A Paradigm Shifting to Wearable Wireless Bio-sensor Technology for Remote Health Monitoring: A review

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ABSTRACT:Latest rapidly emerging technological growth in wireless sensor networks and wireless communications have make life of patients more comfortable through design of wearable unobtrusive, miniature, lightweight, tiny, intelligent, low cost medical sensor nodes that can placed on various body parts of patients, which creates a wireless body area network (WBAN) observe physiological vital signs for twenty four hours through day and to provide second wise (real-time) feedback to medical staff and to patient himself. In this paper various medical sensors as per requirement used to collect the physiological symptoms in the form of digital data and transmit information to the Intelligent Personal digital Assistant (IPDA) by using wireless ZigBee/IEEE802.15.4 standard protocol and also to medical server situated over long distance from patient by using 3G internet[2]. In this three level architecture get introduced which involves improvement in the transmission rate using data compression and priority scheduling to maximize utilize maximum bandwidth.

KEYWORDS: Wireless Body Area Networks, Wireless Sensor Networks, IPDA, ZigBee/IEEE802.15.4

I. INTRODUCTION

Wireless Sensor Networks (WSNs) with embedded intelligent medical sensor nodes enables the wide range of applications for patients who are suffering from various diseases in their life [4]. New generation of wireless sensor networks have enabled miniaturization and integration of medical sensors; advance 8085/AT Mega microprocessors and microcontroller along with electromagnetic radio interfacing devices on a single chip. They can used in for healthcare monitoring, sports science, industrial automation, agricultural applications, environmental monitoring, activity recognition, prevention of road accidents, and many more applicable in our daily life. A wireless sensor network (WSN) involves multiple nodes equipped with sensing and memory unit, microprocessors (microcontroller), communication interface (wireless),power batteries, where multiple medical sensor nodes in the same vicinity communicate with routing network. To increase spatial coverage, accurate fault tolerance, unobtrusive solution, robustness WSNs can be used in ad-hoc manner. WSN greatly used to observe and monitor real-time feedback of the patients who are suffering from various diseases or physical disorders such as asthma, diabetes, blood pressure, cardio-vascular diseases etc. [2] through internet reducing stress and strain of healthcare providers, relaxing workload and increase efficiency of hospital staff, economical cost of travelling, reduce medical errors.

Lack of correct information can leads to the wrong diagnosis of patients health and result in death. So this motility can be reduced if patients are provided required drugs by medical staff with correct information at right time. Also from the patient's safety point of view, it's necessary for the hospital staff to get real-time feedback time to time within short period.

Medical sensor nodes attached to the patient's body creating cluster called as wireless body area network (WBAN) that deployed to collect information from patient's vital signs. Medical sensor nodes are operated by power batteries which act as power bank for that respective sensor for data transmission between medical sensor node to IPDA and reliable data transmission between WBAN and personal server [2]. When information about the patients' health   is transmitted through mobile phones *i.e.* PDA, General Packet Radio Service (GPRS)and internet and used in biomedical applications then that network referred as wireless biomedical sensor net-works (WBSN).WBSN integrates the tiny miniaturized intelligent medical sensor node to monitor internal body functions along with surrounding environment. Each medical sensor node senses vital signs,process and forward to the Super sensor node.

Body sensor networks (BSNs) advantages given below:
1. Patients wearing sensors with BSNs not necessary be physically present in health care center for their diagnostic.
2. Healthcare providers or doctors read updated real-time feedbacks of physiological data in time and suggests correct diagnosis for patient's recovery.
3. Physiological data get stored in database of medical server automatically, so travelling efforts and transportation cost decreases. Need of regular visit to doctor is only in critical health situation.
4. Simultaneously monitoring multiple patients is possible.

WBAN senses, detects and stores vital signs of the patient's body in the form of electrical signals e.g. oxygen level in blood, amount of sugar in plasma cells, heart rate. During first visit to doctor they are can't diagnosis correctly. During an emergency, WBSN automatically supply adequate information so that healthcare providers can take immediate action to improve patient's health.

In this paper, under biosensor technology wireless sensing network is introduced in which multiple body sensors over the human body of WBAN senses physiological vital signs and collects that whole information to Medical Super Sensor (MSS) and forward them to Intelligent Personal Digital Assistant (IPDA) which act as personal server. Personal server prioritizes which data t be transmitted first according to the patient's health condition.

II. WIRELESS BIOSENSORS APPLICATIONS

Wireless Biosensors Technology applicable to diagnosis various critical diseases in human body as well as in other industrial, agricultural, seismic sectors etc.

1) Asthma
Asthma is related to respiration system. When unwanted agents in the form of partials goes through respiratory system human body does accept it. Ultimately patient suffers from asthma. WBAN used to continuously monitor allergic unwanted agents in environment and provide real-time feedback to medical staff as well as to patient himself. The server also stores data national air quality monitoring stations. If air quality is bad then immediately feedback is given to the medical staff or healthcare providers [2].

2) Cardiovasculardiseases
Cardiovascular diseases related to heart problems which impacts on heart and blood vessels. When the diameter of blood vessels is reduced due to oily substances blood circulation get reduced in human body due to which the amount of oxygen decreases to different parts of body. Ultimately heart failure, heart attack and coronary artery disease occurred.According to World Heart Organization near about 17 million annual deaths are due to cardiovascular diseases.WBAN is one of the best real time biosensor technologies which give the update information regarding hart operation, blood vessels diameters to the healthcare providers so that they can provide proper treatment to the patient.

3) Cancer detection
Cancer is related to extra growth of different cells within human body. It is very harmful to human body. According to the survey of National Centre for Health Statistics number of cancer patients is increasing ever year. A WBAN with a

set of various biosensors detects these different cancerous cells, gives the information to medical staff situated over the long distance, due to which diagnosis of tumors without biopsy is possible.

4) Detection of glucose level
Diabetes is related to glucose level in human body [1]. According to World Health Organization (WHO) 220 Millions of people over the world suffering from diabetes and many peoples are died due to it. Diabetes causes kidney disease, high blood pressure, blindness, stroke, amputations etc. With the help of yoga or other exercises diabetes can be controlled. WBAN gives accurate data of glucose level to medical server so that diagnosis is made easy
.

5) Retina
Retina is one of the major part of eye for vision. Merging advance Optoelectronic Retina Prosthesis (ORP) chips into the back of human eye which helps to blind persons or patient having low vision to see normally [3].

III. SYSTEM DESIGN

Under system design three levels get introduced in which remote healthcare monitoring is made possible with embedded advance technology wearable biosensors.
The composed system has three levels as shown in Figure.1 below.
   a)   Wireless Body Area Network (WBAN);
   b)   Intelligent Personal Digital Assistant (IPDA)
   c)   Medical Server for Healthcare Monitoring (MSHM).

3.1 Primary Level
Patient who is suffering from any type of cardiovascular diseases, wearable biosensors get attached to respective body parts so that correct signal can achieve. Whatever signal generated from patients physiological vital signs are transferred to medical super sensor situated at hip level of body. These wearable biosensors provide real time feedback of respective signal to the medical server to improve health status [2]. Generally medical biosensors consisting of following components as:

1) Biosensor: It is the delicate sensing device to sense physiological vital signs from respective body parts of patient. Type of sensors is used as per signal detection. For example, an electrocardiograph (EKG) sensor utilized for monitoring heart beats, a blood pressure sensor can apply for observing blood pressure, a breathing sensor for monitoring respiration, also for monitoring muscle activity an electromyogram (EMG) sensors are used, and an electroenphalogram (EEG) sensors for brain activities etc.

2) Microcontroller: It is the main part in which detected signals are processed as per requirement to analyze and compressed in smaller unit to store in memory in the form of binary bits. Functionality of various parts of biosensors controlled by microcontroller.

3) Memory: Converted electrical signal to binary signal get stored inside memory temporarily in compressed format, so that whenever data is required can fetched from memory.

4) Radio interface: Wireless communication is possible between different biosensors and medical super sensor with the help of radio interface having special frequencies.

5) Battery: It is essential part of biosensor in WBAN network. Power supply is provided with these batteries for interrupted signal detection and transferred it within thin WBAN. Multiple biosensors are integrated into master Medical Super Sensor (MSS).They collect information of Physiological vital signs from various parts of body and transferred it to MSS for storing, processing and communication with personal server. ZigBee is more sophisticated network used for communication between MSS and personal server.

Bluetooth technology is has some limitations ZiggBee technology. Bluetooth seven active slaves can be controlled by one master. But if number of slaves increases then this technology is beneficial. The ZiggBee/IEEE 802.15.4 standard having low cost, low power consumption, short range is beneficial in wireless biosensor technology. ZiggBee network is used to transfer data from MSS to IPDA (Personal server). ZiggBee network can connect 65,000 nodes simultaneously widening range of sensor nodes and reliability of data transfer. Data rate is 250 kbps which uses Industrial, Scientific and Medical (ISM) free band *i.e.* 2.4 GHz.

6) Security through encryption technology: Information recovered regarding patients health is very sensitive from security point of view. Interference of unauthorized person to this information can give wrong data to medical staff, ultimately wrong diagnosis leads to patient's death. So security is major issue during transmission .ZigBee is one of the advance technology used, in which Advanced Encryption Standard (AES 128) to encrypt original data and transmit it securely.

The whole physiological data gathered together and collected by Medical Super Sensor (MSS),which samples physiological data and filtered out unnecessary redundant data from signal so large size of data get compressed into small size and store them into memory temporarily [2]. Physiological data in the form of signal is processed and transferred to personal server IPDA through advance ZigBee/IEEE 802.15.4 standard. Biosensor nodes does not transmits data to IPDA directly but transmit it to MSS only, so power consumption is very low which extends the battery life of each biosensor node.
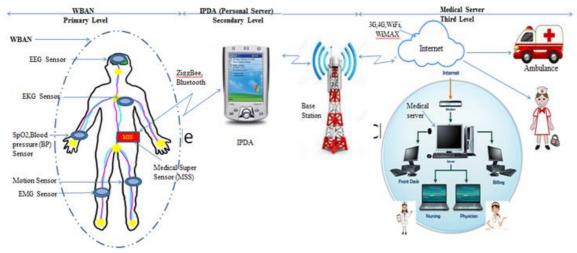

Figure 1.Three Level Architecture.

3.2 Secondary Level

Intelligent Personal Digital Assistant (IPDA)

Physiological data in the form of signal received from MSS to IPDA through ZiggBee network protocol. Personal server is implemented on IPDA. Physiological data is received from WBAN then processed. IPDA stores processed physiological data temporarily, authenticate and configure it with medical server IP address. Priority of data transmission is decided as per the patient's health condition which critical signal should be transmitted first so that patient's health will improve or come out of critical health situation .Configured data is transmitted to respective IP address of medical server for proper diagnosis by medical staff.

IPDA has the basic feature of analyzing the physiological data intelligently. When there is sudden change in physiological signs of patient such as oxygen saturation, glucose level in blood, temperature, cardiovascular signals, and blood pressure, immediate analyzed signal seen in the user friendly and interactive graphical format on IPDA display. It transfers the information through 3G or 4G, Wi-Fi, WiMAX, GPRS, WWAN communication network.

In order to improve the impact of data transmission parameters like latency, data rate, bandwidth utilization, power consumption of batteries should be considered. Based on data rate and latency parameters, transmission of information of patient's vital signs is divided in four sub types as [2]:

a. Data rate = 1, latency = 0
b. Data rate = 0, latency = 0
c. Data rate = 0, latency = 1
d. Data rate = 1, latency = 1

High data rate is represented by 1 means data transfer from MSS to medical server is very fast.
Low data rate is represented by 0 means data transfer from MSS to medical server is very low.
Low latency is represented by 0 means time delay to response of transmission of critical signals of patients vital sign is very low.
High latency is represented by 1 means time delay to response of transmission of critical signals of patients vital sign is very high.

In order to transfer information of patients vital signs received from IPDA to long distance situated medical server within short duration as per priority and do the proper diagnosis by medical staff or healthcare persons to improve the patient's health, physiological signs has given weight as per priority as shown in table 1.Physiological sign having priority weight 1 has highest priority means, that physiological signal should transfer first without time delay. Also it shows that patient is in critical condition and needs immediate help from doctors. Data is compressed in smaller units and transferred due to which utilization of bandwidth is maximum. Priority scheduling decreases traffic congestion as well as improves the transmission delay [2].

Table1. Priority of Physiological Vital Sign

Physiological Signs	Data Rate	Latency	Priority
Electrocardiograph(EKG)	High	Low	1
Heart Rate, Blood Flow (Viscosity of blood), Oxygen Saturation Level	Low	Low	2
Respiration Rate, Blood Pressure (BP), Temperature of Body	Low	High	3
Never Potentials	High	High	4

During no vital signs IPDA becomes in inactive mode but immediately turns to active mode during sensation of vital sign so that medical staff can get sufficient amount of time to reach patient to them and start treatment for patient's safety. Major critical signals having highest priority transmitted first while less critical signals are stored temporarily in database of personal server and transmitted later to long distance situated medical server. Energy consumption during transmission from IPDA to medical server.

3.3 Third Level (Backbone)

Medical Server for Healthcare Monitoring (MSHM)

The third level is related to medical server situated at remote distance which is known as Medical Server for Healthcare Monitoring (MSHM).Medical servers are situated at healthcare medical centers, hospitals where patients information is stored in secured digital format into the database. Patient's current health information and previous treatment records are stored in database of medical server. MSHM keeps this whole information in the form of electronic medical records (EMRs) which can be accessible by respective doctors, healthcare persons and nurses. Medical staff authenticates that patient by its registration into the database then provide electronic medical records (EMRs) from current health information and previous treatment records to the respective doctors so that they can analyze data and make the proper diagnosis to improve the patient's health. As per priority firstly critical signals are analyzed.

The information is accessed by medical staff through internet whether that patient's health readings are within range or not. If health readings are out of range then immediately medical staff comes to know and do necessary actions as per it. The MSHM provides necessary feedback instructions to patient regarding health improvement.

IV. CONCLUSION

From above description, with the help of advance wireless technology monitoring of patient from remote distance is possible through biosensors. Through three level architecture as well as priority scheduling and data compression techniques patient's health related information can transferred very fast in secured and minimized format within short duration with low latency and high data rate to do proper diagnosis of patient by respective medical staff or doctors situated over the long distance by electronic medical records (EMRs) which are stored into the database of medical server. In this way by continuous health monitoring and respective real time feedback doctors are able to provide proper instruction and treatment method to patient. So wireless biosensor technology is very helpful to our health conscious society to reduce the mortality rate all over the world

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