International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 6, Issue 9, September 2017, ISSN: 2278 – 1323

Wireless Body Sensor Networks: From Challenges to Opportunities

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Abstract: The increasing use of wireless networks and the constant miniaturization of electrical invasive/non-invasive devices have empoweredthe development of Wireless Body Area Networks (WBANs). A WBAN provides a continuous health monitoring of a patientwithout any constraint on his/her normal daily life activities. Wireless Body Area Network (WBAN) is a system which used to streamline low power gadgets and to work in or outside of humanbody to help assortment of therapeutic applications. WBAN contains at least one Body Sensor Units (BSU), one Body ControlUnit (BCU), and long range remote gadgets. BAN also called as body sensor network (BSN) set up to make restorative and healthapplications more progressed. WBAN is confined not only to restorative applications but can be utilized in non-therapeuticapplications, for example, sports applications and other. In this paper, there will be an exhaustive study on WBAN applications andthe part of these applications used in real life. Through these uses of WBAN, sensors can foresee unpredictable conduct of bodyparameters and enable patients or sensor gadgets to ready medicinal masters before any severe condition.

Keywords: Wireless Body Area Networks, Heart Beat Monitor Sensors, Temperature Sensors, ECG, BSU.

I. INTRODUCTION

Ubiquitous healthcare is an emerging technology that promises increases in efficiency, accuracy and availabilityof medical treatment due to the recent advances in wireless communication and in electronics offering small andintelligent sensors able to be used on, around, in or implanted in the human body. In this context, Wireless Bodyarea networks (WBANs) constitute an active field of research and development as it offers the potential of great improvementin the delivery and monitoring of healthcare [1]. WBANs consist of a number of heterogeneous biologicalsensors. These sensors are placed in different parts of the body and can be wearable or implanted under the userskin. Each of them has specific requirements and is used for different missions. These devices are used for measuringchanges in a patient vital signs and detecting emotions or human statuses, such as fear, stress, happiness, etc. Theycommunicate with a special coordinator node, which is generally less energy constrained and has more processingcapacities. It is responsible for sending biological signals of the patient to the medical doctor in order to provide real time medical diagnostic and allow him to take the right decisions.

As shown in Fig.1, the WBAN common architecture consists of three tiers communications: Intra-BAN communications,Inter-BANcommunicationsandbeyond-BANcommunications.Intra-BAN communications denote communicationsamong wireless body sensors and the master node of the WBAN. Inter-BAN communications involvecommunications between the master node and personal devices such as notebooks, home service robots, and so on.The beyond-BAN tier connects the personal device to the Internet.

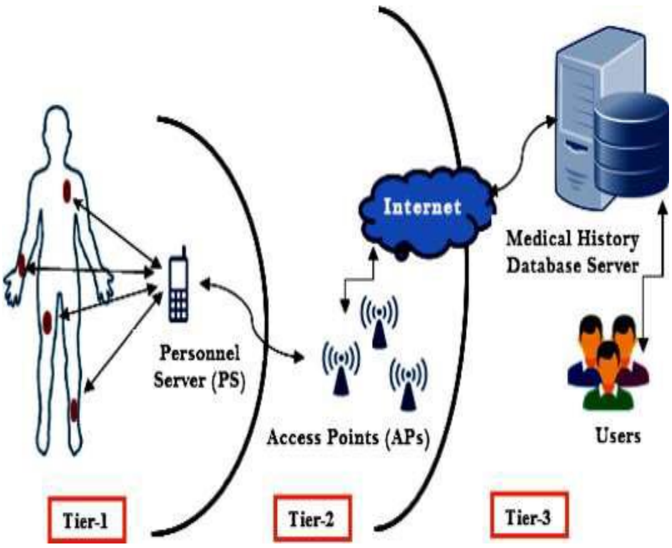

Fig. 1. General architecture for Wireless Body Area Networks

Communications between different parts is supported by several technologies, such as Bluetooth, IEEE 802.15.4. IEEE 802.15.6 was designed especially for WBANapplications while responding to the majority of their requirements. However, it looks less performing in some casesin comparison with other technologies supporting WBAN. Wi-Fi, Bluetooth and mobile networks can be solutionsfor implementing WBAN applications, since each technology offers specific characteristics, allowing it to meet theconstraints of some applications [2]. In fact, WBAN applications cover numerous fields in order to improve the user'squality of life. These applications can be categorized mainly according to whether they are used in medical field or innon-medical field. Non-medical applications include motion and gestures detection for interactive gaming and fitnessmonitoring applications, cognitive and emotional recognition for driving assistance or social interactions and medicalassistance in disaster events, like terrorist attacks, earthquakes and bush fires. Medical applications comprise healthcaresolutions for aging and diseased populations mainly. Typical examples include the early detection, preventionand monitoring of diseases, elderly assistance at home, rehabilitation after surgeries, biofeedback applications whichcontrols emotional states and assisted living applications which improve the quality of life for people with disabilities.

Generally, body sensors used in health monitoring [3] can be either : (a) Physiological sensors used to measure humanbody vital signals internally or externally, like body temperature, blood pressure or Electrocardiography (ECG); or(b) Bio kinetic sensors able to collect human body movement based signals as acceleration or angular rate of rotation.To offer additional information about ambient temperature, environment pressure, light or humidity, ambient sensorscan be combined to body sensors. In fact, since these sensors are in charge of monitoring the environment, they canprovide valuable additional information for medical diagnosis and treatment, which is often the case in home environment [4].However, the conception of WBAN applications should take into account many technical requirements, suchas the motions and the temperature of the nodes, the node locations and the low node capacities in term of energy andprocessing. Other constraints tightly associated to wireless technologies, used for the communications between onbodyand in-body nodes, must be taken into account, such as the short area range, the data rate, etc. ISO/IEEE 11073[5] specifies for some classes of medical applications the required data rates and latencies [5-6]. Besides, WBAN applicationscan involve additional requirements, tightly related to the medical application as well as the patient condition.For example, applications using implanted sensors should rely on mechanisms minimizing energy consumption inorder to extend battery life; while achieving maximum throughput and minimum delay is a perquisite for applicationswith high criticality, like operation of elderly heart patients. All these statements and requirements motivate us tostudy the different WBAN applications and to highlight the constraints to satisfy for the well-functioning. We studyalso the different technologies used and try to associate the WBAN applications with the appropriate technologies inorder to achieve the maximum of QoS.

II. BODY SENSORS & ITS CLASSIFICATION

Sensors are the key components of BSN, as they connect the physical world with electronic systems. They are mainly used to collect the information about physiology and the surrounding environment. Sensor nodes, which have a sensor as their main part, are responsible for processing information by format conversion, logical computing, data storage, and transmitting. One sensor node generally comprises a sensor module, processor module, wireless communication module, and power supply module [7]. The sensor module is responsible for collecting the status of measurands and converting data from physical quantities to electrical signals. The processor module is responsible for controlling the sensor nodes. The wireless communication module, consisting of network layer, MAC layer and wireless transceiver in the physical layer, is responsible for communication among sensors and computers. The power supply module is responsible for providing energy for entire the sensor node.

According to the types of measured signals, sensors in BSNs can be divided into two categories [8]. The first category, which includes accelerometers, gyroscopes, ECG sensors, electro-encephalograph (EEG) sensors, electromyography (EMG) sensors, visual sensors, and auditory sensors, collect continuous time-varying signals. This type of sensor collects signals continuously, placing more emphasis on real-time signal acquisition, and correspondingly both data transmission quantity and power consumption are very large. The second category, such as glucose sensors, temperature sensors, humidity sensors, blood pressure monitors, and sensors monitoring blood oxygen saturation, collect discrete time-varying physiology signals. As the signals that sensors collect change slowly, the amount of data transmission quantity is smaller than for the first category. It is possible to reduce energy consumption by using sleeping mode.

According to the types of data transmission media, the most commonly used sensors in BSNs can be divided into the following three categories: wireless sensors, which employ wireless communication technologies such as Bluetooth or Zigbee, radio frequency identification devices (RFID), and Ultra Wideband (UWB) to communicate with other sensors or devices. Most applications employ this type of sensors for improving wearability and reducing the interference of sensors with usual activities. Wired sensors, employing wired communication technologies, can replace wireless sensors if wearability is not seriously affected. The transmission mode is more stable than that of wireless sensors. However, their installation and deployment is relatively complicated. Removing wires completely will be an inevitable trend for BSNs [9]. Human body communication (HBC) sensors, which use the human body as the transmission medium, have only been proposed in recent years. This type of sensor adopts sub-GHz frequencies without antennae, which reduces the power consumption and the size of sensor nodes. Therefore, they can easily be integrated into body-worn devices. What’s more, the communication distance of a HBC sensor is constrained around human body, which effectively improves the communication security [10]. However, it has less communication speed than a normal wireless sensor. Recently it was supported by the IEEE 802.15.6 standard for use in short-range, low-power and highly reliable wireless communication systems which are close to, on or in the human body [11].

According to the deployment positions of sensor nodes, sensors in BSNs can be divided into three categories [8]: Type 1 are wearable sensors, such as temperature sensors, pressure sensors and accelerometers. The size and weight of the sensor should be considered in the design process, in order not to interfere with the usual activity of users. Type 2 are implantable sensors, which can be implanted or inhaled/ingested into the body, such as a camera pill. This type of sensor needs to be not only tiny enough, but also non-corrosive and biocompatible. Type 3 is placed surrounding people, and can be used to recognize behaviors and collect information about the surroundings, such as visual sensors.

According to their automatic adjustment ability, sensors in BSNs can be divided into two categories: self-adapting sensors, which can automatically adjust processing method, order, and parameters, boundary conditions or constraints according to data characteristics, make themselves adapt to the statistical distribution and structural characteristics of the measured data, in order to get the best treatment effect. Non-self-adapting sensors, which are simple to design and need no consideration of self-adjusting function, are widely used in BSNs at present. Because of the requirements of complexity and accuracy enhancing, self-adapting methods will be gradually applied to design of sensors.

III. Challenges in WBAN's

a) Energy Conservation:

Typically sensor nodes are equipped with small batterieswhich cannot be changed or recharged and a node destroyswhen its battery exhausts. Theexperimental evaluationshighlights that data communication consumes more energyas compare to data processing. The energy cost of receivingor transmitting a single bit of information is approximatelythe same as that required by processing executing a thousandoperations [12] [13]. The continual operation of sensors isvital for healthcare applications.Two major techniques, duty cycling and in-networkprocessing are used in WSN to reduce power consumption.The power reservation algorithms in medical healthcare mustbe able to reduce power consumption without compromisingon system reliability.

b) *Vulnerability:*

Vulnerability is an important part of any system and it is amajor area of research in general WSN. Wireless media isalways more vulnerable than wired media for attackers [14].This is more important in healthcare applications since asecurity breach can result in life threatening situations.We can define security at several levels in healthcareapplications. The security threats can occur during routingthe data where intruders may change the destination, canmake routing inconsistent or even steal the data byeavesdropping the wireless communication media [14]. Theattackers can steal or modify the data routing through GPRSor similar networks [14]. The criminal-minded attackers cantrack the user location or can keep an eye on user's activity.The attackers can fiddle with the data by forging alarms [15].They can also wage the Denial of Service (DoS) andJamming attacks on the networks.Data Encryption and Authentication are major securitytechniques used for security provision. Data encryptiontechniques must be used for secured data transfer andlegitimate devices must be allowed to create or inject datainto the system [15]. One of the solutions against securitythreats is to implement different encryption techniques.

c) Power Sources:

No matter how intelligent the routing mechanism or howadaptive the network, if the sensor loses power the sensor issimply non-functional. Significantly morework is needed onalternative low cost power techniques such as solar, fuelcells and RF coupling.

d) Usability:

Much of the work in this space has stopped at lab type'prototype solutions. More commercial devices are neededand more studies needed on performance in real worldapplications.

e) Autonomic Networks:

Substantive effort is needed in the self- organizing propertiesof sensor networks. Also end-to-end pilots are needed thatdemonstrate the autonomic properties of sensor networks. Inhealthcare the Reliability Dilemma is particularly important,i.e. data needs to be secure and reliable, but this brings highoverheads in terms of data size, power consumption andscalability. This dilemma needs attention throughappropriate studies. Body Sensor Networks need to berecognized as a special category of sensor networks as therequirements can be quite different from general wirelesssensor networks.

f) Privacy:

In parallel with the technical research, research in to thesocietal, ethnographic and demographic effects of wirelesssensor networks need to be performed. This encompasses theprivacy debate also. Concerns such as profiling, 'big brother','one big database' etc need to be addressed up front andpolicies developed and agreed ahead of the technologybecoming mature. Issues around data ownership when datatravel across multiples boundaries arise. Also the legalaspects need to be reviewed, who is liable etc.

g) Design Challenge:

Also one should accept that Wireless devices are slower thanwired because of traffic congestion and hence increases thechallenge to create the devices that could reach to betterperformance. This creates a big challenge for developers inprogramming and designing a secure sensor network.Ensuring patients information security can be a major issuewhen deploying these applications. Privacy of user data overwireless channels can be another major issue. Wirelessnetwork based medical devices can be very limited in termsof power availability and processing strength. Thus ensuringprivacy without using complex encryption algorithms can bea big issue for developers of medical devices [16].

IV. WBAN APPLICATIONS

WBANs support a number of innovative and interesting applications. These applications include several areas suchas smart health care, assisted elderly living, emergency response and interactive gaming.In this section, we present an overview of the maincategories of medical applications.

a) Telemedicine and remote patient monitoring:

The rising healthcare costs and the aging of the world population contribute to the advancements in telemedicinenetwork for the delivery of several healthcare services. Telemedicine enables the remote delivery of patient care usingintegrated health information systems and telecommunication technologies and allows scientists, physicians and othermedical professionals around the world to serve more patients. Patient monitoring applications generally control vital signals, and provide real time feedback andinformation helping the recovery of the patient [17]. In such situation, we can keep the patient under doctor monitoringunder natural physiological states without constraining their normal activities and without injuring him high cost.Daily-life activity monitoring monitors the activity during daily life of patients with some specific diseases; while inhospitalmonitoring focuses on cases in which patients have to stay in a hospital for intensive care and observations,sometimes for a prolonged period. A WBAN can provide continuous measurements of the physiological parametersand allow better revealing organ failures and faster detecting emergency situations. Such remote monitoring systemwill be safer, more convenient and cheaper.

b) Rehabilitation and therapy:

The goal of rehabilitation is to allow patients to restore their functional capability to normal, through appropriaterehabilitative treatments after they were dismissed from hospital [18-19]. Rehabilitation is a dynamic processwhich uses available facilities to correct any undesired motion behaviour in order to reach an expectation (e.g. idealposition).

c) Biofeedback:

Self-remote monitoring of human body is now possible, using WBANs to access data collected by the sensors. Sensorsare implanted or placed in human body to monitor some behaviour or pathologies, and help patients to maintain their health through biofeedback phenomena such as temperature analysis, blood pressure detection, Electrocardiography(ECG), Electromyography (EMG), among others. Biofeedback refers to the measurement ofphysiological activity plus other potential useful parameters and feed them back to the user allowing him to learnhow to control and modify his physiological activity with the aim of improving his health and performance.

d) Ambient Assisted Living:

The aging population, the increasing cost of formal health care and the importance that the individuals place onliving independently, all motivate the development of innovative-assisted living technologies for safe and independentaging. An ambient sensor network can sense and control the parameters of the living environment andthen delivers the body data to a central station, thanks to a continuous cognitive and physical monitoring. The healthcondition of these people can be estimated from their heart beat rate, blood pressure and accelerometer data. Thesystem may be connected to a health care center for observation and emergency assistance, in case of strong changesin the observed parameters or deviations from the normal range [20].

V. CONCLUSION

In this a study about wireless body sensor network is presented. The paper presents applications and challenges in wireless body sensor networks. The wireless body sensors can be implemented for better treatment, real time diagnosis and real time monitoring of patients.

References:

[1] Chen, M., Gonzalez, S., Vasilakos, A., Cao, H., & Leung, V. C. ,Body area networks: A survey. Mobile networks and applications,16(2), 171-193, 2011.

[2] Chen, M., Wan, J., Gonzlez, S., Liao, X., & Leung, V. A survey of recent developments in home M2M networks.Communications Surveys & Tutorials, IEEE, 16(1), 98-114, 2014.

[3] Boulemtafes, A., &Badache, N. ,Design of Wearable Health Monitoring Systems: An Overview of Techniques and Technologies. InmHealth Ecosystems and Social Networks in Healthcare, Springer International Publishing, pp. 79-94, 2016.

[4] Vallejos de Schatz, C. H., Medeiros, H. P., Schneider, F. K., &Abatti, P. J. ,Wireless medical sensor networks: Design requirements andenabling technologies, Telemedicine and e-Health, 18(5), 394-399, 2012.

[5] Ullah, S., Higgins, H., Braem, B., Latre, B., Blondia, C., Moerman, I.&Kwak, K. S., A comprehensive survey of wireless body areanetworks, Journal of medical systems, 36(3), 1065-1094, 2012.
[6] Pervez Khan, M., Hussain, A., &Kwak, K. S., Medical applications of wireless body area networks. Int. J. Digital Content Technol. Applications 2009.
[7] Ma, Q.; Hou, X.H. Study of wireless sensor node's structure. Sci. Technol. Inf. ,24, 371–436, 2008.
[8] Gong, J.B.; Wang, R.; Cui, L. Research advances and challenges of body sensor network (BSN). J. Comput. Res. Dev. 5, 737–753, 2010.
[9] Chen, M.; Gonzalez, S.; Vasilakos, A.; Cao, H.; Leung, V.C.M. Body area networks: A survey. Mob.Netw.Appl. ,16, 171–193, 2010.
[10] Nie, Z.D.; Ma, J.J.; Li, Z.C.; Chen, H.; Wang, L. Dynamic propagation channel characterization and modeling for human body communication. Sensors, 12, pp. 17569–17587, 2012.
[11] IEEE Standard for Local and Metropolitan Area Networks. Part 15.6: Wireless Body Area Networks; IEEE Std 802.15.6-2012; IEEE: New York, NY, USA, 2012.
[12] Crossbow, http://www.xbow.com, 2011
[13]TmoteSkyDatasheet, http://www.moteiv.com/products/docs/tmote-skydatasheet.pdf, 2011
[14]M.A. Ameen and K. Kwak, "Social Issues in WirelessSensor Networks with Healthcare Perspective," TheInternational Arab Journal of Information Technology,Vol. 8, No. 1, January 2011
[15]F. Kargl, E. Lawrence, M. Fischer and Y. Lim,"Security, Privacy and Legal Issues in PervasiveeHealth Monitoring Systems," in Proceedings of 7thInternational Conference on Mobile Business, pp. 296-304, 2008.
[16] Shi, E.; Perrig, A. "Designing secure sensor networks", Wireless Communications, IEEE Volume 11, Issue 6, pp. 38 – 43, Dec. 2004.
[17] Boulemtafes, A., &Badache, N. Design of Wearable Health Monitoring Systems: An Overview of Techniques and Technologies. InmHealth Ecosystems and Social Networks in Healthcare, Springer International Publishing, pp. 79-94, 2016.
[18] Hadjidj, A., Souil, M., Bouabdallah, A., Challal, Y., & Owen, H. (2013). Wireless sensor networks for rehabilitation applications: Challengesand opportunities. Journal of Network and Computer Applications, 36(1), 1-15, 2013.
[19] Zhou, H., & Hu, H. , Human motion tracking for rehabilitationA survey. Biomedical Signal Processing and Control, 3(1), 1-18, 2008.
[20] Acampora, G., Cook, D. J., Rashidi, P., &Vasilakos, A. V, A survey on ambient intelligence in healthcare. Proceedings of the IEEE,101(12), 2470-2494, 2013.

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