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WBANs: A Review on Real Time Healthcare Applications and Challenges

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Abstract - *The real time monitoring of various physiological parameters using wireless sensor networks of wearable and implantable sensors enhanced healthcare spectacularly in recent years. But the potential of the system still rests upon the limitations of the WSNs like network capacity, data storage and energy efficient design. Also, data integrity and security are essential requirements of any data communication system. This paper reviews the recent trends in the wearable Wireless Body Area Networks (WBANs) and Implantable WBAN and the major challenges faced by theses systems when they are deployed in critical healthcare applications. The comparative study of the existing systems and their features are done in terms of network capabilities and power utilization to highlight the open areas and the future research directions.*

***Key Words*: WABN, sensor nodes, patient monitoring, health care**

1. INTRODUCTION

The shortcomings of many traditional healthcare techniques can be overcome by ICT based remote systems [1]. Advances in the wireless networks, information technology and miniaturized medical sensors have enabled continuous real time monitoring of patients and thereby improved the treatment efficiency. The combined applications of multiple technologies added to the development of Wireless Sensor Networks (WSNs) i.e; a group of sensor devices working in collaboration to monitor physical parameters required for a specific application. Sensor nodes typically consist of a power source, processing element, sensors/actuators and a wireless networking modules. Each node will be capable of working autonomously or in collaboration and have the capability to sense, store, process and communicate the data with the neighbouring nodes or servers.

In WSNs designed for medical applications the sensors are placed over the person's body to sense the vital parameters. The sensors can be externally wearable devices or implantable devices [2]. Recent works are concentrating more on real time applications where the sensing nodes sense process and send the data to the terminal user instantaneously. Wireless medical sensors both wearable and implantable system use medical wireless telemetry services to develop a reduced interference network. WBAN are broadly classified into two: (i) general patient condition monitoring systems – those used for ambulatory monitoring of lifestyle diseases like diabetes, pressure variations and sleep disorders etc. and (ii) specific condition monitoring systems – those including implantable sensor monitoring for critical care. The challenges faced in the implementation of WBAN can be placed in two domains – the physical discomfort of the individual using the device and the networks technical challenges.

In the rest of the paper section 2 outlines the architecture and medical applications of the WBAN. The design challenges are given in section 3 and finally, section 4 gives a brief conclusion.

2. WBAN ARCHITECTURE AND APPLICATIONS

WBAN are specialized application networks designed for medical assistance and diagnosis. These networks will have miniaturized sensor devices as their input sources. These sensors can be externally attached transducers or implantable devices. The wide range of parameters sensed by these wireless devices includes vital parameters range from simple pulse rate to bio-potentials in micro volts. The sensor nodes are wirelessly networked and they record the measured data to a central base station or a real time monitoring device. The recorded data is analyzed to detect emergencies or abnormalities and raise alarms at the right time [3].

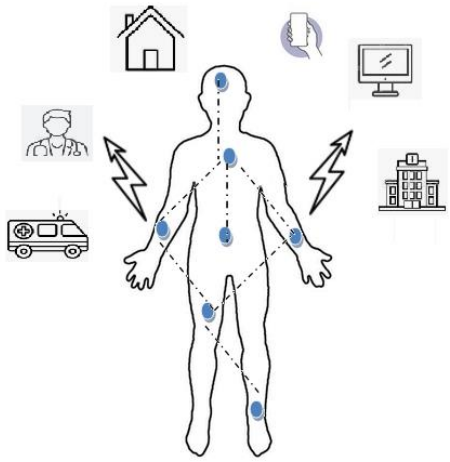

Fig -1: Architecture of WBAN

In systems that use these kinds of remote sensing and wireless data communication can cause errors and false alarms, the main reasons behind reduced computational facilities, poor noise management, wrong placement and

sensing and security issues like malicious node attacks. The simple system architecture of a WABN is shown in Figure 1.

2.1 Wearable WBAN applications

The main aim of any medical WBAN applications include long term monitoring and recording, real time monitoring and control and finally the conversion of this raw data to useful medical records. Any wearable WBAN system consists of several miniaturized, wearable autonomous sensor elements to monitor the biological functions without hindering the person's normal daily activities. The wearable sensors are designed in the shape of simple wearable objects like bandages, watches, bracelets, clothes etc. The main on-body applications of this technique include physiological parameter monitoring, cardiac health monitoring and sleep apnea monitoring. The data recorded at the sensor nodes are stored in different ways [4]. In the first method the data are sending to gateways either processed or unprocessed. Here gateways are acting as the backbone of the remote monitoring system which acts as the relay node that transmits the recorded data to the monitoring system. The second method is to include a personal server application to a personal portable device to store and process the data. Although most of the medical application nodes are autonomous in nature they also work in collaboration with neighboring nodes in analyzing physiological parameters in the nodes itself to control several emergency alarms.

2.1 Implantable WBAN applications

The recent advancements in the design of on-chip technology lead to the in-vivo applications of sensor nodes. These applications are using implantable wireless sensor chips that can do a lot more than simply sense a physiological event. Patients with chronic illnesses benefit from these technological inventions. The recent development in the field of micro-electromechanical systems, nanotechnology, micro-fluidics and biocompatible material designs lead to a tremendous advancement in the design of implantable sensors to detect many parameters for detecting diseases. The sensors aim at identifying physiological changes associated with internal organs (pressure changes, flow rates etc), presence of pathogens and ion concentration variations to predict possible clinical emergencies for critically ill patients.

3. DESIGN CHALLENGES OF WBANS

WSNs when used for medical applications require some specific features to suite the applications. The miniaturization of the sensors is the prime requirement even though each node should include a suitable sensor, a processor, a memory element, antennas for signal transmission and power sources.

Apart from the general network challenges [5] the requirements and challenges faced by the wearable WBAN are;

- Unobtrusiveness: The non-invasive medical sensors aims long term monitoring, so in this scenario the unobtrusiveness means light weight, miniature size, flexible to make it wearable and should also include long lasting power sources for the entire monitoring period.
- Interoperability: This term defines the capability of the sensor node to efficiently deliver the data in an interpretable manner to the required end points like physician, patient, hospitals, medical labs, pharmacies etc. The extraordinary capacity of data mobility is one of the prime challenges faced by the sensor nodes.
- Feature extraction: The real time monitoring of the physiological parameters can lead to a lot of raw data. The feature extraction from the raw data can reduce the storage requirements of the system and channel requirements. So this demands for a high computational ability.

The major challenges faced by the implantable WBAN [6] include;

- Biocompatibility issues: even if the devices are made of biocompatible materials, the long term use of these can lead to unfavorable reactions and other issues.
- Calibration: once the sensors are implanted the routine calibration is difficult.
- Fault correction: as they are implanted within the body the faults like lead dislocation, chemical reaction effects, other hardware faults etc. may lead to faulty analysis and diagnosis errors.
- Power resources: the long term real time data monitoring and data exchange need really efficient and downscaled power consumption. Once implanted to the site the sensor nodes should use minimum power to last long or to have an auto rechargeable power backup system.

The data transmission in these networks can be either continuous or intermittent. In the case of chronic illnesses, the monitoring and data transfer will be continuous and should be uninterruptable. Whereas in less critical cases the data are collected by the central node and is processed and send consolidated information intermittently or on-demand. The overall data management and networking should meet the certain minimum requirement [7] and pose certain challenges to the researchers. The major ones are summarized below;

- The enormity of data: real-time monitoring and recording of physiological events can cause a vast amount of data. The heterogeneity and size of data demand large storage space and computing facilities. Recent advances in cloud storage are one best options for data management.
- Bandwidth limitations: WBAN usually uses bands exclusively dedicated for medical applications like Wireless Medical Telemetry Services, Medical Implant Communication Services but these are sometimes not able to support both video and audio transmissions.
- Prioritization and fairness mechanisms: medical emergencies need to be handled with some proactive

scheduling services to avoid delays in the data transmissions.

- Security: in WBAN applications the security issues can be categorized into two aspects – system security and user security. System security deals with data authentication and mishandling. User security includes the privacy of the person using the system.

The challenges faced by the system design in different aspects are concluded in table 1 below;

Table -1. Design Challenges and applications

Category	Challenges	Applications
Wearable	Unobtrusiveness	Heartbeat, oxygen saturation, temperature, bio-potential recording, glucose monitoring, respiration, gait analysis
	Interoperability	
	Feature extraction	
Implantable	Biocompatibility	Monitoring pathogens, ion concentration, real time of seizures
	Power resources	
	Calibration	
	Fault correction	
Networking	Enormity of data	Node to node communication Node to central point communication Node to cloud storage communication
	Bandwidth limitations	
	Data Prioritization	
	Security	

4. CONCLUSION

The recent advancements in the sensor design and miniaturization of electronic devices made the WBAN applications in the medical field move a step further. The applications in the medical industry include wearable as well as implantable sensor node design and innovative real time monitoring, diagnosis, and medical assistance. This paper surveys the existing technologies to identify the challenges in both design and development of these systems and the data communication stages. The studies show that the future of the system lies in the development of an adaptive data communication technique to suit the optimization of data transfer and reduction in factors like bandwidth and energy consumption. Also, the system demands the design of sensor nodes capable of doing real time data processing to reduce the data overhead and to achieve autonomy for the sensors.

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BIOGRAPHY

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