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Routing protocols of wireless body networks: A review

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Abstract
The wireless body area network is the type of network which can sense the body conditions and pass sensed information to base station. The WBAN is the decentralized and self-configuring type of network in which energy consumption is the major issue of the network. The routing protocols of wireless body area network can be categorized into certain classes. In this review paper, various routing protocols are reviewed and compared in terms of certain parameters.

Keywords: WBAN, mini sensors, routing protocols

1. Introduction

Wireless Sensor Network is a combination of tiny light weight wireless sensors with computing elements. These sensor nodes are generally cheaper in price, with limited energy storage and limited processing capabilities. Wireless sensor network consist of large number of these sensor nodes (usually hundred or thousand of nodes). These types of networks are highly distributed and deployed in hostile environments [1]. Wireless sensor networks monitor the system or environment by measuring physical parameters such as pressure, humidity and temperature. WSNs are best suited for applications like military command, wildlife monitoring, intelligent communications, and industrial quality control, smart buildings, observation of critical infrastructures, distributed robotics; examining human heart rates, traffic monitoring etc.

WBAN is a latest technology which provides high level health care monitoring. Mini sensors are deployed on the body and it continuously monitors person's metal stage. There are number of mobile sensor which can be communicated with a mobile phone using internet interface to form a WBAN.WBAN is a network which monitors individual's health continuously in free living conditions where individual is free to conduct her daily routine activity. The mobile phone in a WBAN is used to gather data related to health from sensors, store and partially process that particular data and transmit the data of health over wireless links to a back end processing server.

A typical mobile phone based WBAN consists of three layers:

1. First component is the sensor layer which measure emotional signals and physiological signals and transfer data wirelessly.
2. Second layer is mobile phone which act as a data collect hub and receive external sensors. It can be attached with GPS, audio and video tags to get accurate information of health of a person with environmental conditions. Data can be processed locally with a mobile phone.
3. The last layer is a back end server

1.1 Routing Protocol for WBAN

Main routing protocols are given below:

i) **QoS- Aware Routing Protocol:** QoS aware routing protocol is modular based protocols and have different modules for different type of Qos services. Due to complexity of different modules and coordination of different design there are many challenges for WBAN.

ii) **Temperature Aware Routing Protocol:** In wireless body sensor, some bio-medical sensor may be implanted inside human body. Due to radio signal magnetic and electric fields are generated in wireless communication. As a result temperature arises because of absorption, power consumption and node's circuitry. This will affect the sensitive organs of human organ. For e.g. TARA. LTR etc.

iii) **Cluster Based Routing Protocol:** Third type of category is cluster based routing protocol. In this technique sensor nodes and biomedical sensor nodes are divided into one or more clusters. There are many methods which can be applied to choose cluster head and data which is send to the sink through these cluster head. It helps to reduce direct communication between sensing node and sensors. For e.g. HIT and Anybody are its protocol.

iv) **Postural Movement based Routing Protocol:** The link between two sensor nodes faces the problem of disconnection because of the postural movements. These protocols choose routes from the bio-medical sensor nodes to the base station with minimum cost to forward the data packets.

v) **Cross Layer Routing Protocol:** This protocol try and address to solve the challenges of both network and MAC layers at the same time to improve the overall performance of the network. For e.g. WASP and CICADA are its sub categories.

2. Literature Review

Javed Iqbal Bangash *et al* (2013) [1] explains that WBAN is a

one of the type of WSN which helps to monitor data from source to destination. WBAN also faces some problem similar to WSN but WBAN has some unique requirement which make it different from WSN. In this paper, first they focus on the architecture of WBAN. After that they focus on various challenges and issues of WBAN routing. They maintained list of routing protocol with their specifications and draw backs. The proposed Qos aware routing protocols consider the problem related to the patients. But it is unable to consider postural movement of the human body.

Samaneh Movassaghi (2013) *et al.* introduce [2] advancement in wireless communication, integrated circuits and MEM's enabled low power, intelligent and non-invasive micro placed in our human body used for monitoring functions of body and its environment. This paper discloses many problems in terms of delay, power, temperature and network lifetime with some design issues. Routing protocol plays very important role for data communication from source to node for the reliable and improves overall performance in terms of delay, power consumption and temperature. This paper also introduces some new routing protocols which are designed for WBAN. These protocols are further categorized into sub division. Moreover comparison between these protocols has also discussed.

Aashima Arya and Naveen Bilandi (2014) reveal [3] that there are basically three types of wireless body area network which are attached on clothes, on body and under skin. In this paper they have discussed various protocols of MAC protocol and current technologies for WBAN. In this paper they have given an idea to improve health care system of India using Telecommunications and technology with the help of wearable and implantable body sensor nodes without effecting mobility of the patient.

Pervez Khan *et al.* (2009) introduces [4] Wireless Body Area Networks which provide efficient solution to the health care system. In this paper it is explained that WBAN is used for monitoring health care and use in wearable implantable WBAN is the key infrastructure. They have described a general system model for the biosensor network rooted inside the human body and some important issues and challenges that a WBAN can face.

LIU Jang (2015) *et al.* explains [5] that WBAN is the most advance technology in the field of networking. It is one of the best technologies in e-applications. Energy is the one of the major issue in WBAN. In this paper, Energy efficient MAC protocol named as Quasi-Sleep-Preempt-Supported (QS-PS) is proposed. This is TDMA based protocol which has number of nodes for transmit data in allotted slots while packet enters in Q-sleep mode in other slot. Node which has energy packet can broadcast a special designed awakening message to wake up the whole network and has right to use the current slot for transmitted that emergency packet.

A. Rahim (2012) *et al.* reveals that [6] comprehensive overview of MAC protocol for WBAN. Small battery are deployed on body parts and implanted sensor nodes to monitor physiological signs like blood temperature, ECG, blood pressure etc. in this paper requirement of the WBAN network has been discussed. Later on they have discussed existing protocols of WBAN with their weakness and limitations.

Mousam Dagar1 and Shilpa Mahajan (2013) explain [7] that WSNs have small size devices and have limited capability of the processing and it has very low battery power. Low power of battery and limited processing capability makes the sensor network prone to failure. Data aggregation is very crucial technique in WSNs. Aggregation of data is used to collect the data from the different nodes and data is collected by the CH in each cluster and after collecting the data by cluster head it combine the data and send the information to the Bs. Data aggregation is used to remove the redundancy. Most of the energy is used for transmitting and receiving the data. Efficient data aggregations provide the conservation of energy and it can also remove the redundancy from the data after that provide the useful data only.

Bin Liu (2012) *et al.* [8] introduced that WBAN is a latest technology of low power technology that communication between body area sensor nodes and a central coordinator. In this paper they focus on challenges of WBAN-MAC to improve reliability and efficiency. They also introduce a context –aware MAC protocol to meet time-varying requirements of WBAN. Thus proposed technique is able to reduce latency, energy consumption and packet loss.

Nourchène Bradai (2013) *et al.* reveal [9] that advancement in wireless communication technologies and micro-electronic system have boasted the development of small and intelligent micro-components that deal with sensing device and wireless communication into a single circuit. This circuit wear inside a human body for the purpose of medical and health care application. The main issue in this network is the medium access used for urgent data. The design for MAC protocol for WBAN is a challenging due to characteristics of WBAN.

K. Shashi Prabh (2012) *et al.* explained [10] that in WBAN number of nodes is placed on human body using wireless links. These networks are operated at low transmit power regime to keep low specific absorption rate. It is known as error prone. The observations show fluctuations when a person moves in a received signal strength. In this paper BANMAC technique is present where a MAC protocol monitors and predicts channel fluctuations when RSS is high. MAC protocol helps to resolve co-channel interference in the event of multiple co-located BAN's in a visicinity. Experimental result shows that packet loss rate and energy consumption of BANMAC is lower than IEEE standard of 804.14.15 MAC.

Sana Ullah *et al.* (2010) represent [11] that MEMS, integrated circuits and wireless communication have allowed apprehension of WBAN. This paper also focuses on antenna design for low power and low profile MAC protocol for WBAN. They help to provide in body and on-body sensor networks for power efficient protocol. Limitation of Low power antenna design has been discussed in this paper.

Sergio Gonzalez-Valenzuela *et al.* (2012) introduces [12] BAN which is subcategory of wireless sensor network for monitoring internal activities of the humans and animals. WBAN also introduce number of challenges which are arisen due to paucity of hardware and software resources. In this paper they have discussed about deployment and design of the BAN. They also discuss issues related to the deploy sensor node, interference with external infrastructure. The main challenges and issue which are being faced by the WBAN discussed in this paper. The main technology, enabling

software and hardware, as well as future trends and open research issues in BANs has been limelight.

Shah Murtaza Rashid Al Masud (2013) introduce [13] that WBAN enables medical doctor to monitor activity of the patients organs and sign to give real time diagnosis. This paper focuses on key components of WBAN. Basic difference between WBAN and WSN has also discussed in this paper. Moreover Technical challenges and its features, quality of service (QoS) and security, analysis of MAC features, different sensors, its applications, \ different data rate, frequency of signals, latency of WBANs, issues related to energy or power efficiency, and existing WBAN technologies. In addition to it, open research challenges are also pointed out in this paper.

Weiya Wang and Chao Li (2009) explain [14] that the integrated application of WBAN and WSN in nursing home health care system. They also proposed a Gradient Routing protocol for wsn to fulfill WBAN requirements of data transfer in limited area. It also considers its principle and implementation. They also focus on locating algorithms and other algorithms for varying situations.

Chun-Hui Chu (2010) explains [15] the development of wireless body area networks to increase the use of wireless networks and constant miniaturization of electrical devices. WBAN sensors are attached to the clothes on the body or implanted under skin. Its applications are measure heartbeat, record ECG. The main goal of WBAN is to improve the health care and quality of the life with the mobility of the patients.

Table 1: Table of Comparison

Author name	Year	Description	Advantage	Disadvantage
Javed Iqbal Bangash	2013	In this paper, first they focus on the architecture of WBAN. After that they focus on various challenges and issues of WBAN routing. They maintained list of routing protocol with their specifications and draw backs. The proposed Qos aware routing protocols consider the problem related to the patients	The proposed Qos aware routing protocols consider the problem related to the patients.	The author focus on to improve quality of service in the network. The quality of service can be reduce in case of body movement. The author donot propose any parameter for body movement
Samaneh Movassaghi	2013	The author introduce advancement in wireless communication, integrated circuits and MEM's enabled low power, intelligent and non-invasive micro placed in our human body used for monitoring functions of body and its environment	This paper discloses many problems in terms of delay, power, and temperature and network lifetime with some design issues. Routing protocol plays very important role for data communication from source to node for the reliable and improves overall performance in terms of delay, power consumption and temperature.	The author categories various routing protocol but donot explain their performance in various scenarios
Aashima Arya and Naveen Bilandi	2014	They have discussed that how anyone can get benefits from WBAN as well as human beings also. They also focused on the technique that how health can be improve using multiple nodes. In this paper they have given an idea to improve health care system of India using Telecommunications and technology with the help of wearable and implantable body sensor nodes without effecting mobility of the patient.	In this paper they have discussed various protocols of MAC protocol and current technologies for WBAN.	The author donot focus on the issues which are related to these technique like main issue of MAC protocols is clock synchronization
Pervez Khan *et al.*	2009	In this paper it is explained that WBAN is used for monitoring health care and use in wearable implantable WBAN is the key infrastructure. They have described a general system model for the biosensor network rooted inside the human body and some important issues and challenges that a WBAN can face.	The author discussed various routing protocols and modal which is developed for human body. This paper explains bio sensors that how it is beneficial for human body	The main disadvantage of this paper is that author directly explain the data routing in wireless body area network. The author donot concentrate on route discovery procedure
LIU Jang	2015	In this paper, Energy efficient MAC protocol named as Quasi-Sleep-Preempt-Supported (QS-PS) is proposed. This is TDMA based protocol which has number of nodes for transmit data in allotted slots while packet enters in Q-sleep mode in other slot.	The concept proposed by the author is responsible for decreasing delay. QS-PS can achieve high energy efficient and have minimum delay for normal and emergency packets.	The disadvantage of this paper is that author donot propose any technique for efficient task scheduling
A. Rahim	2012	In this paper requirement of the WBAN network has been discussed. Later on they have discussed existing protocols of WBAN with their weakness and limitations.	In this paper, author discuss about various requirements for wireless body area network and it also discuss about the differences between WBAN and WSN	The author only discuss about the weekness of wireless body area network and it donot explain any protocol to overcome that loop holes in the network
Mousam Dagar1 and Shilpa Mahajan	2013	In this paper, author explains about the data aggregation procedure in the network. It explains that with the proper data aggregation data redundancy can be reduced in the network	The author proposed an modal for data aggregation which can reduce data redundancy and reduce energy consumption of the network	The author donot provide any counter measure technique which provide secure communication between source and destination

Bin Liu	2012	The author propose technique which can handle latency problem in the network. The sensor nodes can generate time varying traffic in the network which gave arise to latency problem	In this paper they focus on challenges of WBAN-MAC to improve reliability and efficiency. They also introduce a context –aware MAC protocol to meet time-varying requirements of WBAN. Thus proposed technique is able to reduce latency, energy consumption and packet loss.	The author discuss about the latency problem which arise due to time varying traffic. The author donot discuss or provide any solution to bit error rate which increase due to time varying traffic
Nourchène Bradai	2013	This paper focuses on priority MAC technique. In PMAC, Data channels are alike from control channels and priority is given to the emergency traffic. Moreover, Sleep mode is used for save energy of wearable wireless sensor.	This circuit wear inside a human body for the purpose of medical and health care application. The main issue in this network is the medium access used for urgent data. The design for MAC protocol for WBAN is a challenging due to characteristics of WBAN.	The author donot high light any issue which can be raised in the MAC protocol due to non synchronization of wireless sensor nodes
K. Shashi Prabh	2012	In this paper BANMAC technique is present where a MAC protocol monitors and predict channel fluctuations when RSS is high. MAC protocol helps to resolve co-channel interference in the event of multiple co-located BAN's in a visicinity.	Experimental result shows that packet loss rate and energy consumption of BANMAC is lower than IEEE standard of 804.14.15 MAC.	In this paper, some further improvements can be proposed which can reduce packetloss and energy consumption of the network
Sana Ullah *et al.*	2010	This paper represents infrastructure of WBAN which provide solutions for on demand, normal and emergency traffic. This paper also focuses on antenna design for low power and low profile MAC protocol for WBAN. They help to provide in body and on-body sensor networks for power efficient protocol.	This paper provides best solution for efficient routing in wireless body area network. This proposed technique can leads to improvement in packet delivery ration	The main problem which exists in this paper is of antenna. The antenna which is used is of low frequency which reduce network performance
Sergio Gonzalez-Valenzuela *et al.*	2012	WBAN also introduce number of challenges which are arisen due to paucity of hardware and software resources. In this paper they have discussed about deployment and design of the BAN. They also discuss issues related to the deploy sensor node, interference with external infrastructure	The main challenges and issue which are being faced by the WBAN discussed in this paper. The main technology, enabling software and hardware, as well as future trends and open research issues in BANs has been limelight.	The author only high light various problems associated with WBAN. The author donot provide any solution to these problems
Shah Murtaza Rashid Al Masud	2013	This paper focuses on key components of WBAN. Basic difference between WBAN and WSN has also discussed in this paper. Moreover Technical challenges and its features, quality of service (QoS) and security, analysis of MAC features, different sensors, its applications, \ different data rate, frequency of signals, latency of WBANs, issues related to energy or power efficiency, and existing WBAN technologies.	This paper mainly focus on MAC protocol feature. The MAC protocols reduce the packet collision in the network	This paper presents the MAC protocol modal for channel sensing in wireless body area network. This paper donot high light the issues which are related to MAC protocols for channel sensing like congestion or bottle neck
WeiyaWang and Chao Li	2009	This paper focuses on integrated application of WBAN and WSN in nursing home health care system. They also proposed a Gradient Routing protocol for wsn to fulfill WBAN requirements of data transfer in limited area. It also considers its principle and implementation.	The author proposed gradient routing based technique for wireless sensor nodes. The implementation results shows that packet delivery ratio is high of the protocol	The author donot focus on any of the issue which is related to gradient routing. These issues are link failure and load balancing
Chun-Hui Chu	2010	WBAN sensors are attached to the clothes on the body or implanted under skin. Its applications are measure heartbeat, record ECG. The main goal of WBAN is to improve the health care and quality of the life with the mobility of the patients.	The author only high light the benefits of the network and quality of service parameters are presented	The main disadvantages of paper is that author only high light the issues but donot propose any technique to overcome that issues

3. Conclusion

In this work, it is concluded that wireless body area network is the decentralized type of network in which sensor nodes can join or leave the network when they want. Due to dynamic nature of the network, routing and energy efficiency are the major issues. In this review paper, various routing protocols are reviewed in terms of certain parameters.

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