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Wireless Senor Networks Health Monitoring: Trends and Challenges

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ABSTRACT

Wireless sensor network has undergone tremendous development in the last one decade. The reduced size of the sensors coupled with enhanced capability made the dream of unobtrusive monitoring closer to reality. Sensors are cheaper and readily available in the market in these days. These sensors, when deployed on the human body, forms a Body Area Network (BAN) that can detect and forward various physiological parameters to a central node. BAN is under focus by most of the researchers and different applications are underway. BAN is confronted with various challenges due to which it is not yet accepted by majority of people. This paper carries out in depth analysis of technical and functional requirements of BAN. Research challenges to BAN like scalability, power consumption, data rate etc. along with technologies for transferring the data from BAN to central node have also been discussed in brief.

Keywords: *Wireless Sensor networks (WSN), BAN and eHealth*

1. INTRODUCTION

The sluggish life style is giving birth to chronic diseases such as cardiac diseases and hypertension etc. As per the WHO reports 38% percent of all deaths are due to heart diseases. On the other hand the number of diabetic patients is increasing rapidly due to tense life style and other reasons. The healthcare further aggravates due to budget constraints, lack of skilled staff and workload. The tremendous development in the wireless and sensor technology provides an opportunity to improve the quality of life. The development in the field of Wireless Sensor Networks and reduction in the size of sensors for monitoring purpose coupled with wireless technology has given new dimensions in the pursuit to explore the challenges to healthcare. The sensor can be used in the human body to monitor physiological signals of the patient. The installed body sensor monitors and forwards the important signs to the node without disturbing the activities of the wearer. The data like heart rate, blood pressure can be forwarded to hospital in real time through LAN / WAN or through mobile network. The consultant can access the data remotely and can assess the health conditions of the patient. Basing on the symptoms, patients' warning alarms can be generated. Basing on the received values can activate the treatment procedure, so that the patient gets the treatment forthwith e.g. in case of low blood sugar there should be a device that injects required doze whenever required. BAN can improve health delivery while evacuating the patient to the hospital. It is also useful in post operative recovery room.

2. IMPLEMENTATION ISSUES OF BAN

Population of the world is increasing rapidly. Due to healthcare awareness people are more concerned to their well being resultantly. Healthcare costs are also increasing. Owing to this proactive approach there is visible increase in the average age of people. This number will further increase when the healthcare gadgetry will come up. The healthcare application permits in home assistance [1], however this facility in confronted with multiple challenges.

2.1 Energy Constrains

These networks operate on battery and have limited life. Typical alkaline battery provides 50 watt hours of energy. However there is no surety that system will work for a year or two. The researchers have to focus on this vary aspect and come up with some energy efficient mechanism [2] that should be able to support for prolonged time periods. The low power listening and the concept of wake up radios can further reduce the power requirements

2.2 Computational Power

The sensors have less memory and computational power. Hence they cannot perform large bit computations. A methodology has to be evolved, where sensor nodes should have varying capabilities and send the collaborative data message [3].

2.3 Confidentiality

The health information is of personal nature, hence demands that the unauthorized access to the data be denied. This can be ensured by encrypting the data by a key during the transmission.

2.4 Authenticity

In wireless networks any entity may pretend to be a legal one and may forward false data to the control node or may feed misleading information to other sensors and which may cause damage to the host [4].

2.5 Effects of Sensor Material

The sensors are implanted within the human body hence the size, shape and especially the material should not cause irritation / allergy or hamper the efficiency of individual [5].

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2.6 Strength

Under harsh environmental conditions, the failure rate of nodes becomes high. We need to devise such protocol that failure should not stop the routine functioning. Solution to this issue is that every node to operate autonomously and cooperate when needed. For example if a sensor node is capable of sensing and communicating and if sensing fails even then it should be able to forward the data. In this way malfunctioning can be isolated from the rest of the components in the node. This will also reduce the power consumption. The correctness of the data being sent can be checked by using check sums, parity and cyclic redundancy check [3].

2.7 Uninterrupted Health Monitoring

The sensor operates continuously to monitor the different parameters.

3. TECHNICAL REQUIREMENTS

BAN has undergone much technological advancement, yet has limitations due to wide range of applications. Table 1 depicts their varying requirements [6].

3.1 Frequency Allocation

Table 2 shows the salient features of bands that can be used for BAN. BAN radio can operate globally legally. The bands like ISM, WMTS, UWB or Media Radio Wing. But due to low power it will suffer from performance degradation. A new band FCC in the frequency range of 2360-2400 MHZ Spectrum for medical BAN is being considered for opening. The band will have exclusively 24 MHZ [6]

Table 1: Technical Requirement of BAN applications

Application	Data Rate	Nodes no	Topology	Battery Life
Hearing	200 kb/s	3	Star	>40 hours
Endoscope	1 Mb/s	2	P2P	>24 hours
Drug dosage	< 1 kb/s	2	P2P	>24 hours
ECG	72 kb/s	< 6	Star	>1 week
EEG	86.4 kb/s	< 6	Star	>1 week
EMG	1.536 Mb/s	< 6	Star	>1 week
Audio	1 Mb/s	3	Star	>24 hours
Video imaging	< 10 Mb/s	2	P2P	>12 hours

Table 2: Properties of frequency bands [Source: http://www.chiron-project.eu/wp-content/uploads/2011/05/CHIRON-D8_3_1-Assessment-of-existing-standards.pdf]

Frequency (MHz)	**Acronym**	**Merits**	**Demerits**
401~406	MedRadio	Worldwide availability, good propagation characteristics, quiet channel, medical only	Secondary usage, body-worn applications not allowed in 402–405 MHz core band, large antenna size, limited bandwidth
433.05~434.79	General Telemetry	Good propagation characteristics	EU/AU/NZ/SA only, crowded spectrum and limited bandwidth
608~614 1395~1400 1427~1432	WMTS	Good propagation characteristics, medical only	Licensed secondary use limited to healthcare providers inside healthcare facilities in US, limited spectrum, heavily used
868~870	General Telemetry	Good propagation characteristics	EU only, limited spectrum, heavily used
902~928	ISM	Good propagation characteristics	US/Canada only, crowded spectrum
2400~2483.5 (2400~2500)	ISM	Worldwide availability, small antenna, large bandwidth	Crowded spectrum, many standards and technologies 5725~5850 ISM Worldwide availability, small antenna, large bandwidth
5725~5850	ISM	Worldwide availability, small antenna, large bandwidth	Existing standards and technologies, severe attenuation

3.2 Model for Channel

Channel modeling is of utmost importance. However, difficulties arise for experimental channel modeling because it involves humans and healthcare facilities. Both are governed by the regulatory authorities. The size, material and antenna shape also possess problems. The compatible material for implants is platinum but it has poorer performance than copper. It will further limit the designer freedom.

3.3 Protocol Design

The protocol for BAN application should require minimum power consumption. BAN in unlicensed bands may suffer from interference and will result in performance degradation, in throughput. The introduction of sleep mode in case of idle period will contribute towards the saving of energy.

Since BANs are designed for life saving applications so they should provide reliability and security for crowded places like hospitals. We need to have efficient duty cycling method that should minimize power consumption without degrading.

3.4 Performance and Reliability

High priority to be accorded for most important monitoring and it should support alarm message. The protocol should have the capability to switch over to quiet channel if is suffering from heavy interference. Flexibility is the hallmark of BAN Technology. It will send or communicate with any application. Real time application needs to send the data in real time. Hence they are delay and loss sensitive because false data sending may generate a false alarm. BAN sensors have limited computational power and memory. Therefore we need to have better error detection and correction schemes as well as efficient acknowledgement mechanism.

3.5 Connectivity for BAN

BAN can provide round the clock monitoring of any health application provided the connectivity to infrastructure is ensured. BAN can transfer data using gateway devices like PDAs or cell phones. For indoor connectivity WLAN/WPAN is ideal because of short range, however for longer range of communication we need to rely on cellular network. So the application should support heterogeneous wireless network technology.

3.6 Power Consumption

Wireless technologies normally consume more energy. The wireless technology to implement active and sleep modes which will reduce the amount of current power consumption [3]

4. WIRELESS TECHNOLOGY

This section reviews the available wireless technologies suitable for BAN application.

4.1 Bluetooth

It is shortage wireless communication standard. It supports data and voice application. It employs adaptive frequency hopping spread spectrum full duplex signal at a rate of 1600 hops/s. This enables to reduce the interference between wireless technologies. It is very frequently used in cell phones and Laptops. Bluetooth health device profile (HDP) defines the Bluetooth healthcare. We can use Bluetooth for connecting data of blood pressure glues meter to data devices (Mobile phones, Laptops etc). New Bluetooth low energy is a standard that focuses on extremely low consumption of power along with encryption functions [11].

4.2 Zigbee

Zigbee supports flexible networks. Zigbee is optimized for low duty cycle of sensing devices. It means sensor can shut off the radio when it is not sending data. Zigbee has developed personal health & hospital care profile. It supports monitoring of chronic diseases [12]

4.3 ANT

ANT has the ability tradeoff between data rate and power consumption. ANT resolves the interference issues in 2.4 GHz band by employing TDMA. ANT devices include heart rate monitor, footpad etc [13].

4.4 Sensium

Sensium again targets at low power consumption. The technology employs master slave architecture. All body worn nodes act as slave. They periodically send network reading to master node within a single hop. All nodes remain in sleep made unless the stat assigned. It is ideal solution for low data rate [14]

5. UNIFORMITY AND STANDARDIZATION

Standardization supports interpretability. These reduce economics of sale and gives freedom to the buyer to purchase that best suits his requirements. The IEEE 802.15.6 task group the industrial standard that will address the peace power and data rate issues. In order to enable plug and play interpretability the protocols stack data exchange formats and application profiles need to be standardized. IEEE 11073 personal health data working group defined a standard that facilitates exchange of health information between network devices as well as hosting devices e.g. personal computer and gateways. The continuous health alliance defined interpretability goals about the network interfaces. A comparison of commonly employed communication technologies used for Body area networks are illustrated below in Table 3 [12].

Table 3: Comparison of Communication Technologies for Body Area Networks

Market Name Standard	ZigBee™ 802.15.4	GPRS/GSM 1xRTT/CDMA	Wi-Fi™ 802.11b	Bluetooth™ 802.15.1
Application Focus	Monitoring & Control	Wide Area Voice & Data	Web, Email, Video	Cable Replacement
System Resources	4KB - 32KB	16MB+	1MB+	250KB+
Battery Life (days)	100 - 1,000+	1-7	.5 - 5	1 - 7
Network Size	Unlimited (2^{64})	1	32	7
Bandwidth (KB/s)	20 - 250	64 - 128+	11,000+	720
Transmission Range (meters)	1 - 100+	1,000+	1 - 100	1 - 10+
Success Metrics	Reliability, Power, Cost	Reach, Quality	Speed, Flexibility	Cost, Convenience

6. APPLICATIONS OF BODY AREA NETWORK

Body area networks can be helpful in many areas like cardiac arrest [6-8], emergency response [9], Frequency monitoring sleep analysis, emotion detection stress monitoring [10]. The small size of sensor will allow collection of vast amount of data automatically. On the other hand will reduce the cost and save the time as well as inconvenience of visiting the physicians.

Few of the development in this field are:-

6.1 Epileptic – Early Warning

Many people suffer due to epileptic seizures each year. However, with the help of body sensors the behavior of a human can be monitored. The development of "Mobi" device is underway at university Chicago medical centre. This device can detect abnormal brain activity prior to seizure and will send a warning order to concerned staff but still its suffering from some of the teething issues [15]. Figure 1

Figure 1: [Source: http://www.tmsi.com/?id=2]

6.2 Hip Surgery

It is designed for those patients who are recovering from hip surgery. This system monitors leg position. It will send the alarm whenever the positing is wrong in real time. The Figure 2 shows the costume for the patient's rehabilitation. System will also measure the stress applied onto the operated leg. The doctor can analyze the results using some server applications [16]

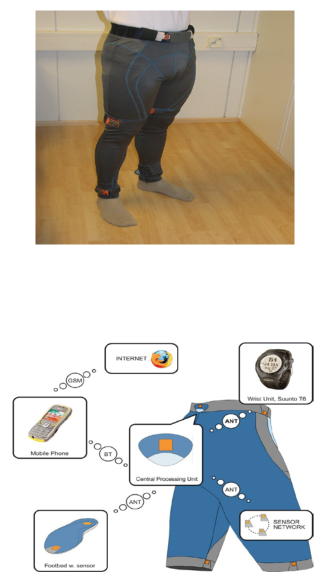

Figure 2: [16]

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6.3 Mobihealth

It uses the wireless communication technologies for the purpose of transferring the data. Aim of Mobihealth is to provide the continuous support and monitoring outside the hospital environment. Under such scenario a patient can perform the routine activities freely [17]. Figure 3

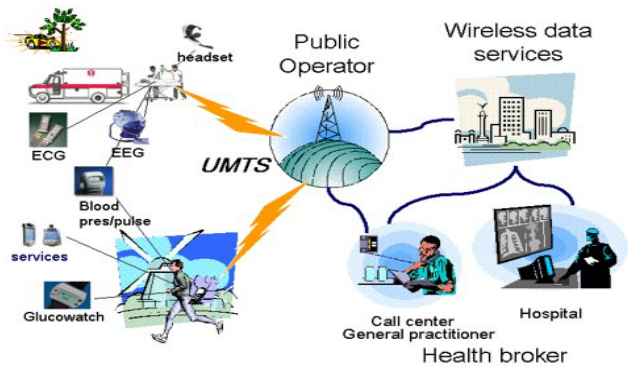

Figure 3: [Source: http://www.ctit.utwente.nl/research/sro/old/ehealth/interviews/dimitri.doc/]

6.4 Ubimon

It is a project which provides ubiquitous monitoring environment that provides continuous monitoring to the patient. Any abnormality in the ECG would be notified [18]

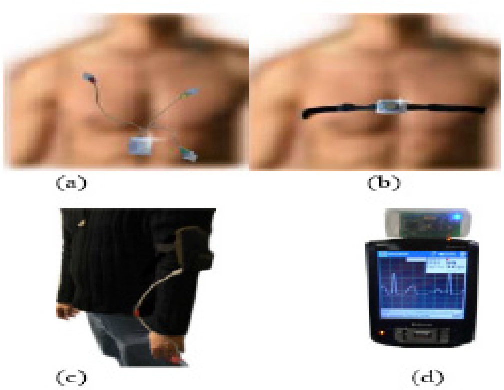

Figure 4: Source: [http://vip.doc.ic.ac.uk/benlo/m775.html]

6.5 E-watch

The e-watch system Figure 5 determines the wellness of the patient. Whenever the user is in trouble system generates a query to confirm that it is a really an emergency. The system can also notify the patient when he tastes a medicine [19]

Figure 5: [Source: http://www.tmsi.com/?id=2]

6.6 Life Shirt

The life shirt contains all essential sensors which enables the professionals to monitor vital signs under normal living conditions. It can also keep the record of physical poster [20] Figure 6

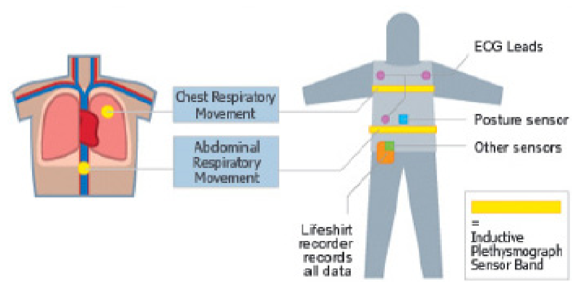

Figure 6: [Source: **http://www.pdacortex.com/VivoMetrics.htm**]

7. SUMMARY

Body Area network has lot of potential to provide unobtrusive health. BAN though brings out a new set of challenges in terms of security, QoS interference and energy efficiency. The wireless technologies contending for BANs have also been discussed. The paper also gives an over view of the BAN applications which that have been developed or are being developed. These new technologies have the potential to provide continuous monitoring to the patients and in abnormal conditions will generate the alarm to all concerned. This paper proves that BAN can be employed widely in health care application. Body area networks would improve the quality of life manifolds

REFERENCES

[1] J. A. Stankovic, Q. Cao, T. Doan, L. Fang, Z. He, R. Kiran, S. Lin, S. Son, R. Stoleru, and A. Wood, "Wireless Sensor Networks for In Home Healthcare: Potential and Challenges," in High Confidence Medical Device Software and Systems Workshop, Pennsylvania, USA, 2005.

[2] B. Krishnamachari, Networking Wireless Sensors: Cambridge University Press, 2006.

[3] L. Schwiebert, S. k. S. Gupta, and J. Weinmann, "Research Challenges in Wireless Networks of Biomedical Sensors," in 7th annual International Conference on Mobile Computing and Networking, Rome, Italy, 2001, pp. 151-165.

[4] Sriram Cherukuri, Krishna K Venkatasubramanian and Sandeep K S Gupta BioSec: A Biometric Based Approach for Securing Communication in Wireless Networks of Biosensors Implanted in the Human Body Proceedings of the 2003 International Conference on Parallel Processing Workshops (ICPPW'03)1530-2016/03 $ 17.00 © 2003 IEEE

[5] Paulo Neves, Michal Stachyra, Joel Rodrigues, "Application of Wireless Sensor Networks to Healthcare Promotion" Journal of Communications

Software and Systems, Vol.4, No.3, September 2008, 1845-6421/08/8143

[6] K. W. Goh, J. Lavanya, Y. Kim, E. K. Tan, and C. B. Soh, "A PDA-based ECG Beat Detector for Home cardiac Care," in IEEE Engineering in Medicine and Biology Society, Shanghai, China, 2005, pp. 375-378.

[7] J.-L. Lin, H. C. Liu, Y.-T. Tai, H.-S. Wu, S.-J. Hsu, F.-S. Jaw, and Y.-Y. Chen, "The Development of Wireless Sensor Network for ECG Monitoring," in 28th Annual International Conference of the IEEE, Engineering in Medicine and Biology Society, New York, NY, USA, 2006, pp. 3513-3516.

[8] S. A. Taylor and H. Sharif, "Wearable Patient Monitoring Application (ECG) using Wireless Sensor Networks," in 28th Annual International Conference on the IEEE Engineering in Medicine and Biology Society, New York, NY, USA, 2006, pp. 5977-5980.

[9] K. Lorincz, D. J. Malan, T. R. F. Fulford-Jones, A. Nawoj, A. Clavel, V. Shnayder, G. Mainland, M. Welsh, and S. Moulton, "Sensor Networks for Emergency Response," IEEE Pervasive Computing, vol. 3, pp. 16-23, October-December 2004 2004.

[10] E. Jovanov, A. O. D. Lords, D. Raskovic, P. G. Cox, R. Adhami, and F. Andrasik, "Stress Monitoring Using a Distributed Wireless Intelligent Sensor System," IEEE Engineering in Medicine and Biology Magazine, pp. 49-55, 2003.

[11] Alexandros Pantelopoulos and Nikolaos G. Bourbakis, Fellow "A Survey on Wearable Sensor-Based Systems for Health Monitoring and Prognosis" IEEE Transactions on System, Man, and Cybernetics-Part C: Application and Reviews, Vol. 40, no. 1 pages 1-12 January 2010.

[12] http://www.zigbee.org/Standards/ZigBeeHealthCare

[13] http://www.thisisant.com

[14] http://www.toumaz.com

[15] TMSI- http://www.tmsi.com/?id=2, Accessed Jan 2012

[16] Mikael Soini, Jussi Nummela, Petri Oksa, Leena Ukkonen and Lauri Sydänheimo "WIRELESS BODY AREA NETWORK FOR HIP REHABILITATION SYSTEM" Ubiquitous Computing and Communication Journal.

[17] Paulo Neves, Michal Stachyra, Joel Rodrigues, "Application of Wireless Sensor Networks to Healthcare Promotion" Journal of Communications Software and Systems,Vol.4, No.3, September 2008

[18] K. V. Laerhoven, B. P. L. Lo, J. W. P. Ng, S. Thiemjarus, R. King, S. Kwan, H.-W. Gellersen, M. Sloman, O. Wells, P. Needham, N. Peters, A. Darzi, C. Toumazou, and G.-Z. Yang, "Medical Healthcare Monitoring with Wearable and Implantable Sensors," in UbiHealth 2004: 3rd International Workshop on Ubiquitous Computing for Pervasive Healthcare Applications, Nottingham, England, 2004.

[19] http://www.chronicle.pitt.edu/?p=942

[20] http://www.vivometrics.com/lifeshirt/about-lifeshirt