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A Review Paper on Healthcare and Hospital Monitoring System Using Wireless Sensor Network

Nupur Parihar
College of Engineering and Technology, Mody University, India
nupurparihar33@gmail.com

Abstract— Wireless Sensor Network (WSN) are becoming increasingly important for monitoring patient's health and providing more comfort to them. In a healthcare (hospital) monitoring system it is obligatory to constantly monitor the patient's physiological parameters. In this proposed system, a coordinator node is attached to a patient's body to gather all the signals from the wireless sensors and send them to the base station.
This paper provides a systematic review of the use of current WSN implementations in the healthcare domain by discussing various techniques and innovative new trends in wireless sensor network for continuous healthcare monitoring.

Keywords— Healthcare, Wireless Body Sensor Network, Wireless Sensor Network, Bike Net, Blood Pressure

I. INTRODUCTION

Wireless Sensor based technology has invaded the medical devices with a huge range of devices available today with wireless network capability, which have the potential to replace thousands of wires connected to devices found in the hospitals. This technology is highly capable of providing reliability as well as enhanced mobility. It is being looked upon as an alternative schema to provide low cost medical solution along with enhanced accessibility to the patients in view of permanent usage of wireless devices. Minimal configuration and quick deployment makes wireless sensor networks suitable for emergency situations like natural or human-induced disasters, military conflicts and emergency medical situations.

Sensor devices are often accustomed to capture continuous data from patients in real time and communicate to doctors & emergency medical staff (Nurses and Technicians) on their handheld devices. This technology can play a vital role during the time of natural disaster resulting in mass casualties where patients' records like identification, previous medication history and other essential information can be stored.

This technology is expected to reduce the amount of time the doctors require to identify the problem and consult fellow doctors through the use of hand held devices while communicating in ad hoc mode. These devices use minimal power and are robust which decrease their dependence on available infrastructure and this makes them an attractive alternative. It promises to reduce the number of visits required by patients for regular health checkups by allowing doctors to remotely monitor the patients and advice them accordingly.

Body sensor network systems can assist people by providing various healthcare services such as medical monitoring, memory enhancement, medical data access and communication with the healthcare provider in emergency situations through the SMS or GPRS. Continuous health observations with wearable or clothing-embedded transducers and implantable body sensing elements will increase detection of emergency conditions in patients which are at a high risk. Not only the patient, but their families will benefit from this technique too. These systems provide functional methods to remotely acquire and monitor the physiological signals without interrupting the patient's normal life and henceforth improving life quality. Although current systems allow uninterrupted monitoring of patient vital signs, these systems require the sensors to be placed near bedside monitors or PCs and limit the patients to their beds. But now, there is minimal relation between the sensors and the bedside equipment due to the wireless devices and wireless networks. These systems do not restrict the patient to be limited to his bed and permit him to move around with a condition to be within a specific distance from the bedside monitor.

Out of this range, it will be an impossible task to collect their data. In most cases, healthcare monitoring will be done by infrastructure-oriented wireless networks like commercial cellular/3G networks or wireless LANs. But the scope of these infrastructure-oriented networks can change with respect to time or location. Sometimes the coverage of wireless network is not accessible or the coverage is available but we cannot access it due to the network issues and lack of obtainable bandwidth. So, with these complications and restrictions, continuous health monitoring is not possible and emergency signals might not be transmitted from a patient to healthcare providers. Under these conditions, we can reach to continuous healthcare monitoring by employing ad hoc wireless sensor networks that can easily transmit vital signals over a short range.

II. POTENTIAL MEDICAL APPLICATIONS

Traditional WSNs are independent, automatic and utilized in a large scale in either a fixed or a distributed manner. Their data rates are limited by their applications. Wireless Medical Sensor Network requires direct human involvement such as with patients, doctor, nurses and other medical providers which are utilized at a small scale depending on the usability for supporting mobility for the patient to carry the device, demand high data rates with reliable communication and multiple recipients. WMSNs has the capacity to assure the quality of safe keeping of patients with a wide variety of healthcare applications as they can be wearable, implantable, portable and can be integrated on many types of wireless communication motes. It has three different types of medical applications as follows.

A. Real Time Continuous Patient Monitoring

These applications are predominantly concerned with the monitoring of crucial signs and recording various statistics of the patients. They can be thought of as an effortless substitution of potential wired medical equipment like ECG.

For example, a wireless sensor network system can be incorporated to continuously monitor and detect cardiovascular diseases experienced in patients at remote areas. A wearable wireless sensor system (WWSS) is designed to continuously capture and transmit the ECG signals to the patient's mobile phone. The fastest alert will be forwarded to doctors, relatives and concerned hospital staff using the proposed data processing algorithm implemented in the patients' mobile phone. The proper information from WWSS will then be transmitted to a central station, which can provide a service to the doctor to examine his patient's record and provide his prescription immediately on his request. A diverse wireless network design is also proposed for the continuous transmission of data from WWSS to a Central Data Centre (CDC).

B. Home Monitoring for Chronic or Elderly Patients

Wireless Sensor Network medical applications are designed with the intent to decrease the duration of patients in the hospitals except for the total time required for procedures. This facilitates the physicians to observe and examine several patients virtually at the same time which cannot be achieved if the patients are hospitalized.

In maintaining the health of elderly or persistently ill patients, it can be useful to monitor their health status through their daily routines in their own home. Several sensors were installed and placed, including

infrared sensors to detect human movement, magnetic switches to detect the opening and closing of doors, watt meters embedded in wall sockets to detect the use of household appliances, a flame detector to detect the use of a cooking stove, sensor to detect the presence of a subject in a room by monitoring the carbon dioxide expired. The sensor outputs were recorded on a personal computer located in each house and the data were automatically transferred daily to another site via the Internet. With the sensors, a network and data system the monitoring was fully automatic and did not require placement of any sensors on the subjects or any operations by subjects. Such monitoring can contribute to the maintenance of health of elderly and chronically ill patients even when they are comfortably residing in their homes.

C. Clustering of Long Term Databases of Clinical Data

These applications are predominantly concerned with the study of epidemic diseases and issues related to community health. Collecting and sharing data across the health care system is equally important for the collection of information about clinical data. Health care involves a divergent set of public and private data collection systems, including health surveys, administrative enrolment and billing records and medical records used by various entities, including hospitals, physicians and health planners.

1) Correlation of Bio sensor readings with various other patients' information.

2) Longitudinal studies across the populations and incorporation of study effects of interventions and Data Mining.

3) Allowing long term care and trend analysis of clinical databases.

The most salient feature of such a network would be in case of some large accidents, fire or natural calamities like floods or terrorist attacks. In such scenarios the normal community services may be damaged or destroyed leaving a large number of patients unattended which can cause a heavy load for the emergency personnel attending the casualties. Since the primary communication infrastructure would be completely damaged, because of which the number of victims might increase to a large extent and the only way to track them would be through papers and reports with manual identification of each one of them.

The sensor networks interconnected with other wireless technologies have the possibility to affect the large number of casualties by providing a method of real time continuous monitoring of vital system of patients. Each patient can be provided with a tag for his/her identification which can be used for their identification and to examine their previous medical history. The emergency staff can thus have more precision and will have the provision to keep a watch on the patients who require immediate care upon receiving alerts from changes in the health status. This can also be transmitted back to the hospital where the patients are being moved so that the doctors have the opportunity to coordinate with the acquired data and identify the necessary procedures for the patients.

Sensor networks are thus a proper set of tools for collecting information, and to access sensitive information either by storing sensor data or by eavesdropping on the network. A system stores the sensed data in an anonymous database, removing the details that an antagonist might find useful. Another possible approach is to process queries of the sensor network in a distributed manner so that no single node can notice the query results in their totality. This approach guards against probable system abuse by various compromised malicious nodes.

III. HEALTHCARE PROJECTS

A ubiquitous healthcare prototype system is designed particularly for hospitals. The proposed system follows the concept of placing unobtrusive wireless sensors on a person's body to form a wireless network with a base station connected to the monitoring PC through which the patient's health status can be observed continuously. The architecture and application of the proposed system is depicted in Fig. 1.

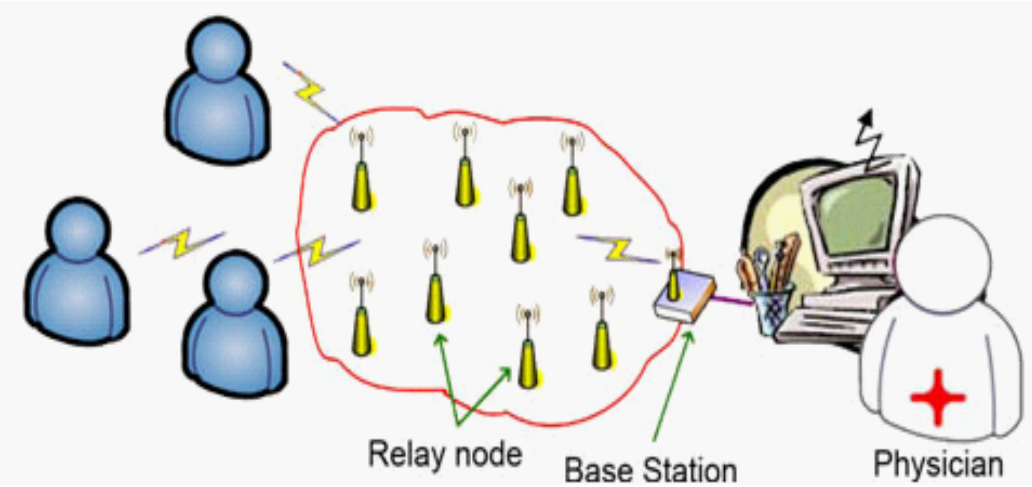

Fig. 1 Architecture for Multi Body Sensor Network System

A. Multi Patient Body Sensor Network System Components

1) *WBSN:* WBSN (Wireless Body Sensor Network) includes four sensors which are responsible for collecting the physiological signals from patient.

2) *WMHRN:* WMHRN (Wireless Multi-Hop Relay Node) consist of a number of wireless relay nodes which sends the vital information to the base station.

3) *BS:* A Base Station (BS) receives the relayed data and sends it back to the PC through a cable.

4) *GUI:* Graphical user interface (GUI) is responsible for storing, analyzing and presenting the received data in graphical and text format and sending an SMS to the healthcare provider or to patient's family members in case of emergency conditions through the GPRS or GSM modem.

The architecture of multi body sensor network includes sensors which consist of a statistical plane to provide coordination and communication across the wireless medical devices. The communication model comprises of Publisher- Subscriber data delivery model where the sensor nodes publish vital signs, location information, its identity and others. Rescue personnel accept this information depending on the area of interest and receive the subscribed information accordingly.

For example sensors for a pregnant woman can be:

1) Motion Detection-Accelerometers: Can be used to measure blood pressure however the patient should be seated or lying down. Hence these sensors can detect a patient's position. If a patient is placed in a proper posture, it can allow other sensors to sense correspondingly.

2) Blood Pressure and Heart Rate: Such sensors are used to return the values for blood pressure and heart rate.

3) Heart rate and Movement of Fetal: Detection of the heart rate and movement of the foetus used by medical practitioners to assess the health of the foetus.

A distributed scheme to manage the dynamic coexistence of Healthcare Monitoring WBANs perfectly defines the effects of dynamic coexistence on the operation of health based monitoring WBANs. The current IEEE 802.15.4 standard is deprived of procedures required for effectively managing the coexistence of mobile WBANs. The pitfall of such a synergic method is the complexity in maintaining synchronization of the super frame arrangement and the high overhead of changed control messages.

B. Code Blue

Code Blue is a sensor network based medical research project being developed at Harvard. The main objective of this project includes pre-hospital care and in-hospital emergency care, stroke patient rehabilitation as well as disaster response. Research from this project has potentials for resuscitative care, real-time sorting decisions and long term patient observations. This project consists of hardware and software parts.

Fig. 2 shows a Mote based pulse oximeter which is a Wireless Vital Sign Sensor which forms a part of hardware which includes a Mica-2 51-pin connector and a DB9 connector for the finger sensor. It helps in sensing and monitoring the content of oxygen in blood. Pulse Oximeter is a non-invasive technique for keeping a track of a person's oxygen saturation. A blood-oxygen monitor presents the percentage of blood that is loaded with oxygen. If the finger sensor is detached from the patient, the board reports an error condition giving out of range vital sign values.

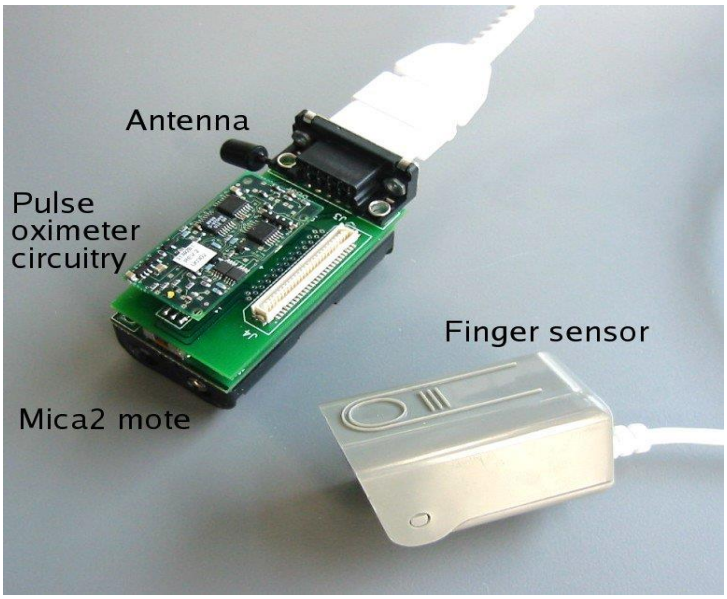

Fig. 2 Mote Based Pulse Oximeter

It contingently monitors the oxygen saturation of a patient's blood (as opposed to determining the oxygen saturation directly through a blood sample) and changes in blood volume into the skin. The pulse oximeter can be assimilated into a multi parameter patient monitor. Portable, battery-operated pulse oximeters are also convenient for transport or home blood-oxygen monitoring.

C. Project Connect

The Connect project fundamentally focuses on developing solutions to help people with disabilities in their everyday life. They are trying to generate a distributed wireless communication infrastructure that enables the individual customization of portable devices such as a PDA (Personal Digital Assistant), though the project initially depended on a GPRS for communication between PDA devices and the central server. The main goal of this project is to permit people with disabilities to customize their wireless devices i.e. PDA to keep schedules for them, give them important reminders and allow them to communicate with their caregivers through any of the possible ways provided. Therefore, this system adapts to the user's needs instantly providing them with more reliability.

D. Life Sync Wireless ECG System

Life Sync Wireless ECG System is a central ECG device that operates by using Bluetooth wireless technology. It has the capability to gather a patient's ECG as well as respiratory data and transmit the information using a two-way radio. In Fig. 3, we can see a set of transceivers that are used within hospital and ambulatory service. The main aim of this device is to provide a more flexible and mobile interface to the existing ECG monitors in hospitals.

Fig. 3 Wireless ECG Transceiver

The device can be positioned anywhere while the results will be shown in the conventional monitors. One of the main advantages of using this device is that it incorporates continuous monitoring in a mobile environment and also that they are designed to interface with existing medical devices. This will moderately decrease the reluctance of hospitals to phase out old but expensive machines. These devices can thus provide a more systematic, efficient and modern standard interface to such expensive machines.

With wireless network based medical technologies, various innovative applications can be designed which can lend a helping hand to the patients as well as to the medical practitioner. All applications based on empirical methods have a step by step process of a development lifecycle. This is normally starting out with a research project and then moving onto the process of commercialization. Healthcare is an area where wireless networks have the most requirements. Smart home based healthcare technologies are also in the process of being designed which will eventually care for those elderly patients who need long term care and want to cure themselves while being in their own house rather than a hospital bed.

E. Bike Net Project

Bike Net is a flexible mobile sensing system which was being developed through partnership of Dartmouth College and Columbia University, for cyclist experience mapping holding opportunistic sensor networking principles and techniques. It constitutes a multifaceted sensing system and explores personal, bicycle and environmental sensing using dynamically role-assigned bike area networking.

The Bike Net system contributes by giving us information regarding a cyclists' performance, fitness management by collecting data about cyclist's current and average speed, distance travelled, calories burned and location metadata. It also presents the environment and experience mapping by emphasizing on the healthiness levels in terms of pollution, allergens, noise and terrain's roughness as well as long term performance trend analysis which authorizes the upload of data traces into personal repository and critical data sharing. The data is thus collected and is remotely presented on the web-based portal which refers to opportunistic networking paradigm that data uploading happens according to the opportunities that arise as a result of cyclists' uncontrolled mobility.

F. Alarm Net Project

Alarm-Net is a wireless sensor network project which was being developed for assisted-living and residential monitoring by University of Virginia. It integrates environmental and physiological sensors in a scalable architecture. The main focus of this network is to provide smart environment and secure patients' monitoring on a daily basis. This system aims to facilitate the concept of health care by including informal caregivers, such as family, friends, and patients' themselves in the process. Early recognition and prevention of diseases insures reduction of costs' with provides simultaneous quality care to patients.

Contributions of the Alarm-Net system includes development of scalable and diverse network based upon the hardware components, implementation of context aware protocols, which enables smart power management and active alert-driven privacy depending on individual's activity patterns and design of secure communication.

IV. CONCLUSION

Wireless Sensor Network technology is emerging as a significant element by playing a pivotal role for next generation healthcare services. Guaranteeing the privacy and authenticity of the transmitted data is also an important objective. Wireless sensor network is a growing field that will change people's healthcare experiences in medical field.

The sensor nets are highly compatible as compared to the existing infrastructures. It can be said that the future of WSNs and their medical appliances looks highly promising. The present medical applications based on wireless sensor networks are still under research and projects with good potential for utilization. Huge orbits of medical scenarios are being covered with these applications that opens wide spectrum of benefits for all caregivers.

They should be able to provide the necessary care whether in emergency situations, or in any healthcare institutions and hospital environments. This paper concludes a careful review of the development on wireless sensor network in healthcare system and the technological requirements for this domain.

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