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The Medical Perspective of WSN

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Abstract—*The advancement in wireless communication, integrated circuits, and sensor technology has made the use of light weight physiological sensor nodes to sense, process and communicate the health related data to the outside world. Wireless sensor networks (WSN) have the potential to become an integral part of health care, as these can cut down the health care costs and even increase the accessibility for both patients and health care professionals. The designed applications using wireless sensors are less intrusive to the daily life style of patients. This paper emphasizes on the impact of sensor nodes in medical ground .The various ongoing health care projects and researches to bring about more and more use of sensor node in medical perspective are discussed. A detailed study on this area is made including identifying the major challenges and security issues, a sensing system can face, and ways to overcome those challenges. WSN promises for improving and mounting the qualities of medical care for all segments of the population .These are found to have immense potential in enhancing the quality of lives through the use of smart environments and these can help in early detection of health deterioration by carrying out real- time monitoring of patients. Although the benefits of sensor networks in medical care is very convincing but still it faces many issues and challenges. The counter measures to overcome these security issues and challenges should be emphasized so that the reliability and flexibility of using WSN in medical purposes gets higher.*

1. INTRODUCTION

The technological advancements in the recent years have witnessed the emergence of wireless sensor networks in health care. The miniaturization of sensor nodes, advancement in wireless technologies, embedded microcontrollers and radio interfaces have enabled the sensor nodes to be deployed extensively. In WSN many tiny nodes cooperate together and form a wireless network. The data collected from the sensors is sent to the sink node, where the data analysis and decision making takes place. The following Fig. shows the architecture of WSN.

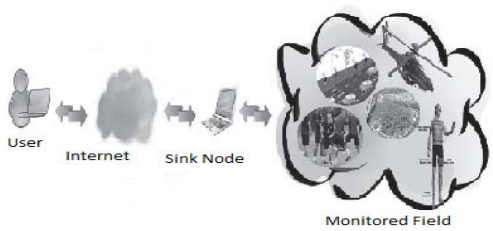

Fig. 1: WSN architecture

The researches in 'urban' and 'people centric' wireless sensor networks has been very prevalent these days [4]. The wireless sensor network is an assembly of tiny nodes which are responsible for collecting data and sending it to the sink node for decision making and data analysis. These sensors are being used for traffic pattern guidance, habitat monitoring, have a lots of applications in battlefield [3] agriculture and plant monitoring, are used as earthquake and landslide detectors and have wide applications in infrastructural and health monitoring. Applications ranging from patient management to equipment management are in the development process. Some of the typical applications include monitoring of body temperature, location of person, heartbeats, recording performance of a patient while he/she is in hospital or home. This domain is popularly referred as Wireless Body Area Networks [1] (WBAN). There are many restrictions for WBAN as compared to WSN as it has to deal with the human body. The sensors are required to function for a longer period of time as it is not practically possible to change the sensors again and again. The sensor motes typically use microcontrollers of 8 or 16 bits with ROM of hundreds of KBs, RAM in tens of KBs for external storage and program storage in form of the flash memory. These devices operate at about 10MHz and require a few mill watts of power.

The health applications of WSN are widely discussed in this paper. The sensor networks applications like the drug administration, diagnostics, ambulatory monitoring, movement monitoring of small animals and insects, collecting periodic data of the elderly people, providing interfaces for the disabled ones, tracking patient and doctor inside the hospital etc. These sensors even access the vital signs during casualties and observe responses during emergency situations. The wearable sensors have made the process further easier as the patient can monitor the health changes himself/herself and the health experts can provide feedback if the system is an integrated tele-medical system. These applications will definitely revolutionize the system of health care. However these sensors suffer from many challenges like the data reliability, security management, limited processing capabilities, small memory foot-prints, and efficient routing. The security, legal and privacy issues even add to these challenges.

2. PREFERENCE OF WSN FOR MEDICAL PERSPECTIVE

Medical Care can use wired networks, Bluetooth, video cameras to monitor the health conditions of patients but the light weighted, wearable and low power consuming wireless sensor nodes have made the health monitoring process much easier. The video cameras require large memory and powerful processors and hence are not cost effective, whereas the senor nodes can work with fewer power consumption .These sensors even provide information of different types with quantified parameters about the health state of a patient, because of which alarm and the emergent signals can be detected easily. It is even easier to set up wireless sensor networks as compared to the wired networks which require a large number of wirings. These can easily communicate within the wireless network coverage and unlike the wired networks these can be attached to the body of the patients. More importantly the sensor networks are mobile and highly scalable. Bluetooth even requires low power and provides communication within short ranges, but still these are found to have inferior performance as compared to the sensor networks as the devices in a Bluetooth network use the master slave mode to communicate and even a tight synchronization is required while performing a fast frequency hopping operation. Sensor networks can monitor the physiological parameters of a patient without affecting his/her activity. These have minimized the human errors in health care, brought about commercial benefits and better understanding regarding the origin of diseases.

3. HEALTH CARE PROJECTS

There are various ongoing health care projects and researches to bring about a heavy impact of WSN in the medical perspective, and various projects are in the development and implementation stage [2, 5, and 12]. Indeed a lot of research time is devoted to wireless health care systems by both the government and private organizations to cover areas like glucose level monitoring, cancer detection, stress monitoring etc. Various research projects include Alarm-Net [6], MobiCare, CodeBlue, UbiMon, and MEDiSN which are discussed below. The main consideration of these projects is to optimize cost and power consumption.

3.1 Alarm-Net

Alarm-Net[18] is a prototype of wireless sensor medical network system. This is a three network tier [6] design to function health monitoring in a home environment and assisted living. This was first designed at the University of Virginia. This uses both body sensor networks and the environmental sensor networks. This carries out location tracking and physiological monitoring functions. Basically in Alarm-Net the sensors on the body transmit physiological data of an individual to the environmental sensors by using a single-hop communication and these environmental sensors convey the data to the IP sensors which further lead the data to the back end servers through multi-hop communication.

3.2 MobiCare

To facilitate the continuous monitoring of a patient, MobiCare [7, 8] was designed. This has WBAN architecture with wearable sensors (e.g. SpO_2, ECG and blood oxygen). Here the IBM wristwatch acts as a client, the patient's body is sensed through the medical sensors and then the data is broadcasted to the client who then aggregates the data and sends it to the MobiCare server using a cellular link. The patient is allowed to be fully mobile while he/she is undergoing any such health monitoring. The server in turn provides patient care by analyzing the physiological data offline.

3.3 CodeBlue

The Harvard University carried out this project to make the sensor nodes to work with a vast number of wireless devices. This is a popular research [8, 9] project whose architecture consists of Mica2 [10] motes. It has potential for real time triage decisions, resuscitative care and long term observation of a patient.

Fig. 2: A typical Mica2 mote used in CodeBlue[9]

CodeBlue is to be deployed more and more for disaster response, in-hospital and pre-hospital cases and even for rehabilitation of patients with stoke. A localization service is even provided by the CodeBlue where a set of nodes broadcast beacon signals continuously and the mobile nodes use these broadcasted signals to estimate their location. This principle can be used in hospitals to locate doctors, patient and nurses in a timely fashion. Some of the hardware and software products of this project includes, wireless two lead EKG, wireless vital sign sensors, CodeBlue software platform, gyroscope, accelerometer and electromyogram (EMG).

3.4 UbiMon

The ubiquitous monitoring environment for wearable and implantable Sensors Project (UbiMon) [11] was designed to cater the needs of transient and life-threatening abnormalities.

It basically uses sensors that are implantable and wearable with WBAN architecture. This project covers two major areas; firstly it undertakes the patients with heart diseases and even monitors the post operative conditions of patients who had major surgeries.

3.5 MEDiSN

MEDiSN [12] was developed for the disaster surgery scenario; the design here includes multiple numbers of battery powered physiological monitors. These monitors consists of sensors in order to obtain the patient's information , store the sensed data temporarily and then the data after being processed is transmitted to the relay points to bring about a reliable communication, Quality of Service and routing. The MEDiSN store the medical data constantly and then presents tem to the client.

3.5 Capsule Endoscope:

This project has facilitated the use of wireless capsule endoscopy which has far reaching benefits as compared to the conventional endoscope. It provides in-body monitoring [19,20] of digestive organs. The collaboration between the implanted WBAN in capsule monitoring system and the wearable WBAN results in transmission of images and videos relating to the internal gastrointestinal diseases to the outside world.

3.6 CIMIT

The Center for Integration of Medicine and the Innovative Technology (CIMIT) is a non-profitable association which provides resources to the researchers for developing novel technologies which can help in urgent medical problems. It has recently developed a miniaturized prototype of a wireless sensor to monitor vital signs of a patient in homes and even in hospital waiting rooms. The goal here is to develop a wearable device which can provide information regarding respiration, heart, temperature and movement. This device then integrates with the existing wireless network of the hospital to provide direct indications to the health care teams even when the patient is moving. This team aims at designing functional operating rooms [20] in which the process and technology can be integrated, evaluated and then improved to provide best results. This project is to be implemented in near future.

The researchers aim to indulge the sensor networks into the medical ground abundantly and try to make it cost effective so that it is easily accessible to everyone. These ongoing projects and researches are even limited with the privacy, security and legal issues which are discussed in the next section of this paper.

4. SECURITY CHALLENGES

Challenges come hand in hand with the new technology and its application. The challenges here can be both technical and non-technical. The Technical issues deals with constraints to make these sensors reliable easily operate able and manageable under worse scenarios. The non-technical issues deal with privacy and security concerns.

As the health applications are being discussed in this paper, the security in this field holds a vital importance. Assurance and quality requirement is must in the medical field. Absence of appropriate privacy measures can lead the information straight away to the public domain[17]. Deployment of wireless networks can bring about social, engineering and patient well-being issues. WSN applications in medical care undergoes many threats and attacks [14]. A little negligence in the security perspective can risk the life of a patient. The security issues includes the risk of data being accessed by someone unknown and unauthorized, the risk of reliability and consistency in data transfer, the injection of false data, denial of service attack, eavesdropping etc. Various types of attacks in health monitoring mentioned by the authors[15] include modification of medical data, eavesdropping, location tracking of users, forging of alarms, jamming attacks and activity tracking of users . Data confidentiality and Data integrity is even an important consideration while applying the sensor networks into the medical care. All the possible benefits can eventually get altered if an outsider is able to measure the information while it s being transmitted between the two nodes. The data from the biomedical sensors should always be available even in the case of external attacks. Even after the data confidentiality and integrity is maintained , it should be followed by a data freshness mechanism in order to monitor that no data packets are being repeated.

The following section highlights the technical challenges and issues of wireless sensor networking in medical perspective along with the counter measures.

5. RESOLVING SECURITY CHALLENGES

The authentication and encryption mechanism are two widely used security measures to counter major threats. These mechanisms when applied to the administrative, technical [16] and physical level can resolve the security issues and challenges for health care applications. The administrative level security should provide a well defined user hierarchy and there should be security measures to monitor the staffs responsible for the operation of the system. The technical level security should provide client based security at the user side and server based security at the server side. As the wireless networks are susceptible to intrusion, the technical level security should provide techniques for intrusion detection and prevention including a secure routing of data. As the devices get degraded due to the natural causes like wear and tear, the physical level security should provide careful designing of the devices so that they are least affected by the worse physical scenarios. The possible security attacks and their effective solutions are listed below.

Table 1: Possible Security attack and their Solutions

Security Threats and Attacks	Countermeasures
Routing attacks	Use of efficient routing protocols
Eavesdropping attack	Encryption
Denial of Services[13]	Digital Signature and Authentication
Data/Message Modification	Data Integrity as well as Digital Signature
Data Replay Attack	Data Freshness
Impersonation Attack	Authentication
Jamming and Interference Attack	Repeated use of electro-magnetic interference filters

In a WBAN scenario when a patient wears several sensor devices, a centralized control device can be used for transmitting data in and out. This centralized device acts as a gateway between the outside world and the internal network. Various firewalls, authentication and other security measures can be applied to the controlling device in order to handle the traffic.

6. CONCLUSION

The WSN has brought health monitoring in homes itself rather than moving frequently to the hospitals. These have made life easier and comfortable, the wearable sensors have become an integrated part of the daily life activities .The application of WSN in this field is not only convincing but also has far reaching advantages. Efforts are made to overcome the challenges like improving the reliability and flexibility of nodes, enabling adhoc deployment mechanisms, making sensors more robust and improving the Quality of Services . Further studies are being carried out to bring new applications of this technology.

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