# A survey on Body Area Network applications and its routing issues

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**Abstract -** *Body Area Networks are stated as "a communication standard optimized for power devices and operation on, in or around the human body to serve a variety of applications including medical, consumer electronics/personal entertainment and other." This technology came into exsistence in 1995 implementing communication over the human body. Few years later it was also considered for communication in the immediate proximity of human body. Typically body area networks consists of small sensors, a control unit and a transceiver which helps in gathering health related information continuously. BAN face many difficulties related to requirements in terms of delay, power, temperature and network lifetime which need to be taken into serious consideration in design of different protocols. Since routing protocols plays an important role in overall system performance of BAN. This paper provides a survey of body area networks, its working, applications and brief study of routing issues.*

**Key Words*:* Body Area Networks(BAN), Wireless Sensor Networks(WSN), Body area sensing, Types of nodes, Routing in BAN, Applications.**

## 1. INTRODUCTION

Recently, there has been increasing interest from system designers application developers and researches on a newly invented type of network architecture generally known as body sensor networks (BSNs) or body area networks (BANs), one made feasible by novel advances on ultra-low-power, lightweight, small-size and intelligent monitoring wearable sensors. In BANs, sensors are used to continuously monitor human's physiological activities and actions, such as health status and motion pattern. Although many protocols and algorithms have been proposed for traditional wireless sensor networks, they are not well suited to the unique features and application requirements of BAN. To illustrate this point, the differences between BAN and WSNs are listed as follows:

– **Deployment and Density**: Based on different factors the number of sensor/actuator nodes are deployed by the user. Typically, BAN nodes are placed strategically upon the human body, or are hidden under clothing. In addition, they do not employ redundant nodes to cope with various types of failures—an otherwise common design provision in conventional WSNs. Consequently, BANs are not node-dense. WSNs are deployed in places that may not be easily possible by operators, which requires that more nodes be placed to repay for node failures.

– **Data Rate**: Most WSNs are employed for event based monitoring, where events can happen at discontinous intervals. By comparison, BANs are employed for registering human's physiological activities and actions, which may occur in a more periodic manner, and may result in the applications data streams exhibiting relatively stable rates.

– **Latency**: This requirement is dictated by the applications, and may be traded for better reliability and energy consumption. However, while energy conservation is definitely beneficial, replacement of batteries in BAN nodes is much easier done than in WSNs, whose nodes can be physically unattainable after deployment. Therefore, it may be necessary to maximize battery life-time in a WSN at the risk of higher latency.

– **Mobility**: BAN users may move everywhere. Therefore, BAN nodes share the same mobility pattern, unlike WSN nodes that are usually treated as stationary.

There are several advantages introduced by using wireless BANs which include:

– **Flexibility**: Usage of non-invasive sensors is done to automatically monitor physiological readings, which can be delivered to nearby devices, such as a cell phone, a wrist watch, a headset, a PDA, a laptop, or a robot, based on the application needs.

– **Effectiveness and efficiency**: The signals produced by body sensors can be effectively handled to obtain reliable and accurate physiological estimations. In addition, their batteries are long-lasting due to their ultra-low power consumption.

– **Cost-effective**: As there is increased demand of body sensors in the consumer electronics market, more sensors will be mass-produced at a comparably low cost, especially in gaming and medical environments.

## 2. BAN COMMUNICATION ARCHITECTURE

In a BAN, the body embedded and wearable sensors send their information to a central device known as the body coordinator. Then, through a WLAN connection, these data are transferred remotely to a medical doctor's site for real time diagnosis, to a medical database for record keeping, or to the corresponding equipment that issues an emergency alert. Thus, BAN architecture is defined with a three Tier design: Tier-1 communications (i.e., intra-BAN communications), Tier-2 Communications (i.e., inter-BAN communications,), and Tier-3 communications(i.e., beyond-BAN communications). The intra BAN communications works into the BAN of a person and runs between a body sensor of this person and its body coordinator. Inter BAN communications run between one or many body coordinators and a static coordinator. The static coordinator runs as an Internet gateway and is able to command a set of body coordinators in order to control their personal-BAN. An inter BAN communication may be a centralized BAN communication and a distributed BAN communication.

In a centralized BAN communication, the stable coordinator is directly connected with each body coordinator. In a distributed BAN communication, data transmission between a body coordinator and the stable coordinator may run through intermediate body coordinators. Centralized communications are easier to handle and produce low transmission delay. However when the body coordinator is out of reach of the static coordinator, centralized communications cannot be settled. Distributed communications introduce flexibility and maximize communication reach.

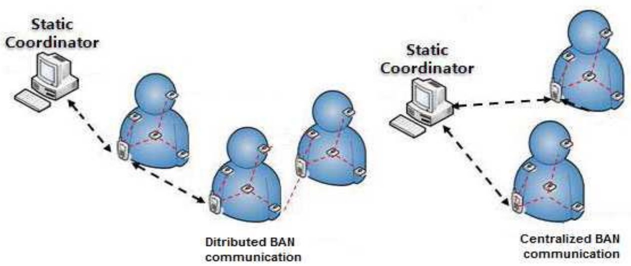


**Figure 1:** Centralized and distributed BAN communications

## 3. BODY AREA SENSING

BASN nodes create a network to humans, typically encapsulating an energy source, one or more sensors, a mixed-signal processor, and a communication transceiver. Some nodes also guide data storage or feedback control to body-based actuators, such as an insulin pump or robotic prosthetic. Although BASN and WSN nodes have same functional architecture, differences in their operative characteristics—sensing, signal processing, communication, caching, feedback control, and energy harvesting—present unique challenges and opportunities for BASN nodes.

### 3.1 Sensors

Sensors fall into three categories. *Physiological* sensors measure ambulatory blood pressure, continuous glucose tracking, core body temperature, blood oxygen, and signals associated to respiratory inductive plethysmography, Electrocardiography (ECG), Electroencephalography (EEG), and Electromyography (EMG). *Biokinetic* sensors measure acceleration and angular rate of rotation derived from human body movement. *Ambient* sensors measure environmental phenomena, which includes humidity, light, sound pressure level, and temperature.

### 3.2 Signal processing

Signal Processing is needed to extract valuable information from captured data that stems from transient events, consisting of falls, as well as from trends, such as the onset of fever. BASNs may generally needed to concurrently capture, process, and forward information to different stakeholders. Processing information at a given rate will consumes less power on average than transmitting the information wirelessly, and minimizing the data rate will reduce power consumption for both wireless transceivers and microprocessors. On-node signal processing will consume power to extract data, but it is going to reduce in-network data rate and power consumption.

### 3.3 Communication

Communication is important to node coordination. BASNs are precise in that they can restrict the communication radius to the body's periphery. By limiting the transmission range, it reduces a node's power intake, decreases interference among adjacent BASNs, and facilitates in maintaining privacy. WSNs generally communicate over radiative radiofrequency (RF) channels between 850 MHz and 2.4 GHz. Unlike WSNs, wireless BASNs are claimed by using the dramatic attenuation of transmitted signals resulting from body shadowing—the body's line-of-sight absorption of RF energy, which, coupled with motion, causes particular and highly variable path loss.

### 3.4 Storage

The lower power nonvolatile memory is explored by microelectronics industry such as MRAM and RRAM. Therefore, BASN functionality might be enhanced by availability of on-node storage. Due to the fact long time period information series regularly calls for no actual time aggregation, on-node storage is a perfect solution for archiving data, thereby increasing battery life. Longitudinal assessment is insensitive to postpone metrics that challenge time-critical monitoring. Some applications may pick out to cache data until body channel conditions are more favorable for transmission.

### 3.5 Energy harvesting

Despite the fact that the microelectronics enterprise has faithfully adhered to Moore's frenetic pace, advancements in business battery technology had been innovative. To remain a practical energy source for BASNs, battery technology must continue to increase energy density, and investments in accelerated power density must have well suited ranges of investment in battery safety—especially in light of recent battery recalls. The high strength density of lithium-primarily based batteries is assisting strength of many transportable purchaser technologies. Such batteries work well for handheld electronics, but their capacity is limited in miniature BASN enclosures. Super-capacitors and carbon-nano-tube based energy stores have great potential to improve battery capacity, however have no longer but matured to business availability.

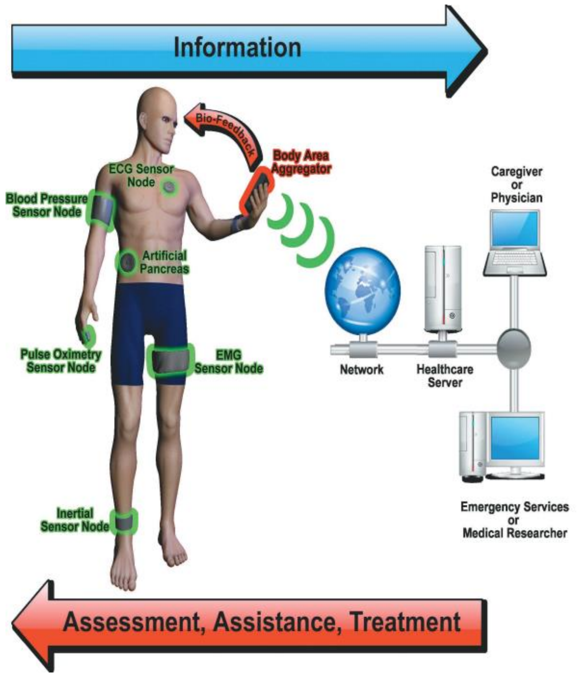


Figure 2: Sensors used in BAN

## 4. TYPES OF NODES IN BAN

An independent device in a WBAN is defined as node which exhibits communication capability. Nodes can be categorized into three different groups based on their functionality, implementation and role in the network. The classification of nodes in WBANs based on functionality is as follows:

***Personal Device (PD)*** – It collects all the information received from sensors and actuators and handles interaction with other users. The PD then informs the user through an external gateway, a display/LEDs on the device or an actuator. This device may also be refered to as body gateway, sink, Body Control Unit (BCU) or PDA in some applications.

***Sensor*** – Sensors measure certain parameters in one's body either internally or externally. The nodes collect and reply to record on a physical stimuli, process necessary data and provide wireless response to information. These sensors are either physiological sensors, ambient sensors or bio-kinetics. Some existing types of these sensors could be used in one's wrist watch, mobile, or earphone and consequently, allow wireless monitoring of a person anywhere, anytime and with anybody. A list of various types of commercially available sensors used in WBANs are as follows: EMG, EEG, ECG, Temperature, Humidity, Blood pressure, Blood glucose.

***Actuator*** – The actuator interacts with the user upon receiving data from the sensors. Its role is to provide feedback in the network by acting on sensor data, for example pumping the correct dose of medicine into the body in ubiquitous health care applications.

***Implant Node*** – This type of node is planted in the human body, either immediately below the skin or inside the body tissue.

***Body Surface Node*** – These types of nodes are either placed on the surface of the human body or 2cm away from it.

***External Node*** – These types of nodes are not in contact with the human body and rather a few centimeters to 5 meters away from the human body.

The classification of nodes in WBANs based on their *role* in the network is as follows:

***Coordinator*** – The coordinator node is like sort of gateway to the outside world, another WBAN, a trust center or an access coordinator. The coordinator of a WBAN is the PDA, through which all other nodes communicate.

***End Nodes*** – The end nodes in WBANs are limited to performing their embedded application. But, they are not able to relaying messages from other nodes.

***Relay*** – The intermediate nodes are called relays. They have got parent node, possess a child node and relay messages. In essence if a node is at an extremity (e.g. a foot), any data sent is required to be relayed by other nodes before reaching the PDA. The relay nodes may also be capable of sensing data.

## 5. ROUTING IN BAN

Routing is very much necessary in BAN due to the changing location of the patients which has its adverse effects on the network topology. For designing an efficient routing protocol, a standard network topology is an essential prerequisite. Once the topology structure is finalized the connectivity between the sensor nodes is to be decided prior to setting up a routing protocol because each of the communication process has different effects on the network. The possible types of connectivity practiced for effective communication are Line-of-Sight and Non-Line-of-Sight. Maintaining the energy and battery power of the sensor nodes is essential in case of WBANs as the sensor nodes are not replaceable once implanted into human body. So the principal goal of routing protocol design must be as robust and efficient and aim at conserving energy.

The radio frequency resources allocated to the WEANs are very much limited with less storage, lesser capacity and very low computational abilities. This has resulted in the need for a routing protocol design which is efficient in terms of conserving energy and power along with servicing the needs of the growing population of aged people and their health related issues.

## CHALLENGES IN ROUTING

BANs span a wide area of medical and non-medical applications from sport and entertainment to ubiquitous health care, military and many more. The main goal of all BAN applications is to improve one's quality of life. However, BANs applications have different architectures, technological requirements, constraints and goals. There are some general views of challenges in different BAN applications.

a) **Postural Body Movements**: The link quality between nodes in BANs varies as a function of time due to postural body movements. Thus, the routing algorithm to be proposed should be adaptive to different topology changes. In this regard, BANs to be considered in the category of Delay Tolerant Networks (DTN) due to disconnection and frequent partitioning concluded from postural body movements.
b) **Efficient Transmission Range**: Low RF transmission range causes the disconnection and frequent partitioning among sensors in BANs which leads to similar performance to DTNs. More specifically, if the transmission range of sensor nodes in a BAN is less than a threshold value, the choice of the next sensors for routing is reduced which causes higher number of transmissions to obtain a route leading to an overall average temperature rise.
c) **Limitation of Resources:** The bandwidth used in BANs is limited and varies with interference, noise and fading. Hence, the proposed routing protocol needs to be aware of the limitation on network control, energy and data gathered as the nodes in BANs may deplete due to unavailable memory, battery and bandwidth which may affect Quality of Service (QoS).
d) **Interference and Temperature Rise**: In terms of computing power and available energy, the energy level of nodes needs to be taken into account in the proposed routing protocol. The transmission power of nodes needs to be extremely low in order to avoid tissue heating and minimize interference.
e) **Limitation of Packet Hop Count**: Only one-hop or two-hop communication is defined for BANs. Multi hopping will increase overall system reliability by providing stronger links. However, the larger

number of hops the higher the energy consumption. Most proposed BAN routing protocols have not considered the limitation of number of hops.

f) **Local Energy Awareness**: The proposed routing algorithm should not rely on one route and one node in the network but has to further disperse its communication data to avoid total power usage of a specific nodes leading to node failure.

g) **Global Network Lifetime**: Network lifetime in BANs is defined as the time interval between which the network starts working to the time the first node dies. Network lifetime is of greater importance in BANs compared to WSNs and Personal Area Networks (PAN) as devices are expected to operate over a longer period e.g. charging and battery replacement is not feasible in implantable medical devices.

h) **Heterogeneous Environment:** Nodes in BANs can be heterogeneous. More specifically the memory and power consumption of nodes may be different from one another, which imposes several challenges to QoS in BANs.

## 6. BAN APPLICATIONS

The ability to deploy a finite number of wireless sensor nodes on the human body leads to the opportunity of developing a large number of applications in several fields.

*a)* ***Healthcare****:* At a first glance this is the most promising field of application for a WBAN. Several non-intrusive sensors deployed inside or on the human body allow the patients and the doctors to sample continuous waveform of biomedical signals in a remote and continued fashion. Events that require prompt assistance like heart attack and epileptic seizure, can be detected and even foreseen thanks to the continuous monitoring of the heart and brain activity, respectively. WBANs cannot only detect fatal events and anomalies, they can also improve the life style of hearing and visually impaired people by means of hearing aid, cochlear implant and artificial retina. The following is a non-exhaustive list of applications that can benefit from WBAN usage: electrocardiogram (ECG), electroencephalogram (EEG), electromyogram (EMG), pulse oximetry, drugs delivery, post operative and temperature monitoring, glucose level, toxins, blood pressure, etc..

*b)* ***Sport and Entertainment:*** A real-time log of vital parameters like blood pressure, heart beat, blood oximetry and posture can improve fitness and sport experiences. In this way users can gather information concerning their sport activity and use them to prevent injuries and to plan future training to improve their performance. WBANs bring more realism in the user experience in the field of entertainment. Motion capturing techniques make possible to track the position of different parts of the body by means of a network of gyroscopes and accelerometers wirelessly connected to a central node and worn by the user. The real-time information about the motion allows the user to use his body as a controller in videogames. Moreover, film industry takes advantage of motion capture along with post production techniques to realise highly realistic digital movies where actors play the role of non-human subjects.

*c)* ***Military and Defence:*** Network-Enabled Capability (NEC) is the name of the long term program aimed to achieve enhanced military effect through the use of information systems. New capabilities added by a WBAN will enhance the performance, at both individual and squad level, of soldiers engaged in military operations. At individual level, a set of sensors can monitor vital parameters and provide information about the surrounding environment in order to avoid threats, while information taken at squad level will make the commander able to better coordinate the squad actions and tasks. Spatial localisation techniques and communication between different WBANs (inter-WBAN communications) play an important role in this field, as well as security in order to prevent sensitive information from being caught by the enemies.

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## REFERENCES

[1] C. Kriti, S. Divya, "Body Area Networks: A Survey",International conference on sustainable global development, pp.3319-3323, 2016.

[2] J.J. Jijesh, Shivashankar, "A survey on wireless body sensor network routing protocol classification", 11th International conference on intelligent systems and control(ISCO), pp. 489-494, 2017.

[3] M. Samaneh, A. Mehran, L. Justin, S. David, J. Abbas, "Wireless Body Area Networks: A Survey", IEEE Communications surveys and tutorials, vol. 16, issue no. 3, pp. 1658-1686, 2014.

[4] C. Riccardo, M. Flavia, R. Ramona, B. Chiara, V. Roberto, "A Survey on wireless Body Area Networks: Technologies and design challenges", IEEE Communications surveys and tutorials,vol. 16, issue no. 3, pp. 1635-1657, 2014.

[5] D. Emmanuel, S. Kola, J. Mohana, "A Survey on wireless Body Area Networks", International journal of scientific and research publications, vol. 4, issue no. 3, pp. 1-7, 2014.

[6] K. Rani, N. Parma, "Performance comparison of various routing protocols in WSN and WBAN", International conference on computing,communication and automation(ICCCA), 2016.

[7] S. Omar, K. Adda, Z. Youssef, C. Bernard, "ESR- Energy aware and Stable routing protocol for WBAN Networks", IEEE publications, 2016.

[8] E.B Hadda, C. Lamia, K. Lotfi, "A Survey of routing protocols in Wireless Body Area Networks for healthcare applications", International journal of E-health and medical communications, vol. 3, issue no. 2, pp. 1-18, 2012.

[9] D. Kavitha, M. Balapriya, T.V.P Sundrarajan, "A Survey of routing protocols in Wireless Body Area Networks", South Asian Journal of Engineering and Technology, vol. 2, issue no. 21, pp. 44-51, 2016.

[10] A. Javed, Z. Fareeha, "Review of Body Area Network technology and wireless medical monitoring", International Journal of Information and Communication technology research, vol. 2, issue no. 2, 2012.

[11] I.F.Akyildiz, W. Su, Y. Sankarasubramaniam, and E.Cayirci, "A Survey on Sensor Networks," proc. IEEE Communication. Magazine, Aug. 2002, pp.102-114.

[12] P. Maulin, F.J.Wang, "Applications, Challenges and Prospective In Emerging Body Area Networking Technologies", IEEE Wireless Communications, pp. 1284-1536, 2010.

[13] K. Jamil, Y and Y. Mehmet, "Wireless Body Area Network (WBAN) for Medical Applications,"New Developments in Biomedical Engineering, no. 1, pp. 591-628, 2010.

[14] C.V. Garth, G. Tirthankar, M. Renita, C.A. Craig,"Wireless Body Area Networks for Healthcare: A Survey," International Journal of Ad hoc, Sensor & Ubiquitous Computing (iJASUC) vol.3, issue no.3, pp. I- 26, 2012.

[15] K. Pervez, Md. Asdaque Hussain, K.S. Kyung, "Medical Applications of Wireless Body Area Networks," in international Journal of Digital Content Technology and its Applications, vol. 3,issue no. 3, pp. 185-193, 2009.

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