Patient Health Monitoring Using Wireless Body Area Networks

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ABSTRACT

The rapid technological developments in intelligent sensors, low power integrated circuits, and wireless networks have facilitated the design of intelligent wearable and implantable devices for long term monitoring of physiological signals. We believe that the recent development in wireless body area networks (WBANs) promise the low cost health care and continuous health monitoring of patients suffering from chronic diseases such as heart disease, kidney disease, diabetes and hypertension. In this paper, we have discussed the existing architecture of WBAN and their applications. Furthermore, we have also talked about the current research issues, challenges and future trends.

Keywords: Wireless Networks, Wireless Body Area Networks, Wearable Computing, Health Monitoring, Sensors.

1. INTRODUCTION

According to World Health Organization (WHO) in Republic of Korea 17% people die due to cerebrovascular disease [1]. In United States between 44000 and 98000 people die to preventable medical error by physicians [2] and the overall national’s annual medical cost is reached around $1.8 trillion in 2004 [3]. In Europe, 90% of people die due to arrhythmogenic event [4]. Irregular heart beat causes such deaths and can be monitored before heart attack. Currently, holter monitor is used to collect cardio rhythm disturbances but the system doesn’t provide real time feedback and the ECG data is collected for offline processing. Transient abnormalities are sometimes hard to capture. For instance, many cardiac diseases are associated with episodic rather than continuous abnormalities such as transient surges in blood pressure, paroxysmal arrhythmias or induced episodes of myocardial ischemia and their time cannot be predicted [4]. In future the WBAN technology will improve the quality of life at low cost and reduced hassle of medical professionals with the availability of vital information of patients at any time and at any place.

A recent development in intelligent sensors and wireless networks are playing significant role in our routine lives. Though WBAN can not avoid all medical errors but in order to reduce the medical cost and avoid preventable medical errors, WBANs offer the early detection of disease and continuous access of patient’s vital data. Typical WABNs consist of light weight, miniaturised, low power and inexpensive sensors, either wearable or implanted into the human body, which monitors the vital physiological data of the patients such as electrocardiogram (ECG), electromyography (EMG), blood pressure sensor, motion sensor and breathing sensor etc. [5]. The WBAN technology is just started and is hot research area world wide, and is expected to be an integral part of healthcare solutions leading to concepts like telemedicine and m-health [6]. This paper contains a brief overview of WBAN architecture. We have presented various research and industrial applications of WBAN technology. We also talk about various research issues and challenges and finally, we discuss various possible research trends.

2. WBAN ARCHITECTURE

A health monitoring system or WBAN is a multi-tier architecture as shown in Figure 1. The lowest tier consists of a set of intelligent physiological sensors either wearable or implanted in to human body which monitors the vital physiological signals and communicates with the second level i.e. a personal server, which forwards information to the medical database stations.

The lowest level is called the sensor level and consists of physiological sensors such as electrocardiogram (ECG) for monitoring heart activity, electromyography (EMG) for monitoring muscle activity, blood pressure sensor for monitoring blood pressure, movement sensors for monitoring user’s activity, and oxygen saturation sensor (SpO2) for monitoring the level of oxygen etc. depending on the patient’s clinical requirements. These
physiological sensors are extremely low power which makes them suitable for human body [7]. These physiological sensors collect the vital patient information and transfer to a personal server through WBAN technologies such as Bluetooth (IEEE 802.15.1) or ZigBee (IEEE 802.15.4). The personal server can be a cell phone, personal digital assistant (PDA), user’s personal computer, or any other intelligent node which pull together the patient’s vital information and communicates with the top level remote base station i.e. health provider’s medical server through the internet or mobile telephone networks such GPRS or 3G.

The top level of the tired architecture is consisting of remote base stations or health provider’s medical servers. The medical server automatically collects the patient’s data and processes them and issues recommendations and if necessary store them into the patient’s medical database for future use [5]. The GPRS system is used to locate the exact location of patient. The medical server also authenticates the registered users and triggers the events to emergency care givers when serious health irregularity is recognized [8].

3. CURRENT RESEARCH AND APPLICATIONS

Traditionally, Holter monitors were used to collect cardio rhythm disturbances for offline processing without real time feedback. Some other monitoring systems such as portable Holter monitors [9], simple pulse monitors [10] and activity monitors [11] have been developed. However, these traditional systems are unsuitable for ambulatory health monitoring. The sphymacor and portapress system are installed in laboratories and hospitals for hypertensive study. Both methods provide invalid information of arterial health and don’t reflect any form of arrhythmias [12].

A CodeBlue project at Harvard University has developed various hardware platforms such as Wireless pulse oximeter sensor, EMG sensor for stroke patient monitoring shown in Figure 2 and 3 and developing various software application for wireless medical services [13]. A project called Connect focuses on the development of a distributed wireless communication infrastructure to customize wireless devices of disabled people for communicating with their health service provider [14]. A project called MobiHealth has developed a wearable monitoring system for health monitoring of patients in tandem allowing them to freely move and hound their daily life activity [15]. The aim is to develop a fast and reliable system in case of accidents to send audio and video data continuously to the health care centre from the accidents’ site.

Recently many researchers concentrate on power consumption issue for body area network. The existing WBAN architecture including BSN node uses IEEE 802.15.4 (Zigbee) wireless link as a low power communication protocol. But the narrowband implementation doesn’t satisfy the energy consumption budget of the sensor nodes. The extreme usage of power

![Figure 1: Pervasive Health Monitoring System](image-url)
consumption in body area network leaded researcher to choose an alternative solution and hence the emerging UWB technology is considered to be the best alternative. A pulse-based UWB scheme for body area network has been proposed where the transmitter can be duty-cycled at the pulse rate which reduces the baseline power consumption [16]. ETH Zurich has presented a UWB channel measurement with antennas placed on human body where the influence of the body on the channel is highlighted [17]. Moreover, a UWB antenna for WBAN operating in close vicinity to a biological tissue is proposed in [18]. This antenna can be used in UWB wireless body area network applications between 3GHz and 6GHz. Within the framework of its Human++ program, IMEC in collaboration with the University Hospital of Leuven, developed a prototype of a wireless electroencephalogram (EEG) [17]. A Low-power star-topology BAN Controller is proposed at KAIST [19]. In their work a low power controller chip is designed in order to reduce the baseline power consumption. An intelligent for wireless body area network has proposed for stress mentoring [20]. An arrhythmia systems is presented for sending ECG signals with GPS data over GPRS network [21]. The 802.11 WLANs with Bluetooth technology can be used for transferring the patient’s vital information such as ECG signals [22]. Ad-hoc wireless networks can also be used in health monitoring as patients can transmit their vital information to the near by patients and so on until it received by the health care experts [22].

4. RESEARCH ISSUES AND CHALLENGES

Health care monitoring with WBAN is a real-time service and requires strict and quality requirements [22]. The health monitoring with WBANs may become reality but it includes a number of research challenges [4].

System Design Issues

The trouble-free use of health monitoring requires extremely low power, light weight and small size sensors. The system should be environmental aware and ensure reliable and secure communication [23]. The system requires flawless configuration, integration and intuitive user interface.

Interoperability

Since WBAN is new and developing technology and doesn’t have well defines standard, therefore, interoperability becomes an important issue such as different sensors and prototypes developed by different organizations follow different standards. Different sensors working on different frequencies, and different communication protocol such as ZigBee, Bluetooth needs to work together in a reliable fashion.

Reliability

Since the health monitoring requires real time data in order to provide better recommendations to users but the application can not guarantee reliability due to unavailability of bandwidth, communication range etc. Therefore reliable communication is a challenging issue for health care service providers.

Security and Privacy

Security is another important aspect of wireless BAN since the WBAN uses transmit patient’s data through the internet which requires reliable encryption algorithm to secure patients vital information, and creating a secure application is also a challenging task.
Software Issues

Since the health monitoring system consists of large number of physiological sensors and operates in highly dynamic environment. University of Oregon has developed a mechanism called resource qualification which allows the monitoring system to check the availability of sufficient resources required to send patients vital information [24]. Wireless BAN requires efficient prototype and software methods for reliable and secure communication.

5. FUTURE TRENDS AND CONCLUSIONS

Wireless BAN is a promising technology has a great potential in long term health monitoring and can provide better quality life and health awareness. Though WBAN is still in development stage, few companies are developing product in order to make life better and healthy such as Patient Home [25], iRevive [26], etc. Future applications include smart health care services, remote diagnostic and telemedicine, wearable technology to monitor vital signs, smart nursing homes, emergency communication and patient’s data maintenance. WBAN requires the resolution of many technical issues and challenges such as interoperability, QoS, scalability, design of low power RF data paths, privacy and security, low power communication protocol, information infrastructure, and data integrity of the patient’s medical records. An adaptable wireless BAN requires the use of broadband signaling scheme such as UWB. The protocol such as WASP and CICADA needs further improvement in order to provide uplink communication from sink to the nodes. In future, we aim to modify the existing BSN platform by disabling the on board radio (which uses ZigBee) and investigate the uses of UWB technology on body sensor network (BSN) platform. The received physiological signals from BSN node will be calibrated into FCC mask. The calibration process is a challenging task due to the discrepancies between higher and lower frequencies. The integration of UWB technology on BSN node could satisfy the energy scavenging limit and improves the lifetime of sensor nodes.

We described the importance of wireless BAN in healthcare applications. Furthermore, we discussed about WBAN and BSN architectures. Current research and development in wireless BAN has briefly discussed. Finally, we described the technical issues and challenges in wireless BAN along with alternative solutions. We believe that Wireless BAN will remove the restriction from the patients and allows them to move freely while maintaining their health status.

REFERENCES

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