Wireless Body Area Sensor Network for Healthcare Industry

Dimple D. Bavlecha
dimple.bav@gmail.com
Usha Pravin Gandhi College of Management

Smita S. Sawant
smitu_ij@yahoo.co.in
S.I.W.S College

Introduction:

Coming along with the urgent development of wireless technology, wireless devices have invaded the medical area with a wide range of capability. Not only improving the quality of life of patients and doctor-patient efficiency, wireless technology enables clinicians to monitor patients remotely and give them timely health information, reminders, and support – potentially extending the reach of health care by making it available anywhere, anytime.

Present Scenario:

Figure 1 [9] depicts how the process of data collecting at health centres works today. The interactions are described below:

Figure 1
Current scenario: manual data collecting.
i - a staff member collects patient’s data at bedside, writing it down to a paper spreadsheet;

ii - the notes are typed in a data entering terminals;

iii - the data is transmitted to a database server that organizes, indexes, and make it accessible through a database interface, and;

iv - the medical staff access this information through an interface application.

Body Area Networks (BANs): Wireless BANs are intended to replace wired cables between body (implanted, connected, or worn) sensors and such monitoring health conditions, controlling the delivery of medication, and regulating body functions. A wireless BAN consists of a set of sensors installed in, on or around the patient’s body, transmitters and receivers connected to the sensors, and monitoring and control equipment. These networks can provide real-time data for diagnostic and therapeutic purposes.

Sensor Networks: Sensor networks have been applying in various aspects of medical care. Medical equipment is one application area for wireless body area network (WBAN) where a couple of sensors will monitor a patient’s activity, e.g., electrocardiogram (ECG), blood pressure and report if something abnormal happens. All kinds of sensor networks put requirements on long battery life time in the sensing node. Therefore, the architecture of a sensor network intended for medical applications must be carefully designed in order to have a long time[1]. By equipping patients with tiny, wearable vital sign sensors, physiological status of patients can be obtained easily. In emergency or disaster scenario, sensor networks can be used to track healthcare personnel and patient status as well as location continuously in real-time mode.

Recent technological advances in sensors, low-power integrated circuits, and wireless communications have enabled the design of low cost, miniature, lightweight, and intelligent physiological sensor nodes. These nodes, capable of sensing, processing, and
communicating one or more vital signs, can be seamlessly integrated into wireless personal or body networks (WPANs or WBANs) for health monitoring. There is considerable interest in using wireless and mobile technologies in patient monitoring in diverse environments including hospitals and nursing homes.

**Wireless Sensor area Networks:**
Wireless sensor networks (WSNs) consist of nodes that consume very low power and are extremely small in size. This facilitates easy integration with non-invasive biomedical sensors. These network nodes are specifically designed for low power consumption and with minimal circuit components. They are intended for small packet, short distance range applications and typically consist of a low power processor with minimal resources and interface capabilities. They also have a conservative transceiver that is capable of transmitting only a few bytes of data at a time and has a moderate transmitting range of about ten meters. Therefore, WSNs seem to be a perfect fit for remote patient monitoring. This paper investigates the practicality of using WSNs for monitoring patient vital sign data. [1]

**System Design Issues:**
The development of pedometers and Micro-Electro Mechanical Systems (MEMS) accelerometers and gyroscopes show great promise in the design of wearable sensors. [2]

The main system design issues include:
1. types of sensors
2. power source
3. size and weight of sensors
4. wireless communication range and transmission characteristics of wearable sensors
5. sensor location and mounting
6. seamless system configuration
7. automatic uploads to the patient's electronic medical record
8. intuitive and simple user interface

We should develop on this vision of delivering rugged and reliable body sensor networks that are able to gather information of the same quality and quantity that can be currently gathered from laboratory based reference sensing systems, and to generate more complex body sensor networks whereby information from multiple positions on the body can be brought together through the use of simple wearable sensors and a wireless communication platform.

**ICU : an important domain in Healthcare**
In recent years, healthcare institutions like ICU face problems in accessing and maintaining the physiological information of the large number of patients that are hospitalized and need constant medical care. Monitoring patients and maintaining their health records is important for effective health management. Technologies that support effective patient-monitoring will not only reduce burden on the existing healthcare system but also improve healthcare cost impact on the overall economy of the nation. In the case of ICU monitoring, difficulties increase due to the high cost of equipments necessary to maintain an efficient monitoring. Therefore, there is a demand for lowering the monitoring cost, as the only way to guarantee the survival of most hospitals. Every hospital has monitoring equipments, which in most cases do not allow remote monitoring. This problem could be solved by adding this functionality to the existing equipments without acquiring new ones. Another problem most ICU equipments face is to monitor the vital signals only instantly. Most of standardized monitors do not keep records of data; normally, the monitoring is done at 1 hour intervals manually. The doctors may not have access to the information between the intervals. In our project we would present a * remote patient monitoring service through World Wide Web (WWW), which allows physicians to monitor their patient from remote sites using the popular Web browser. Hence we propose a system concerned with remote patient monitoring in ICU by providing a User-interface to make the information available to the health professionals and most importantly at an extremely low cost.
Properties of Wireless Sensor Networks:

**Portability**: Small devices collect data and communicate wirelessly, operating with minimal patient input. They may be carried on the body or deeply embedded in the environment. Unobtrusiveness helps with patient acceptance and minimizes confounding measurement effects. Since monitoring is done in the living space, the patient travels less often, which is safer and more convenient.

**Ease of deployment and scalability**: Devices can be deployed in potentially large quantities with dramatically less complexity and cost compared to wired networks. Existing structures, particularly dilapidated ones, can be easily augmented with a WSN network whereas wired installations would be expensive and impractical. Devices are placed in the living space and turned on, self-organizing and calibrating automatically.

3. **Real-time and always-on**: Physiological and environmental data can be monitored continuously, allowing real-time response by emergency or healthcare workers. The data collected form a health journal, and are valuable for filling in gaps in the traditional patient history. Even though the network as a whole is always-on, individual sensors still must conserve energy through smart power management and on-demand activation.

4. **Reconfiguration and self-organization**: Since there is no fixed installation, adding and removing sensors instantly reconfigures the network. Doctors may re-target the mission of the network as medical needs change. Sensors self-organize to form routing paths, collaborate on data processing, and establish hierarchies.

**Potentials of wireless technology in medical applications**

Wireless inside-body monitoring is a hot application of wireless network in patients’ monitoring. Using WBAN technologies to transmit data from monitoring, to outside body, by video or successive image data should be possible. In an operation, doctors have to monitor the patient’s vital signs to have timely actions. These signs can be obtained by applying to the patient adhesive electrodes so that the signs are transmitted over wires to display monitors. The large number of wires used around the operation table prevents the medical team’s access to the patient. To help surgeons and medical teams operate more freely, a device should be developed which displays patient’s signals without adhesives or wires. Although real-time patient monitoring field is not a new topic in wireless medical applications, researchers and industries are investing a lot of effort and money to it. These applications basically use biomedical sensors monitor the physiological signals of patients such as electro-cardiogram (ECG), blood oxygen level, blood pressures, blood glucose, coagulation, body weight, heart rate, EMG, ECG, oxygen saturation, etc. Using the system can reduce the hospital stay of patient and increase patient safety and mobility. The system should collect periodic and continuous data and then transmits it to the centralized server. Patients’ information is accessed by physicians remotely. These applications save large amount of time for doctors as well as patients. The doctors can monitor several patients simultaneously which is can not be done by traditional monitoring, in which the patients are monitored directly by the doctors. The patients are no longer required to be present at the hospitals periodically. Wireless sensor network can be applied to medical applications to build up databases for long-term clinical uses [McLoughlin06]. It also can be used for emergency medical care and many other applications. The section presented the fields that wireless networks can contribute. The following part will identify challenge of deploying wireless networks based solutions in medical care.
Framework Proposed:

Figure 2. Remote vital sign monitoring system. (Original figure source: ttp://www.enel.ucalgary.ca/People/Haslett/WCLM/CCHE/WebPage/VijayDevabhaktuni_Wireless_Proceedings)

Figure 2 shows the concept of an in-hospital WSN that can be used to monitor patient vital sign data from instruments such as ECGs, pulse-oximeters, and blood pressure monitors (BPMs). These units can be interfaced to WSN nodes that can be programmed as sensor nodes. These sensor nodes are required to perform the function of sensing vital sign data from the patient and are typically required to be ambulatory in nature. Therefore, it is convenient to allow them to run on stable sources of energy such as batteries. Additional nodes (router nodes) are required to pass the data to the monitoring station (also called the base station). There might be several such router nodes distributed in these WSNs, and their density and number would depend on the hospital size and coverage requirements. Typically, each router node in the network has a fixed location and its only function is enabling prompt data transfer to the next router node or base station. These router nodes obviously need to be continuously on so that data can be promptly transferred. Referring to Figure 2, the base station in such networks consists of a mote that receives data and is connected to a server. The data received by the base station is displayed to allow constant patient monitoring and can be routed to the patient’s physician for easy access in real-time requirements of patient monitoring and satisfying these requirements using wireless networks. The future research should address how to improve the reliability of patient monitoring under varying coverage of WLANs, wireless link variations and access point failures. This new technology has potential to offer a wide range of benefits to patients, medical personnel, and society through continuous monitoring in the ambulatory setting, early detection of abnormal conditions.

Conclusions and future research

There is considerable interest in using wireless and mobile technologies in patient monitoring in diverse environments including hospitals and nursing homes. However, there has not been much work in determining the

References:

4. Eoin McLoughlin, Dympna O'Sullivan, Michela Bertolotto, and David C. Wilson; “MEDIC Mobile Diagnosis for Improved Care”, SAC’06 April 2327, 2006,