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IMPLEMENTATION OF WIRELESS BODY AREA NETWORKS IN HEALTH MONITORING

Andrews. J, Venkatraman. S, Mrs.Sunitha.C
III M. Sc. Software Systems,
Department of BCA and MSS.,
Sri Krishna College of Arts and Science,
Kuniamuthur,
Coimbatore
andrewsj13mss007@skasc.ac.in

Abstract— **Wireless Body Area Networks (WBANs) provide well-organized communication solutions to the ubiquitous health care systems. Monitoring human health, tele-medicine, military, entertainments with human interaction and audio/video system-portability are some of the fields using WBANs. The miniaturized sensors are combined with the advanced Micro-Electro-Mechanical Systems (MEMS) technology to create a WBAN, which has the complete monitors on the patient health condition. This paper contains comprehensive information on the applications of WBANs which works on smart health care systems. We have highlighted a number of projects that provides WBANs an unremarkable enduring healthcare monitoring along with the updated condition of the patient to the health centre. Additionally, we have list many medical applications of a WBAN which has the capability of epileptic seizure warning, glucose monitoring, and cancer detection.**

Index terms- **Wireless Sensor Networks (WSNs), Body Area Network (BAN), Body Sensor Networks (BSNs), Healthcare and medical Applications, Smart Biosensor,**

I. INTRODUCTION

Improvements in wireless communication and micro-electro-mechanical systems (MEMS) allow the establishment of a huge scale, less power consumption, multi-functional, and perfectly small cost network. Wireless sensor networks (WSNs) can find many applications in multiple fields, such as medical monitoring, industrial automation, emergency response, infrastructure protection and optimization, security, seismic detection, environment and agriculture, automotive and aeronautic applications and military applications. Wireless sensor networks could be used efficiently in healthcare to increase the quality of life provided for the patients as well as the quality of healthcare services. For instance, patients who have been equipped with a wireless body area network (WBAN) have no need to be present physically for their diagnostics to the physician. A body sensor network evidences is suitable for emergency cases, where it independently sends data to that physician about patient health which helps physician to prepare for the treatment immediately. The biosensor based methodology can make the medical care further effective by reducing the response interval, and reducing the *heterogeneousness* of the application. After the sensors are embedded inside the human body it can form a wireless network between the sensors and few activities which are outside the human body. A wired network necessitates positioning wires inside the human body but the method is not appropriate therefore wireless network is the most appropriate selection. A wireless network can be used for a variety of applications and they include both data combination and data distribution applications. Biosensors are used for observing the physiological factors like blood pressure, glucose levels, collecting the health conditions for further analysis. Wearable health monitoring system provides an individual to closely observe the changes in the vital signs and provide a feedback which helps to maintain a finest health status. If the system is integrated into a tele-medical system, it can also alert the medical personnel during the life-threatening changes when occur. In the last decade there has been a substantial growth in the number of numerous wearable health monitoring devices, which ranges from simple pulse monitors, activity monitors, and portable Holter monitors, to refined and expensive implantable sensors.

II. THE SYSTEM MODEL

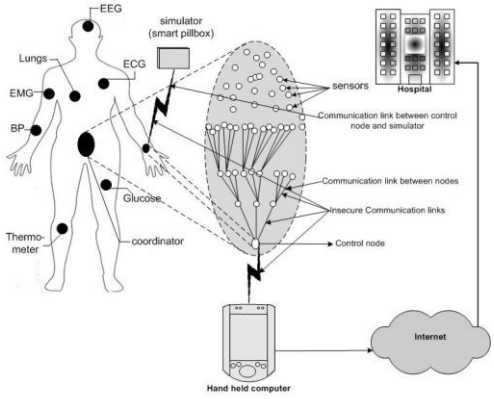

Figure-1: System Model *

This part describes the system model as shown in the Figure 1*. The biosensor network involves a group of biosensors embedded inside the human body, control node (external device) placed on the human body and a base station. The biosensors (between themselves) and the control node

form a network. The control node is linked to an external base station. The biosensor part consists of a processor, memory, transceiver, sensors/simulator and a power unit. These biosensors can perform some tasks like identifying information about the human body, processing it, and transmitting it to the control node, receiving external signals to activate action inside the body. The control node acts a both the data combination and distribution point. The data collected is sent spontaneously by the control node to the base station, the place where all data's are stored for additional processing. When the biosensors, the control node and the base station are compared, the base station has expressively faster transmission and high processing abilities. Biosensors have inadequate quantity of power and it cannot support heavy computation (calculation) and communication. Communication is much costly than computation, and sensing. Beside the additional expectations that the biosensors has the ability to perform multiple sensing functions instantaneously, we can also take note that the presence of a propagation model which can be used in figuring the transmission power on the basis of distance of communication. All sensors in the network don't have the ability to connect with the control node in a single hop. In wireless communication there are three types of links in the biosensor health care network system. They are the links between the biosensors, the links between control node and the biosensor, and the link between control node and the base station. Not like a wired channel, the wireless links data are accessible to everyone who maintains to attend the channel, and so all these wireless links are stated to be insecure. As an outcome, the data exchange process using these communication links should be secured. As stated before the base station and the control node has high computing and communication capability, so the link can be protected by asymmetric cryptography.

III. WBAN APPLICATIONS IN PERSONAL HEALTHCARE PROMOTION

Recent health monitoring applications of wireless sensor networks objective is to diagnose heart problems, asthma and emergency response, stress monitoring. The combination of surviving focused on medical technology with general wireless networks will be seen in the future. Medical applications profit from wireless sensor networks in various techniques. The latest developments in reduction of smart biosensors can create new opportunities for unremitting monitoring of patients health. Nonintrusive, tiny wearable sensor allows collecting of enormous volumes of data spontaneously, decreasing the cost and inconvenience of systematic visits to the doctor.

A. Cardiovascular diseases

Smart sensor nodes, which are inserted in the body of the patient in a modest method, can avoid a huge quantity of deaths affected in terms of cardiovascular diseases. This helps the resultant medical staff to prepare in advance when they obtain the patient's health status concerning heart rate and anomalies of the patient's heart.

B. Cancer Detection

The second foremost cause of death in US with increasing numbers each year and nowadays one of the biggest threats for human existence is cancer. A sensor with this facility to sense nitric oxide is positioned in the suspicious position. These sensors have the capacity to distinguish cancerous cells, among dissimilar sorts of cells.

C. Glucose Level Monitoring

The US NIH (National Institute of Health) stated that 15.7 million people had diabetes in 1999 in the US. Diabetes can produce further problematic diseases like heart stroke, High BP (Blood Pressure), eye blindness, kidney problems, etc. A biosensor embedded in the patient's body provides a regular, perfect, and fewer offensives which can monitor glucose levels and transmit the body's status to a wireless PDA and by Vaccinate insulin habitually when a particular glucose level is reached.

D. Asthma

A wireless sensor network helps millions of patients who are suffering from asthma. With the help of sensor nodes, it can sense the allergic agents in the air and transfer the status constantly to the physician.

E. Preventing medical accidents

About 98,000 people die every year due to medical calamities produced by human error. Sensor Network can sustain a record of former medical accidents, and it can also notify the existence of the same calamity so that we can reduce future medical calamities.

F. Epileptic Seizures Strike Early Warning

Due to Strokes 700,000 people affect each year in the US and around 275,000 die due to stroke every single year. Scholars from the University of Chicago Medical Centre have developed a device named "Mobi" as given in Figure 2. The scholars are trying to improve an initial cautioning algorithm for epilepsy. This portable unit "Mobi" was planned to identify abnormal brain activity which happens before an annexation. When the device picks the electrical trouble sign, it will convey an alert to the receiver so that the patient can intend to tell someone. An algorithm to detect a particular patient annexation is about to start is still an issue.

Figure 2.TMSI Device "Mobi"

G. Code Blue

Code Blue was developed at Harvard University. It is a medical research project based on sensor networks. The system assimilates small power wireless wearable vital sign sensors, handheld computers and location trailing tags. It has also services like testimonial establishment and handoff, location tracing, and in-network straining and collection of sensor-produced data. A modest request interface allows emergency medical technicians to request data immediately. Figure 3 shows a Mote based pulse oximeter and a Wireless Vital Sign Sensor which forms a part of hardware.

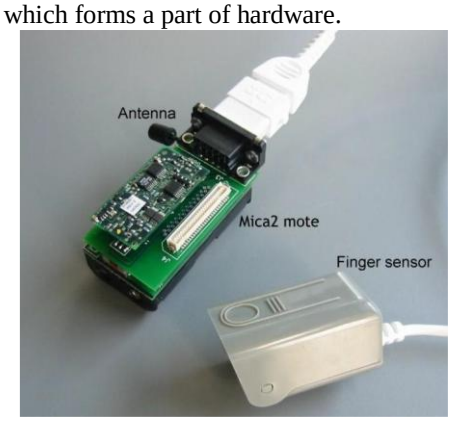

Figure 3. Wireless Pulse Oximeter Sensor

H. MobiHealth

MobiHealth uses (GPRS) wireless communication technology for transmitting data. MobiHealth targets to deliver uninterrupted monitoring of outer patients of the hospital. MobiHealth targets in enlightening the life of patients. It has also enabled fresh cost added services like disease prevention, disease diagnosis, and remote assistance, physical state monitoring and even in clinical research. So if a patient requires monitoring for short or long periods of time need not to stay in hospital for monitoring.

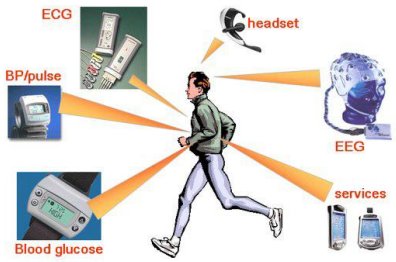

Figure 4. MobiHealth system, monitoring a patient outside the hospital environment

I. eWatch

Figure 5.eWatch computing

The eWatch is a portable wearing health computing platform. It is a built in a wristwatch and developed for environment aware computing study. This eWatch is used in areas such as elderly monitoring and fall detection. A eWatch system sense if the user is in trouble or not and then request to authorize that in emergency. If the user has response then the eWatch uses its own network facilities in calling for help. Figure 5 shows the ewatch system.

J. UbiMon

The UbiMon objects provide a constant and modest monitoring system for the patient to capture momentary events. In addition, a compact flash WBAN card is industrialized for PDAs, where sensor signals are collected, presented and examined by the PDA, as shown in Figure 6d.

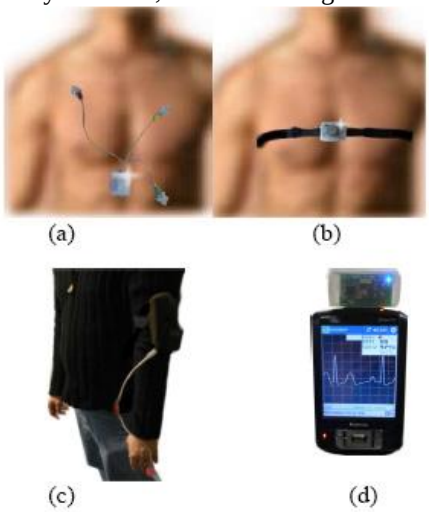

Figure 6. (a) Wireless 3-leads ECG sensor, (b) ECG strap (centre), (c) SpO2 sensor, and (d) The PDA base station

K. LifeShirt

LifeShirt is a relaxed and totally non-offensive "smart garment". It collects the patient's data routinely, provides the thorough distant representation about the patient's health. LifeShirt gathers persistent data using unified sensors including respiratory bands and an ECG. It also traces and collects posture and physical activity of the patient. Figure 7 shows smart LifeShirt.

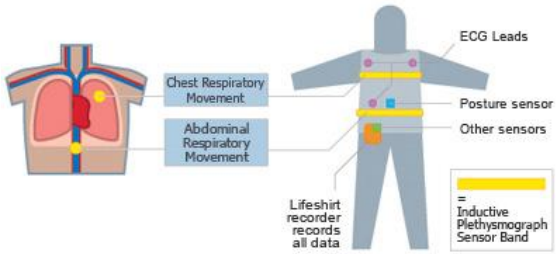

Figure 7. Smart LifeShirt

L. Artificial Retina

WBANs also assist blind people. A patient who has blind vision or limited vision can be given a sensible level vision by means of retina prosthesis chips embedded inside the human's eye, as shown in Figure 8.

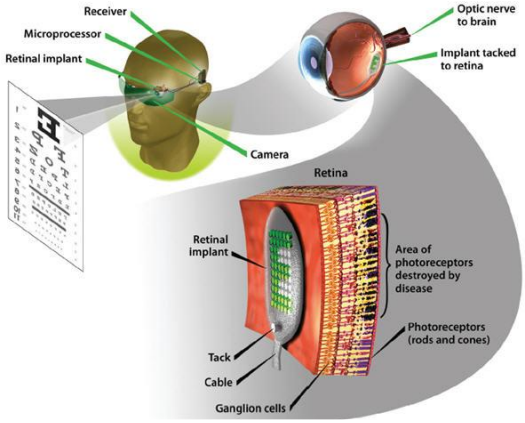

Figure 8. Artificial Retina for Blind People

IV. CHALLENGES IN A WBAN

The increasing population of all developed countries grants a nurturing portion of government's budget, and grants innovative tasks to healthcare systems, especially with aged people living on self-governing senior housing. In general, health monitored is done in a periodic basis. In this case the patient necessity thinks of its symptoms; the doctor performs some exams and strategies a diagnostic, then screens patient improvement along the treatment.

A. Power Challenge

As most wireless networks based devices are battery operated, power challenge is present in almost every area of application of wireless sensor networks. Limitation of a smart sensor implanted on a person still poses further challenges. In a full active mode a node can't operate more than a month because a typical alkaline battery provides about 50 watt-hours of energy. In practice, for many applications, they have to guarantee that the device will work for a year or two without any replacement. This could include devices such as heart pacemakers. To deal with these power issues the developers have to design better scheduling algorithms and power management schemes.

B. Computation

Due to both limited power as well as memory, computation should also be limited. The biosensors cannot perform large bit computations due to lack of enough memory. Unlike conventional wireless sensor network nodes, biosensors do not have much computational power. Since communication is vital and memory is low, little power remains for computation. A solution is that some sensors may have varying capabilities that communicate with each other and send out one collaborative data message.

C. Security and Interference

One of the very important issues that are to be considered especially for medical systems is Security and interference. Physiological data collected by the sensor network is the health information, which is of personal nature. It is critical and in the interest of the individual, to keep this information from being accessed by unauthorized entities. This is referred to as Confidentiality, which can be achieved by encrypting the data by a key during transmission. Data Authenticity is also one of the security requirements. This property is very important for the biosensor network because absence of this property may lead to situations where an illegal entity disguise as a legal one and reports false data to control node or gives wrong instructions to the other biosensors possibly causing significant harm to the host.

D. Material Constraints

Another issue for wireless sensor networks application to healthcare is Material constraints. A biosensor should be implanted within the human body, therefore the shape, size, and materials might be harmless to the body tissue. For example, a smart sensor designed to support the retina prosthesis might be small enough to fit within an eye. Also chemical reactions with body tissue and the disposal of the sensor are of extreme importance.

E. Robustness

Whenever the sensor devices are deployed in harsh or hostile environments, Robustness rates of device failure becomes high. Protocol designs must have built-in mechanisms, that the failure of one node should not cause the entire network to cease operation. A possible solution is a distributed network where each sensor node operates autonomously though still cooperates when necessary. For instance, if the sensor part is not working, the communication part should be used if it benefits the network and communication is operated as expected. One way to achieve this would be that a node might be comprised of a sensing block, a communication block, a scheduling block, and a data block. This would be a good way to isolate the malfunctioning block from the rest of the components in the node, as well as reducing power consumption among the various components. In order to ensure that the proper data is being sent and received, there are few alternatives that can be used, like checksums, parity check, and cyclic redundancy check.

F. Continuous operation

Continuous operation must be ensured along the lifecycle of a biosensor, as it is expected to operate for days, sometimes weeks without operator intervention. Hence it is important to keep the amount of communications to the minimum. It is necessary that those communications which occur for purposes other than the actual data communication should be minimized if it is not possible to eliminate them.

G. Regulatory Requirements

Regulatory Requirements must always be met. There must be some testimony that these devices will not harm human body. The wireless transmission of data must not harm the surrounding tissues and the chronic functioning. Power utilization of these devices must also be non-malignant. Design for safety must be a fundamental feature of biomedical sensor development, even at the earliest stages. It is conceivable that some immoral researchers could perform tests and trials with devices that are dangerous to the volunteers. Therefore, it is imperative to have diligent oversight of these testing operations.

V. CONCLUSION

This paper demonstrates the use of Wearable and implantable Wireless Body Area Networks as a key infrastructure enabling unobtrusive, constant, and ambulatory health monitoring. This new technology has the potential to tender a wide range of assistance to patients, medical personnel, and society through continuous monitoring in the ambulatory environment, early detection of abnormal conditions, supervised restoration, and potential knowledge discovery through data mining of all gathered information. We have described a general system model for the biosensor network implanted inside the human body and some important issues and challenges that a WBAN can face.

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