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A Review on Wireless Body Area Network (WBAN) for Health Monitoring System: Implementation Protocols

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ABSTRACT
As in the present era use of wireless networks is increasing day by day and the electrical devices are getting smaller; both factors expand the research area of Wireless Body Area Networks(WBAN).The devices used in WBAN can record various physiological parameters like the body temperature, the BP or to take ECG, EEG, etc. With the use of WBAN, a patient experiences a greater physical mobility. The patients need not stay longer in the hospital as WBANs are placed on the human body and often transport private data; Security is considered as an important issue. It will in turn increase the quality of patient care and the productivity of hospital staff. Field of Wireless Body Area Networks comes up as a major research area in past few years as it is beneficial in health monitoring even in remote areas and patient's care can be done in real time. However, if the security of patient's data is concerned with WBANs, design issues should be taken care of. In the present paper, a short review on various aspects of Wireless Body area Network, various implementation techniques and MAC protocols are discussed. The technique which is best suited to the user is also presented.

Keywords
Wireless Body Area Network, MAC Protocol, Topology, Health Monitoring System

1. INTRODUCTION
Wireless Body Area Network (WBAN) has emerged as a vital technology that is capable of providing better methods to diagnose various hazardous diseases. This technology works in actual time to monitor the health issues cum physiological parameters of the patients [1]. WBAN is a fast developing technology; hence various issues need to be addressed till now. In WBAN either sensor network on a band or various sensors are worn by a patient [Fig 1.] or which are light in weight that monitor various physiological signals .They are able to transmit bio signals (vital signs) to the concerned System at a Healthcare Center. The monitoring healthcare specialist retrieves the patient data and processes it. WBAN comes up as a revolutionary technique from the past few years and it is easily acceptable as explained by [2].

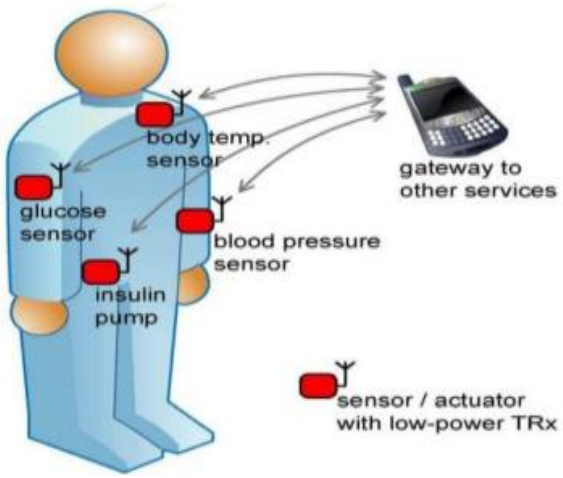

Fig.1 Wireless Body area Network

The paper is organized as follows:

Section 1 describes architecture and devices used in WBAN and design considerations.

Section 2 represents aim and scope of review

Section 3 represents various design approaches and literature review.

And finally section 4 describes conclusion and future scope

1.1 WBAN Architecture
In last decade, Wireless communication technologies and standards have grown exponentially. With this research can be applied in various domains that were not feasible, years ago. E-Health and Telemedicine are two areas at the forefront of this development that take full advantage of current wireless communication technologies to provide emergency and on-demand medical services, enable outpatient monitoring and treatment, aid in patient recovery, directly connect doctors and nursing staff with patients, WBAN is one of the examples. WBAN is a wireless networking technology, based on Radio Frequency (RF) that interconnects some small nodes with sensing unit or actuator capabilities. These nodes operate in close vicinity to, on or few cm inside a human body, to support various medical and non-medical area applications. WBAN uses medical bands to obtain physiological data from sensor nodes. The medical band is selected in such a way that it reduces interference and thus increases the coexistence of sensor node devices with other network devices available at medical centers. The collected data is then sent to remote stations with a multi-hopping technique using the medical gateway wireless boards [3]. WBAN technology is highly

appreciated in the field of medical science and human healthcare [4-7] Also; a significant contribution has been delivered to the field of biomedical and other scientific areas [8]. Moreover, its applications are widespread in non-medical areas like consumer electronics and personal entertainment [9].

Previous work done by [10] discusses a low-cost WBAN using off-the-shelf hardware and successfully tested in real time where data were successfully taken and shown on a website. The BAN collected the pulse rate, the temperature and the location of the patients. The captured data was made available through a graphing application programming interface, where data can be continuously monitored on a website. Currently, the BAN is powered using a 9V battery.

1.2 Devices used in WBAN

There are various devices in WBAN architecture. These are discussed by [11].

1. *Sensor nodes*: These form the base of any WBAN.As on this basic stage, there are various sensors to monitor the physiological parameters i.e. BP, ECG, Pulse Rate, EEG, etc. These sensors nodes work in close vicinity to, on or in the body; picks up the bio signal and gives to further unit for processing. The sensors can be either mono or multifunctional. Nodes can be Implant node, Body surface nodes, and External node.
2. *Base Station*: It is a local processing unit that forwards the data, processes and analyzes it and gives output/feedback to the patients. Preferably various research organization and companies make their base station so that patient can take that transmitter to its home and he is not bound to stay in the hospital.
3. *Central Server*: In this unit database is maintained and further sent to a specialist for consultancy or proper medical guidance.

1.3 Design Considerations cum requirements for WBAN

[12] have discussed certain design considerations:

1. To make wireless devices non-invasive and unobtrusive, the sensors used in it should be small and light in weight.
2. The sensors used in WBAN should be reliable as patient's sensitive information is collected by them
3. The system should be robust.
4. No overhead so that latency is reduced.
5. Energy efficiency of WBAN should be high with minimal power dissipation
6. There is a direct relationship between frequency and tissue warming. The higher the frequency of the EM signal, the higher is its absorption by the tissue and more the tissue warming. Hence, it is desirable to use lower frequencies for communications. However, the lower the frequency, the larger the antenna dimensions have to be. Therefore, there is a trade-off between antenna dimensions and tissue warming

2. AIM AND SCOPE OF REVIEW

The prime aim of this review is to provide readers an idea that MAC protocols can be used for transmission of signals. Choice of the right MAC protocol is an important aspect as in WBAN signal ranges are short and for proper patient monitoring fading and latency is unacceptable. In this review, some of the MAC protocols, current topologies and work done so far are discussed.

3. RELATED WORKS

3.1 MAC protocols for WBAN

[13] Have discussed the protocols. MAC protocols used by [7] in WBAN stressed that they must be accurate with low power consumption and latency. The main objective of an MAC protocol lies in the real-time patient monitoring system.It must be good energy efficient and allows collision-free transfer [14-15]. MAC protocols can be categorized as: scheduled and random access protocols. The scheduled access protocols offer high quality of service (QoS) by accepting packet delay and packet loss whereas random access protocols are dynamic in nature that allocates the resources to the communication nodes only when a node has a message to transmit the data [2]. At varying traffic load, this gives better efficiency. TMAC, SMAC, ZigBee MAC, and Baseline MAC are some of the common protocols.

3.1.1 Scheduled TDMA MAC Protocol:

In this protocol transmission channel contention is absent as it offers deterministic delay and there is no packet loss.

3.1.2 Random Access MAC Protocol (RA-MAC):

It is also known as ON demand access protocol and is suitable for short range communications for specially designed sensor networks. Many RA-MAC protocols offer sensor applications but a sensor network design with CSMA/CA protocol is the best suited for short-range communication networks [16-17]

3.1.3. Polling MAC Protocol:

This protocol has master-slave architecture. It is based on scheduled transmission technique. In this type of network, the central controller is provided to avoid any contention probability [18].

3.1.4. TMAC:

It is a duty-cycling protocol. Here the node is open for a limited time whch is called active time. Duty cycle varies with a traffic load of the network. Higher the traffic load higher will be the duty cycle and vice versa.

3.1.5 SMAC:

This protocol is somewhat like TMAC, but the only difference is that it has fixed duty cycle. For varying data rates in WBAN, this protocol gives better efficiency.

3.1.6 ZigBee MAC:

This protocol uses two different techniques- CSMA/CA or TDMA. If one uses CSMA/CA scheme with this protocol, it gives average output but with TDMA scheme power consumption reduces to the maximum extent. If the system is properly designed using CSMA/CA , WBAN is scalable as it offers lower delay with high Quality of service [12][19].TDMA based system has been described by [20] As

traffic load decreases, the data loss will be less and TDMA scheme gives better performance.

3.1.7 Baseline MAC:

This MAC protocol uses CSMA/CA scheme. Energy consumption is not average, but throughput is average.

3.1.8. *QS-PS MAC*:

It is energy efficient protocol. Compared to other protocols it gives high efficiency and reduces delay in both emergent and normal packets [21].

3.2 Literature Review

As in WBAN sensors are placed in/on the body, the battery size is small. Battery life is proportional to battery size. In WBAN data is processed in power efficient manner. Power efficiency is the key feature while designing WBAN besides the use of high layered energy-efficient MAC protocols. One such protocol is proposed by [22] in which multi-hop architecture has been discussed. As the data handled by WBAN is of low power, he suggested a gossiping strategy based on TDMA based MAC protocol for data transmission between sensor and the gateway. Results show that power consumed is low in comparison to TDMA based Star network.

Another energy efficient model was proposed by [23] which are known as a wireless device driver for low duty peripherals. This device controls all the devices connected to it to make the system reliable. The device driver is not always connected with the peripherals and user can depart/rejoin it according to the requirement. These techniques save the latency time by making use of either Bluetooth or Zigbee.[33]

Collision, overhead, packet overhead, etc. are the main reasons for energy wastage in the design of MAC protocol in WBAN [24-25].In these two protocols proposed were CSMA/CA and TDMA. For research and implementation purpose, they used IEEE standard 802.15.4 (Bluetooth and Zigbee) as communication protocols. The Zigbee has low data rate and low bandwidth as compared to the Bluetooth. Zigbee is used with star topology whereas Bluetooth is widely used with master –slave configuration.

For super frame-structured WBAN MAC protocols [26] suggested user defined and easily understandable handling scheme for crisis times. Instead of Contention-Free Period (CFP), they proposed Mixed Period. Next, they also discussed another scheme for data transmission that is known as Extended Period (EP), which provides guaranteed time slot (GTS) to that slots that are not assigned time because of massive traffic and crisis. This scheme can be implemented to a general super frame-structured MAC protocol named ex. IEEE 802.15.4 and its next version. That also helps in random Contention-Free Period allotments.

According to design choices [27] gave a practical solution to the implementation problems. In the application model, sensors decode the data and send output periodically. Accordingly a sensor may be added and removed in the network at any unit time. By making use of the offset-free scheduling model in which the processes are processed periodically, and schedule length is equal to the hyper period of the process. Because of limitation in resources, it may not be practically possible for a sensor node to keep a long global schedule covering the hyper-period.

[28] Proposed a novel MAC protocol for BAN that uses an out-of-band wakeup radio. This special wake-up radio circuit attached with each node is used for triggering a node to wake up from a sleep state. The implementation cost for the same device is very low, and design is very simple. It can save power, but it has a limitation of range up to 10-15 feet only.

By the use of new technology, Cooperative Network Coding (CNC), [29] have given a WBAN, which is highly reliable and provides increased throughput and removes single points of failure. CNC in WBAN gives a wonderful idea to mitigate the loss of packets; latency is reduced as data is sent again and again. It removes any point loss, and increases the percentage of successful recovery of the meaningful data at the receiver end in real time applications. Now a day's CNC is not only used in its original configuration (one-to-one) but also multiple-input-multiple-output (MIMO) systems.

3.3 Current Topology Used in WBAN

According to task group 6 of IEEE standard 802.15 in WBAN, either Star or multi-Hop technology is used with the node in the center of the star being placed on a location like a waist as described by [19][30-31] Two feasible ways of data transmission in the one-hop star topology is transmitted from the device to the coordinator and vice-versa [32].

The star topology communication involves two methods-beacon mode and non-beacon mode. In the beacon mode, the coordinator of the network, which is the center node of the star topology, controls the data communication and also to define the start and the end of a super frame that periodically transmits beacons so as to enable the control of network association and device synchronization. Based on the WBAN's standard and the user, the duty cycle of the system (which is the length of the beacon period), can be specified.

In the non-beacon mode, there is no need for a coordinator to receive the data. A node in the network is capable of sending data to the coordinator and can use Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) when required.

4. CONCLUSION AND FUTURE SCOPE

In this paper, various aspects of WBAN and its implementation techniques have been discussed. Before implementing WBAN, some considerations should be taken care of as suggested in the paper. Based upon the literature survey, it is concluded that amongst various MAC protocols, CSMA/CA is the better technique if there data is high. In case of time consideration, TDMA proves better one but scalability is one of the issues.So, if one has to work with heavy traffic and data security CSMA/CA is the best where a collision is first detected and then avoided which in turn maintains the data with fewer chances of loss. Either CSMA/CA or TDMA can be used according to user's need. In future, a new MAC protocol using CSMA/CA scheme is proposed to mitigate the fading in the captured signal so that patient can see the actual data and doctor is also able to prescribe the right treatment.

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