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Study of Wireless Body Area Networks

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Abstract: The wireless body area network has emerged as a new technology for e-healthcare that allows the data of a patient's vital body parameters and movements to be collected by small wearable or implantable sensors and communicated using short-range wireless communication techniques.WBAN has shown great potential in improving healthcare quality, and thus has found a wide range of applications from ubiquitous health monitoring and computer assisted rehabilitation to emergency medical response systems. The security and privacy protection of the data collected from a WBAN, either while stored inside the WBAN or during their transmission outside of the WBAN, is a major unsolved concern, with challenges coming from stringent resource constraints of WBAN devices, and the high demand for both security/privacy and practicality/usability. In this article we look into two important data security issues: secure and dependable distributed data storage, and fine-grained distributed data access control for sensitive and private patient medical data. We discuss various practical issues that need to be taken into account while fulfilling the security and privacy requirements. Relevant solutions in sensor networks and WBANs are surveyed, and their applicability is analysed.

Keywords: Monitoring and Sensing, architecture of wireless sensor network, BAN applications to healthcare promotion.

I. INTRODUCTION

Wireless Body Area Network (WBAN) is an exciting technology that promises to bring health care to a new level of personalization. Miniaturized sensors can be worn on the body and they can non-intrusively monitor a person's physiological state. Multiple sensors communicate with a mobile phone using wireless interfaces forming a WBAN. WBANs enable monitoring an individual's health continuously in free living conditions, where the individual is free to conduct his/her daily activity. The mobile phone in a WBAN is used to collect health data from sensors, store and even partially process data locally, and transmit the health data over wireless links to a back-end processing server. A typical mobile phone based WBAN consists of three layers as shown in Figure 1. The first component is the sensor layer which measures physiological and even emotional signals and transmits this data wirelessly. The second layer is a mobile phone which acts as a data collection hub and receives the external sensor data. It may further enrich the sensor data with GPS , audio and video tags to get an accurate state of a person's health and environmental conditions. The mobile phone may also process data locally. The last layer is a back-end server that processes the data.

Fig 1 An Example 3-Tier WBAN System

II. MONITORING AND SENSING(WEARABLE SENSORS)

We begin with a review of current examples of wireless sensor technology in the field of mobile healthcare. The examples are organized according to a taxonomy that distinguishes between wearable and implantable sensors. Within these two sensor categories, the examples are organized by the type of signal acquired by the sensor.

A. Pulse Oximetry

A pulse oximeter is a medical device that indirectly measures the oxygen saturation levels (SpO2) in an individual's blood as well as the changes in blood volume in the skin that coincide with the cardiac cycle. Typically, a pulse oximeter is attached to a finger or an earlobe, and it consists of red and infra-red light-emitting diodes (LEDs) and a photodetector.The photodetector measures the amount of red and infra-red light that is transmitted through or reflected by the body part, which is partially dependent on the amount of light absorbed by the blood that perfuses the body part. The

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relative absorption of red and infra-red light by the blood is related to the ratio oxygenated hemoglobin to deoxygenated hemoglobin, and this serves as the basis of the SpO2 measurement. The overall amount of light absorption varies as the pulsatile volume of blood within the body part changes with time. This quasi-periodic signal is called a photo plethysmograph (PPG), and can be used to determine heart-rate.A wearable PPG biosensor in the form of a ring has been developed by Yang and Rhee [1].As an article of clothing, a ring is more likely to be worn continuously, making it suitable for continuous monitoring applications. Asada et. al. have further refined the design of the ring sensor to ensure that the PPG signal output is more resistant to noise components due to motion artifacts and changes in ambient light levels [2]. Also, they have sought to reduce power consumption by using a high frequency, low duty cycle modulation scheme. A picture of thering sensor is illustrated in Figure 2.

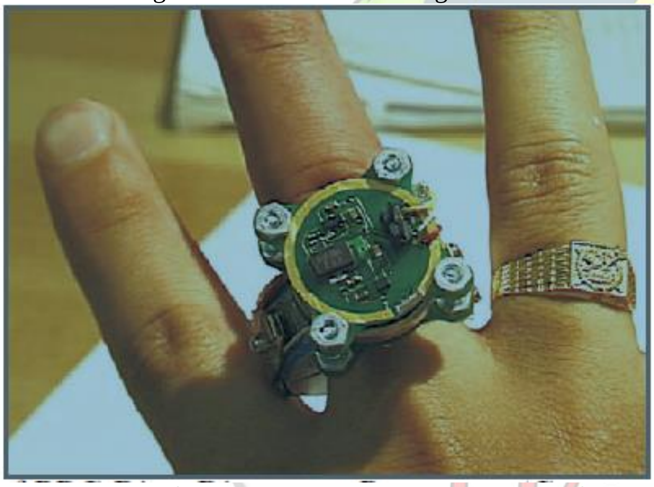

Fig 2 Photograph of PPG Ring Biosensor Prototype (Courtesy of Asada et. al [2])

B. Blood Pressure

A blood pressure (BP) reading is a measure of the force exerted by circulating blood on the walls of blood vessels. BP varies between a maximum (systolic) and a minimum (diastolic)pressure during a cardiac cycle. It has been observed that ambulatory BP is more closely related to target organ damage and cardiovascular events than BP readings taken in a clinical environment [3]. This fact provides the motivation for the creation of wireless BP sensors.The AMON system has a BP sensor that uses an inflatable cuff around the wrist and obtains systolic and diastolic readings via the oscillometric method [4]. Though this method can used to obtain ambulatory BP readings, it cannot monitor BP variations continuously and the cuff based measurement may cause user discomfort. These issues are remedied by Poon et. al. in the creation of a cuff-less BP watch sensor, based on the pulse transit time (PTT) method for measuring BP [5] (Figure 3)

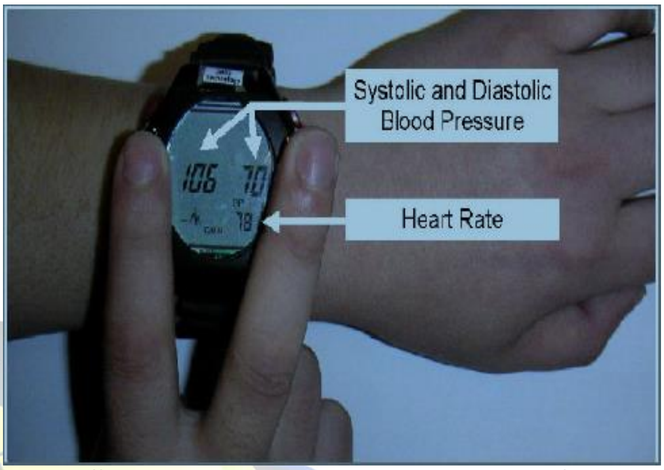

Fig. 3. Cuff-less Blood Pressure Watch Prototype (Courtesy of Poon et. al. [5])

C. Electroencephalography (EEG)

Electroencephalography (EEG) is a representation of the electrical activity of the brain.Currently, ambulatory EEG (AEEG) recordings have been shown to have great value in the diagnosis of epilepsy and in the monitoring of patient response to therapy [6]. Much of the information obtained from AEEG recordings may not be obtained during a routine, 20-min EEG test. This serves as motivation to develop wireless EEG sensors that will make the recording of AEEG signals during daily activities less obtrusive and less cumbersome. Jovanov et. al. have proposed using their Wireless Intelligent SEnsor (WISE) for EEG signal acquisition applications [7]

III. ARCHITECTURE OF WIRELESS SENSOR NETWORK/WBAN

There are three kinds of devices used in wireless body area network: medical sensors, special sensor for patient identification and setup pen as show in below diagram. We connect all these devices with health care system for display diagnostic results and further processing. One sensor node has a unique patient identifier which is used in hospital wide identification of patient. All sensors are connected to a patient from complete monitoring system. It works as medical sensor system having knowledge about the sensor configuration. The actual usage of these sensors are to discreetly sample vital signs and transfer the respective data on health care system using ZigBee and Bluetooth wireless technology[9,8].

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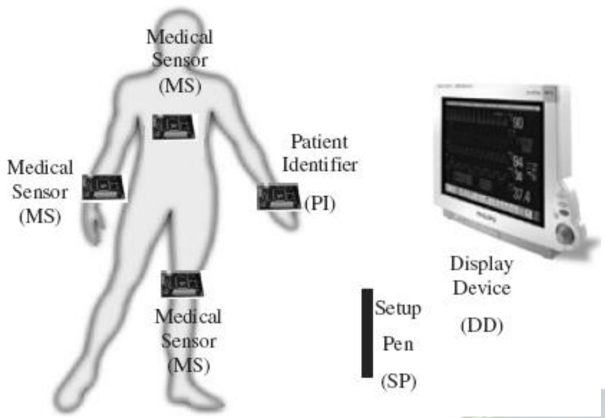

Fig 4 WBAN Architecture

We can implement health care server on PDA (personal digital assistant), smart phones and personal computer, and it control wireless body area network, provide suitable graphic or audio interface to client and transfer health related data to medical server through internet, wimax, or mobile telephone networks. [10]

IV. Body Area Network Applications To Healthcare Promotion

A. Cancer Detection

The second leading cause of death in US with rising numbers each year and nowadays one of the biggest threats for human life is cancer [11]. A sensor with the ability to detect nitric oxide (emitted by cancer cells) can be placed in the suspect locations. These sensors have the ability to differentiate cancerous cells, between different types of cells.
Preventing medical accidents

Approximately 98’000 people die every year due to medical accidents caused by human error [12]. Sensor Network can maintain a log of previous medical accidents, and can notify the occurrence of the same accident and thus can reduce many medical accidents [13].

B. HipGuard System

HipGuard system is developed for patients who are recovering from hip surgery. This system monitors patient’s leg and hip position and rotation with embedded wireless sensors. Alarm signals can be sent to patient’s Wrist Unit if hip or leg positions or rotations are false, and hence HipGuard system can provide useful real-time information for patient rehabilitation process [44].

C. eWatch

The eWatch is a wearable sensing, notification, and computing platform built into a wristwatch and developed for context aware computing research [14]. ewatch can be used for applications such as context aware notification, elderly monitoring and fall detection. An ewatch system can sense if the user is in trouble and then query to confirm that it is an emergency. If the user does not respond, then the ewatch can use its network abilities to call for help. The ewatch can also notify a patient when he takes certain medication

V. Conclusion

A WBAN intended for medical applications could be seen as a wireless sensor network since most medical applications will rely on sensors collecting data about, e.g., the heart and the brain. As such the sensor nodes must be kept simple in order to fulfil requirements on energy-efficiency and long battery life time. Things that influence the battery life time is the duty cycle of the sensing node, i.e., the active time period of the sensor node. To conserve energy the sensor node should be kept as long as possible in power-down or sleep mode. A drawback with long sleep periods is the clock drift implying that a node must also be awake longer once it wakes up due to clock drifting apart from other sensor nodes in the network making a rendezvous in time more complicated. The communication protocols within the node should be kept simple not requiring a lot of computation and also more advanced data/signal processing should be avoided in the sensor node.

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