

Applications of Wireless Body Area Network (WBAN): A Survey

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Abstract: Wireless Body Area Network (WBAN) is a network which used to optimize low power devices and to operate in or outside of human body to assist variety of medical applications. WBAN contains one or more Body Sensor Units (BSU), one Body Central Unit (BCU), and long range wireless devices. BAN also called body sensor network (BSN) established to make health and medical applications more advanced. WBAN is not only restricted to medical applications but it can also be used as non-medical applications such as Consumer Electronics (CE), personal entertainment and other. For medical applications it plays a key role to help medical professionals and patients for the monitoring of medical situation through intelligent body sensor networks (IBAN). There are many WBAN sensors that can measure different type of physical parameters, such as electrocardiogram (ECG), electromyography (EMG), body temperature, blood pressure, and diabetes of human body. In this paper, there will be a comprehensive survey on wireless body area network applications and the role of these applications in real life. Through these applications of WBAN, sensors are able to predict irregular behavior of body parameters and allow patients or sensor devices to alert medical specialists before any brutal condition.

Keywords: *Wireless Body Area Network (WBAN), Body Sensor Network (BSN) Electrocardiogram (ECG), Electromyography (EMG), intelligent body sensor networks (IBAN)*

1. Introduction

The use of wireless devices has been increasing very constantly; many modern technologies have been designed that are using wireless networks and producing decent results and making many challenging and demanding technologies so accessible and easy to use. Special wireless devices for health care systems are called Wireless body area networks (WBANs). WBAN introduced a dynamic arena of development and research in today's life. It contributes in monitoring different activities of human body and most importantly it provides an excessive improvement in human life by making it easy to monitor health conditions of human [1]. These WBANs are intelligent systems placed inside or outside of human body and monitor real time response of human health condition and sends feedback to end user or physicians through wireless signals. These WBAN systems are mostly used to monitor diseases like heart attack, temperature, Asthma, stress and oxygen level; but they can also be able to monitor daily routine of exercise and requirements of human body.

In this world where population is growing vastly but the resources are not more enough, then there should be some systems that satisfy imminent healthcare demands. The main purpose behind these low power wireless body area network devices is to efficiently utilize hospital facilities for those patients who need more care than those who's health is not critical but still the monitoring of their health is required and due to any reason they are not able to stay at hospital for long [2]. Systems that are taking care of these basic requirements are more reliable and efficient. Some basic requirements of these WBAN systems is to ensure that data passing from one device to another is secure, the sensor devices are less power consuming and

easy to use and also it should take care that because of these wireless devices there should not be any impact on human's daily routine activities. Different applications and methodologies have their own way to monitor health condition but the common approach of all WBANs is tier architecture, the first tier is a sensor device placed inside or outside of human body; through this sensor the system will be able to collect data related to a specific disease or exercise. The second tier is a wireless device that gets data from sensor device through wireless signals and measures the data according to given methodology and if the resultant data did not contain normal values it will send signal to a third tier which is an end user device. The end user may be a doctor or a physician and that device could be a Personal Computer or some monitoring device. End user saw coming data results on the system and ask patient a make sure to take care using their recommendations [3]. Many researchers are concern about the hundreds of diseases that should be monitored in real time but still are not able to be monitored by these available approaches.; so the research on WBAN is still continuous and providing many effective results.

The rest of the paper is structured as follow in section 2 illustrate the WBAN setup section 3 express WBAN Architecture section 4 demonstrate some WBAN application section 5 covers the standard of WBAN section 6 depict the challenges and issues section 7 discuss Research Works Based On WBAN Systems section 8 conclusion respectively and section 9 based on related work.

2. WBAN Setup

WBAN systems are based on three tier architecture with the combination of different hardware and software,

where each of this hardware or software will design according to the requirement of system. On each WBAN system there should be a sensor node, a central server and also a remote device. The sensor will help to gather required information and sends it to central servers and that sends calculated data to remote server through any internet or wireless object.

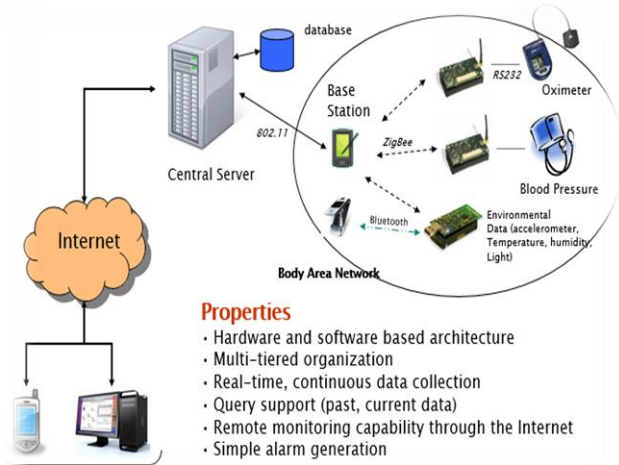


Figure 1. Wireless body area Network Setup [18]

The Fig.1 shows the setup of basic WBAN systems that contains a central server that connects end user’s machine and sensor devices. These central servers can gather and also protect sensor’s data and later sends it to end user when required. This will help medical specialists to check patient’s history. The main advantage of WBAN systems is that they are not connected to wires and it is easy for users to use these devices quiet comfortably and without any restriction of traveling from one place to another.

3. WBAN Architecture

All WBAN applications are based on three tier architecture. All three tier or levels are based on some devices, these devices helps WBAN to get and monitor data obtained from human body. The Fig.2 shows the WBAN architecture and its levels where as these three levels are defined as follows.

3.1 Level 1

First level of WBAN architecture is called body sensor unit that is based on one or more body sensor units and are placed outside or inside of human body, these sensor gets required data from human body and sends it wirelessly to next layer.

3.2 Level 2

Second layer is called body central unit. Body central unit contains personal servers, these servers’ gets data from sensors calculate and manipulate this data and gets required results. This layer can be based on a wireless computer system, an android mobile phone or any GPS supported system that can manipulate received data.

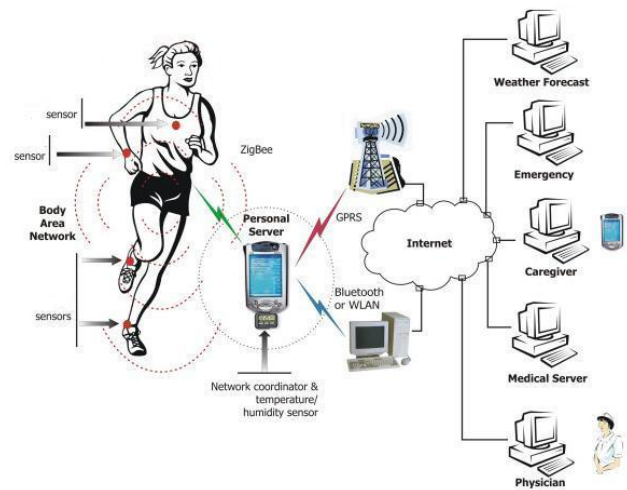


Figure 2. WBAN Architecture [19]

3.3 Level 3

Third layer based on end user’s machines where end users are medical assistance or physicians and their machines can be a computer or mobile phones. These machines gathered required information, from layer two, and ask end users to give response to patient’s fitness. if there is some emergency results then machine sends alarm to end user and make it possible to give quick response to patient so that patient can get proper treatment.

4. WBAN Applications

Wireless body area network applications are proving themselves very efficiently and these applications are not just for human health care monitoring but there are also many other applications such as sports, fitness, gaming, electronics, measuring body position, location of a person, military and many other that are using WBAN approach for different purposes, Fig.1 shows some applications that are used by human and are based on WBAN systems. The astonishing use of WBAN applications is for health care, entertainment, sports and fitness applications, all these applications are very demanding and reliable.



Figure 3. Applications of WBAN

From the list of many advanced WBAN applications there are few that are fully developed and are able to

empower their technologies in real time environment; some of these applications are discussed below.

4.1 Health Care

The real time monitoring of human health condition is more demanding and reliable application of wireless body area network. There are many WBAN applications that are using to monitor or diagnose different diseases such as, asthma, heart rate, temperature, blood pressure and others. The real time term used to monitor health condition using wireless devices is known as m-health [4]. Each disease can be treated differently according to the process proposed by the WBAN systems. Many recent improvements in these applications make it easy to monitor health condition by simply place a small low power consuming and less costly devices or sensors in or outside of human body. These sensors will be able to collect a large amount of data through wireless signals and allow physician to monitor patient's health through collected data continuously [5]. As almost 80 percent of people in the world are effected by heart disease so most of the application are focusing on heart disease such as An ECG (electrocardiogram) ensures the issues with electrical movement of your heart basically ECG has keep the record of electrical changing's of heart. An EEG (Electroencephalogram) is a test that sense anomaly in your brain and check the electrical activity of your brain. EMG (Electromyography) is an analytic process to evaluate the health of muscles and the nerve cells that control those (motor neurons). By this modern and intelligent WBAN application, patients are allowed to do their daily routine activities, go anywhere and this device will work on any condition and monitor their health condition.

4.2 Entertainment

Research on WBAN systems is much enhanced and applications are not just for health care but also there are many other applications such as gaming, smart mobile devices, music devices and other that are used by humans and are very effective in their own manners [6].

4.3 Lifestyle and Sports

Many WBAN applications have been developed that are used to monitor physical position of a body while a player is playing any game for example when a golf player monitors when the ball is hit then what should the best position of body to hit the ball efficiently. So that there would be more accuracy in player's game when it plays next time. Also there are other applications that monitor the stress and heartbeat of player before, during and after some sports activity of that player. Some applications are developed to monitor the workout of a person like how much time it takes to do a single activity and also how much steps are taken during walk. These type of applications are placed on any part of body or it can be simply a belt that consist of a sensor. These small applications are not necessarily working as wireless devices as same person monitor his own activities [7].

4.4 Military

The use of BAN application in military is also playing a very important role. The basic use of this network in BAN is to locate a military person's location when that person is on a mission or at a specific place where there is

no other way to communicate or where it is recommended to locate that person's movements. Other usage of these WBAN is the smart devices which a person can wear and can take important information of specific place and send real time data to their end users [8].

5. Standards of WBAN

To meritoriously practice the WBAN systems some defined standards are used by every researcher in their work. These standards are not specifically designed for WBAN system but they are also used by any wireless technology, for WBAN these are used to optimize communication and procedure of monitoring health condition and other data. The defined and popular standards of wireless technologies which are used by WBAN systems are IEEE 802.15.6, ZigBee/IEEE 802.15.4, GSM, Bluetooth, WLAN and WIFI [9]. From all of these standards the widely used standard is ZigBee because it takes less power consumption and WBAN devices need to be less power consuming but sometimes this standard fails to robustly communicate data between body sensor unit and central control unit. To overcome this concern a new standard IEEE 802.15.6 was introduced that make it possible to transfer data robustly and to send data on enormous distances, the modified standard was also introduced that is called WIFI; in this standard the fears about security, robustness and power consumptions have been overcome [10].

6. Challenges and Issues

In today's life where the technology in networks and wireless sensors have been growing rapidly, there are some challenges that are encountered by these new technologies and can be overcome by making these technologies more advanced and reliable. There are some important challenges and issues [11] which are mostly faced by WBAN applications. The most important and big challenge of WBAN systems is Data security [12] of wireless devices. As many communication devices send data through same type of encryption for all data, and if anyone could be able to get encryption key once than that person may get all the decrypted data and if the data is secure and should not be share by others than it may proceed to unwanted way. And sometimes may be there is a person who can check and change data of patient and then sends the wrong information to end user, so the data passing between devices should be highly secure [13].

This challenge should be avoided while creating military application using WBAN. The other challenges that should be avoided are, at first the sensor devices should be low power consuming and are not needed to get charged after very short time. The other concern should be that the sensor devices should be of small size as if the patient placed any sensor device onto their body it should not be uncomfortable and should not affect their routine activities.

7. Research Works Based On WBAN Systems

WBAN system are now very popular concept among many researchers and a lot of work is proposing using this

approach to monitor health condition, most work is done to monitor heart condition of heart patients but it is a wide field so it is not limited to just monitor heart, From various work below are some researches that have been surveyed in our research.

A. A WBAN-ECG Approach for real-time Long-term Monitoring

This paper [2] proposed an approach for real time Electrocardiogram (ECG) signal monitoring using WBAN healthcare solutions. The proposed system uses low power monitoring device, a wireless network system to monitor ECG data of a patient’s body and transmit the data to the central control unit located at specified short distance locations. The authors have done some research of interrelated work in which they study different type of wireless body area network systems, specifically for ECG. In the study they found that most system is proposed just for the diagnosing of abnormal heart conditions. Fig.2 shows the architecture on which this system is based. The sensor nodes and electronics are placed on human body that are connected to central control unit and getting required information through wireless signals from human body.

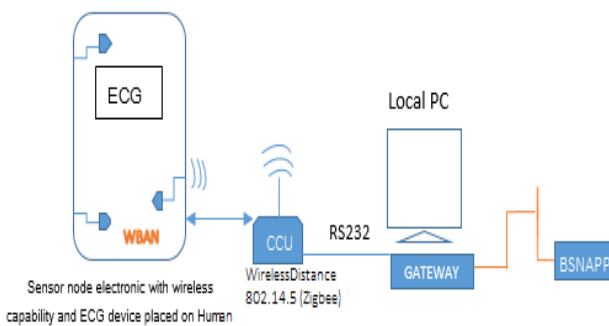


Figure 4. A WBAN-ECG Approach for real-time Monitoring

This central unit sends the data to a system where it manages to convert data into readable form; so that doctors or physicians can read it and is able to understand the condition of patient and then sends a message or required information to the body sensor device networks.

The basic purpose of the proposed methodology is to monitor heart state of those patients who are recovering from heart diseases and are not require to unnecessarily be taken into the hospital. Two types of nodes have been used to monitor heart condition, the senatorial (SA) nodes and the atrioventricular (AV) nodes to get the wave forms of heart.

The wave forms represent the super positioning of electric potential signals generated by electric activity of heart beat. To monitor the heart electrical waves two important properties of cardiac tissue have been used. These properties used to analyze the potential and current distribution associated with these propagation waves. The cellular cells have interconnected by low resistance pathways. There are also some mathematical formulas have been discussed which have been used for velocity dividing and transmission of current in the form of electrical waves generated through heart. The methodology described in this paper is based on three tier architecture; the first one is

WBAN layer that is a wearable wireless devise through which system will be able to raise an alert when the electric wave forms surpasses outside the defined threshold. The second one is Central Control Unit layer that collects wireless electric signals using sensor nodes, the main task of this is layer is to continuously monitor the transmitted signals; and the third layer is receiving device that collects the monitored signals and make sure to get communicated with patients. So this paper have proposed a reliable and fast method to monitor the ECG signals of patients who are far away from their hospitals and have to be monitor continuously by their consultants.

B. BSNs: A Special Approach to Monitor Heart Rate

The proposed method in this paper [14] is also about to monitor the heart rate diseases through BAN terminology. To classify the patients' daily activity and provide the context information this approach used accelerometer data from the Body Sensor Networks(BSNs), also A sensor device ,placed inside human body, is used to monitor heart rate and body activities and if there is some inappropriate behavior by heart is detected then a signal will be detected by sensor device and it will pass an emergency signal to the attached wireless device, kept by physician, that detect the emergency level and then physician will send appropriate message or alarm though a computer system to inform patient about their health. As normal BAN systems of health care this system also uses three tier architecture, in which first tier is low power wireless device attached to the patient’s body which is used to monitor changes in patients heart’s condition using sensor and microcontroller. The second tier is personal server based on intelligent personal digital assistant, this system contains every patients endorsement information and whenever there is some certain change in patient’s health behavior it collects the data from WBAN using GPRS and if it is critical the alerts the relevant physician to check patient’s condition.

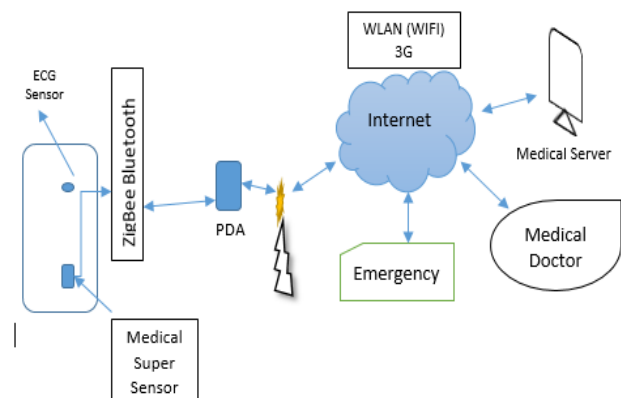


Figure 5. BSNs: A Special Approach to Monitor Heart Rate

The third tier is the remote device used by physicians to observe the patient’s condition using received data and then send message to patient that which medicine has to take.

Fig.3 shows the architecture defined in this paper, in this system the medical super sensor and ECG sensors are placed on the human body and are using Zig Bee standard

to communicate and sends data to a wireless device. That wireless device is a PDA device that sends data to a computer device using wireless internet service, through this computer a physician or doctor can get data and treat patient according to requirements of received data.

According to this paper the use of sensor network and other devices still has some limitations and they can be removed by making improved devices but it will take some time and research.

C. Stress Monitoring Using a Distributed Wireless Intelligent Sensor System

This paper [15] proposed an intelligent stress monitoring system using wireless body area network system. As stress considered as the base of many diseases, it is necessary to monitor stress in real time using efficient systems. It is a client-server network system uses multiple wireless intelligent system and high level signal processing. The approach, researchers have introduced is based on low power wireless transceiver, a PDA-based device to communicate between wireless sensor to collect data into a secure device and a polar chest belt as a sensor belt. This sensor belt is called HRV device and it communicates with personal server called WHRM. In addition this intelligent wireless system is also able to monitor battery status and temperature of the system hierarchy. The main purpose of this stress monitoring system is to monitor person’s stress, with very low power devices, during stressful training using synchronization measurements. The wireless communication between PDA and computers has been performed to collect sensor data and to monitor stress of human.

The Fig.4 shows the architecture of distributed wireless intelligent systems that are able to send and receive data using Bluetooth devices. The sensor placed on human body can be a breathing monitoring, movement monitoring or ECG monitoring system. These sensor nodes collect the respective data and sends it to a Bluetooth device near by a user, and sends the data to an internet enabled computer.

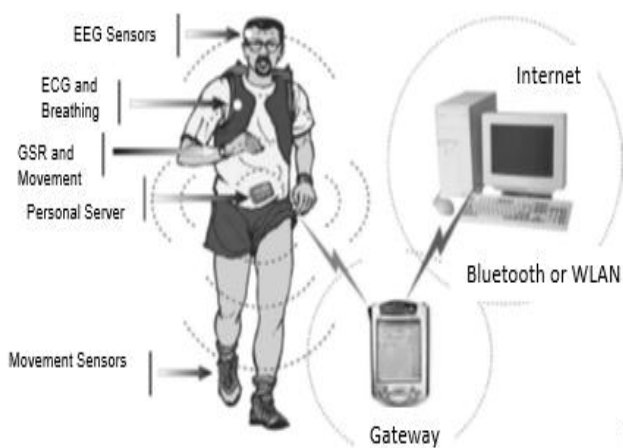


Figure 6. Distributed Wireless Intelligent Sensor System [20]

To get low power devices this system is established for short range transmissions using gateway mobility. On each communication the collected data is placed on different files and then these separate files will be used to improve wireless communication and to decrease power consumption. This collected data has also been used to create a training session files that will be used in gateway PDAs. The researchers apply real time approach on military persons and collect data, on their different activities, to monitor individual’s stress level. This methodology gets their goal by making low power consuming device but is not able to monitor a person while is on a long distance.

D. Wireless Body Area Network for Heart Attack Detection

The Ban system proposed in this paper [16] uses an antenna, Bluetooth device and an android based mobile device for communication. The antenna is based on low fabrication technique, Bluetooth device is used to send and receive signals and data communication is done using android device. This system allows the user to detect ST elevation through their GPS enabled smart phones. At the time of emergency; patients can easily be traced through these GPS enabled smart devices. The microcontroller placed at the sensor would be able to monitor the blood thickness in the body and if it found any clot in the blood then the system immediately is able to alert the patient and at that time the doctor instantly calls on android system of patient to take any aspirin to prevent further blood clotting.

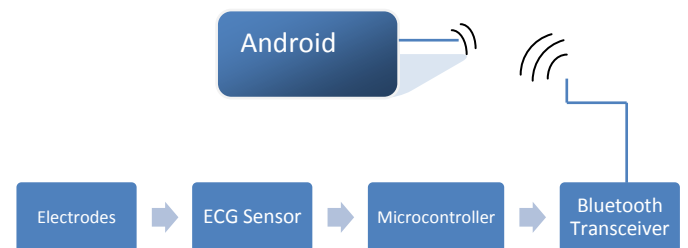


Figure 7. WBAN for Heart Attack Detection

The Fig.7 shows the architecture of this system, where the overall system is based on four things. The first one is ECG sensor that is used to monitor and calculate electrode signals of a human body. Then the calculated valued signals are sent to microcontroller that helps these signals to transfer into Bluetooth transceiver. This Bluetooth transceiver is attached with researchers own designed antenna called PIFA that helps signals and calculated data to be received on patient’s android devices.

The signals that are sent and received are monitoring ECG through a sensor placed on patient’s chest. That ECG sensor connected to electrodes through a wire and also attached to the transceiver. Researchers have tested their system by applying system on different sides of body and in their results they found that the system will perform better while sensor is placed in front side of body as it takes strong signal strength at that position. The results works fine and works with comfort by making good results and reducing noise.

E. Wireless Body Area Network For Monitoring Body Temperature, Heart Beat And Oxygen In Blood

In this paper [17], a WBAN based monitoring system is proposed. This system can monitor temperature, heart beat rate and oxygen saturation in blood. The proposed system is based on a desktop application, in this system at first it read physiological data of patient and sends it to a desktop application. The received data will be converted into reports based on graphs and tables and placed onto a website so that authenticated users can view their related data. The defined system is using ZigBee standard because the proposed system is suitable for applications that are created for low power consuming, short distance wireless monitoring network servers.

The Fig.8, shows the architecture of this proposed WBAN monitoring system. The hop topology is used for data communication where data sensor unit gathers the data from user's body and sends it to body central unit, using ZigBee technology, which works as a medium to send and receive data between sensor and desktop application.

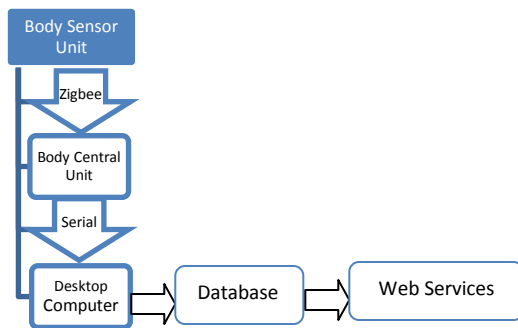


Figure 8. WBAN for Monitoring Body Temperature, Heart Beat and Oxygen in Blood

The data received by desktop monitor is saved through MYSQL database and will also be available for web services. This proposed methodology has been performed on advanced processing, advanced level computer systems and some hardware systems to get full and best required results. The experiments have been done on different persons and with different ranges to find that on how far this system would work fine and from experiments it are found that this system would work fine till 50 meter. The idea behind the web service is to make this system easily available for all the users wherever they are and use this application on their computing systems and also registered users can saw their previous data which was stored in database. According to authors this system will work very fine if the body central unit and sensor unit are exists in the required distance but if they are out of range then system will not perfume quit and in their future work they will work on this drawback.

8. Conclusion and Future Work

In this work, we have done a survey on WBAN and discussed some applications of WBAN, the standard which are used by these applications; also we have discussed some challenges that are concerned in these applications. From survey, we have found that these applications are working quite effectively in their own manners but still some more research is needed to make these applications very efficiently and according to the vat growth of many new and advanced diseases. There are still some issues and diseases that should be monitor through these devices; so there is a need to make more WBAN devices and make a human life more secure and relieved. There are a lot of applications based on WBAN system that are monitoring different type of diseases, but still in this era there are still some disease that are not properly monitored through these applications; one of which is "Cancer". In our future work we will develop a mechanism that should be able to monitor a patient's cells that are affected by cancer, should be able to efficiently monitor cancer patient's condition.

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Table 1. Applications of WBAN

MEDICAL	ENTERTAINMENT	CONSUMER ELECTRONICS	SPORTS AND FITNESS	LIFESTYLE	DEFENSE
ECG	Computer Games	Cell Phones	Sports Safety	Motion Detection	Soldiers Vital Sign Monitoring
EEG	Dance Lesson	Music Players	BP	Posture Detection	Blast Dosimeter
EMG	Gesture Detection	Wireless Headphones	Heart rate	Ambient Intelligence	
Health Care Monitoring		Hearing aids	Activity monitor		
Glucose Monitoring			Weight Scale		