptop are organized using an ad hoc network which are used by doctors and nurses for monitoring patients details.

The following figure.6 shows a remote heart beat monitoring system using wireless technology for new-born premature babies kept in hospital incubators. The Zigbee network which contains a coordinator and end systems..A ZigBee Coordinator establishes the ZigBee network, and collects heart rate information from various end-devices within the network. A ZigBee end-device transmits the heart rate information to the Coordinator periodically.

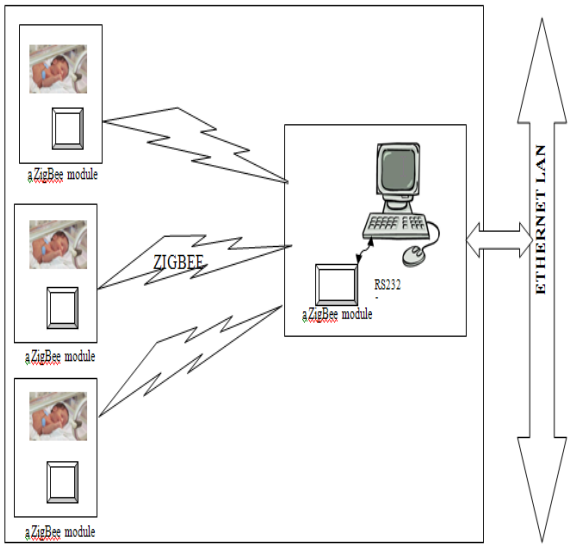

Figure 6. Incubator room with Zigbee network.

On detecting, an abnormal heart rate (above 160 beats/min and below 120 beats/min) for new-born babies, it sends the information immediately.ZigBee Coordinator transmits the received heart rate information to a computer using RS232 serial communication.

The computer will have a software that will display the heart rate information.Each end-device has a unique device address, which is used to map heart rate information to a particular baby in the incubator room. Ideally, heart rate sensor would be based on electrodes attached to a baby. An

analog input on the Zigbee device would collect electric signals from the sensor and Analog-to-Digital converter would provide digital data. These data will used by the doctors responsible for the monitoring the baby.

V. CONCLUSION

In future these sensors can be widely used in ambulance vehicles so that the condition of the patient in the ambulance can be send to the doctor in the hospital so that when the patient reaches the hospital the treatment can be started without any delay and also has possibility for remote consulting including audio visual communication. Wearable sensors can also be useful for taking care of old age people at home.

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