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A Review on Wireless Body Area Network

Kiran[1], Pooja Ahlawat[2]

[1]M.tech Student, R. N. College of Engineering & Management, Maharshi Dayanand University, Rohtak, Haryana, India

[2]Associate Professor, Department of Computer Science and Engineering, R. . N. College of Engineering & Management, Maharshi Dayanand University, Rohtak, Haryana, India

Abstract: ***WBAN is in recent trend due to its numerous applications in health monitoring. This paper studies the WBAN and its architecture. Various applications along with difference between the WBAN and the WSN are also given in the paper. This paper mainly focuses the various MAC issues available for WBAN. The paper also discusses the various works done in the WBAN field.***

Keywords: WBAN, MAC, WSN, Base station, ECG

1. Introduction

A Wireless Body Area Network consists of small, intelligent devices attached on or implanted in the body which are capable of establishing a wireless communication link. These devices provide continuous health monitoring and real-time feedback to the user or medical personnel. Furthermore, the measurements can be recorded over a longer period of time, improving the quality of the measured data [1].

Generally speaking, two types of devices can be distinguished: sensors and actuators. The sensors are used to measure certain parameters of the human body, either externally or internally. Examples include measuring the heartbeat, body temperature or recording a prolonged electrocardiogram (ECG). The actuators (or actors) on the other hand take some specific actions according to the data they receive from the sensors or through interaction with the user. E.g., an actuator equipped with a built-in reservoir and pump administers the correct dose of insulin to give to diabetics based on the glucose level measurements. Interaction with the user or other persons is usually handled by a personal device, e.g. a PDA or a smart phone which acts as a sink for data of the wireless devices. In order to realize communication between these devices, techniques from Wireless Sensor Networks (WSNs) and ad hoc networks could be used. However, because of the typical properties of a WBAN, current protocols designed for these networks are not always well suited to support a WBAN.

A lot of research has investigated to physical layer. At the beginning of WBAN research a number of authors proposed Ultra Wide Band (UWB) as a physical layer for WBANs.UWB has the advantage of low energy consumption, good co-operation with existing wireless networks and a range large enough to support the entire body. Due to standardization issues and difficulties delivering the very high speeds UWB does not progress well. As opposed to the wide bands proposed by UWB, other researchers propose the small, Industrial, Scientific and Medical (ISM) bands of the IEEE 802.15.4 and IEEE802.15.6. Current most working WBAN prototypes are based on ISM bands.

WBAN Architecture

Figure 1 shows secure 3-level WBAN architecture for medical and non-medical applications. Level 1 contains in-body and on-body BAN Nodes (BNs) such as Electrocardiogram (ECG) – used to monitor electrical activity of heart, Oxygen saturation sensor (SpO2) –used to measure the level of oxygen, and Electromyography (EMG) – used to monitor muscle activity [3].

Level 2 contains a BAN Network Coordinator (BNC) that gathers patient's vital information from the BNs and communicates with the base-station. Level 3 contains a number of remote base-stations that keep patient's medical/non-medical records and provides relevant (diagnostic) recommendations. The traffic is categorized into on demand, emergency, and normal traffic. On-demand traffic is initiated by the BNC to acquire certain information. Emergency traffic is initiated by the BNs when they exceed a predefined threshold. Normal traffic is the data traffic in a normal condition with no time critical and on-demand events.

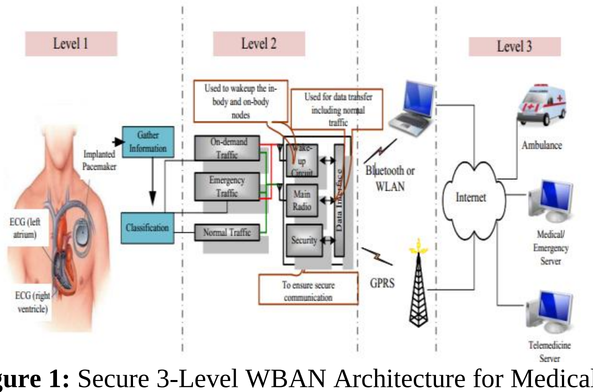

Figure 1: Secure 3-Level WBAN Architecture for Medical and Non-Medical Applications

The normal data is collected and processed by the BNC. The BNC contains a wakeup circuit, a main radio, and a security circuit, all of them connected to a data interface. The wakeup circuit is used to accommodate on-demand and emergency traffic. The security circuit is used to prevent malicious interaction with a WBAN.

Difference between WSN and WBAN

The following illustrates the differences between a Wireless Sensor Network and a Wireless Body Area Network:

- **Deployment and Density:**

The number of sensor/actuator nodes deployed by the user depends on different factors. Typically, BAN nodes are placed strategically on the human body, or are hidden under clothing. In addition, BANs do not employ redundant nodes to cope with diverse types of failures—an otherwise common design provision in conventional WSNs. Consequently, BANs are not node-dense. WSNs however, are often deployed in places that may not be easily accessible by operators, which require that more nodes be placed to compensate for node failures.

- **Data Rate:**

Most WSNs are employed for event based monitoring, where events can happen at irregular 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 improved 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 unreachable after deployment. Therefore, it may be necessary to maximize battery life-time in a WSN at the expense of higher latency.

- **Mobility:**

BAN users may move around. Therefore, BAN nodes share the same mobility pattern, unlike WSN nodes that are usually considered stationary [2].

WBAN Applications

WBANs have great potential for several applications including remote medical diagnosis, interactive gaming, and military applications. Table 1 shows some of the in-body and on body applications [4]. In-body applications include monitoring and program changes for pacemakers and implantable cardiac defibrillators, control of bladder function, and restoration of limb movement [5]. On-body medical applications include monitoring heart rate, blood pressure, temperature, and respiration. On-body non-medical applications include monitoring forgotten things, establishing a social network, and assessing soldier fatigue and battle readiness. The following part discusses some of the WBAN applications:

WBAN MAC Requirements

Most important attribute of a good MAC protocol for a WBAN is energy efficiency. The device should support a battery life of months or years without intervention, as others may require a battery life of only tens of hours due to the nature of the applications. E.g., cardiac defibrillators and pacemakers should have a lifetime of more than 5 years, as swallow able camera pills have a lifetime of 12 hours [6]. Power-efficient and flexible duty cycling techniques are required to minimize the idle listening, packet collisions, overhearing and control packet overhead problems. Additionally, low duty cycle nodes should not receive frequent synchronization and control information (beacon frames) if they have no data to send or receive.

WBAN MAC should support simultaneous operation on in-body is called Medical Implant Communications Service (MICS) and on-body frequency bands/channels [Industrial, Scientific and Medical (ISM) or Ultra Wide Band (UWB)] at the same time. It means, that should support Multiple Physical layers (Multi-PHYs) communication. The important factors are scalability and adaptability to changes in the network, throughput, bandwidth utilization and delay. The position of the human body network topology, the node density and the position of the human body should be handled rapidly and successfully. MAC protocol for a WBAN should consider the electrical properties of the human body and the diverse traffic nature of in-body and on-body nodes. Example, the data rate of in-body nodes varies and ranging from few kbps in pacemaker to several Mbps in capsular endoscope. Figure 2, shows some of the potential issues of a MAC protocol for WBANs.

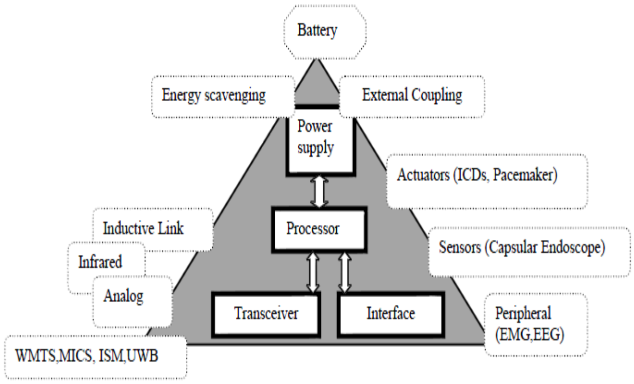

Figure 2: Issues of MAC protocol for WBAN

MAC-Layer-Related Sensor Network Properties

Maximizing the network lifetime is a common objective of sensor network research, sensor nodes are assumed to be dead when they are out of battery. All these circumstances, the MAC protocol must be energy efficient by reducing the potential energy wastes [7].The types of communication patterns that are observed in sensor network applications should be investigated. All these patterns determine the behavior of the sensor network traffic that has to be handled by a MAC protocol.

Table 1: In- Body and On- Body Sensor Networks Application

Application Type	Sensor Node	Date Rate	Duty Cycle (per device)% per time	Power Consumption	QOS (Sensitive to Latency)	Privacy
In-body Applications	Glucose Sensor	Few kbps	<1%	Extremely Low	Yes	High
	Pacemaker	Few kbps	<1%	Low	Yes	High
	Endoscope Capsule	>2Mbps	<50%	Low	Yes	Medium
On-body Medical Applications	ECG	3 Kbps	<10%	Low	Yes	High
	SpO2	32 bps	<1%	Low	Yes	High
	Blood Pressure	<10 bps	<1%	High	Yes	High
On-body Non-Medical Applications	Music for Headsets	1.4 Mbps	High	Relatively High	Yes	Low
	Forgotten Things Monitor	256 Kbps	Medium	Low	No	Low
	Social Networking	<200 Kbps	<1%	Low	No	High

2. Related Work

Author Name	*Year*	*Contribution*	*Drawback*
June S. Yoon et al. [18]	2010	Proposed PNP-MAC to provide QoS in BAN. PNP-MAC supports QoS in accordance with priority of traffics.	Doesn't consider any variation in wireless links.
Majid Nabi et al. [19]	2010	Proposed a multi-hop protocol for human body health monitoring. The protocol is robust against frequent changes of the network topology due to posture changes, and variation of wireless link quality.	Doesn't consider mobility of the patient.
Jocelyne Elias et al. [20]	2012	Proposed a reliable topology design and provisioning approach for Wireless Body Area Networks (named RTDP-WBAN) that takes into account the mobility of the patient while guaranteeing a reliable data delivery required to support healthcare applications' needs.	Topology of the sensor nodes is not considered.
Jocelyne Elias et al. [21]	2012	addressed the topology design problem for Wireless Body Area Networks, proposing a novel and effective model based on mathematical programming that determines (1) the optimal number and placement of relay nodes, (2) the optimal assignment of sensors to relays, as well as (3) the optimal traffic routing, taking accurate account of both the total network cost and energy consumption	No cost function considered.
Q. Nadeem et al. [22]	2013	Proposed a mechanism to route data in Wireless Body Area Networks (WBANs).	Not energy efficient
N. Javaid et al. [23]	2013	Presented an analytically discussion about energy efficiency of Medium Access Control (MAC) protocols for Wireless Body Area Sensor Networks (WBASNs).	Ignore interference of the nodes
Anagha Jamthe et al. [24]	2014	address the problems of intra and inter-WBAN interference	Not adaptive.

3. Conclusion

A Wireless Body Area Network (WBAN) is the network of low-powered devices for measuring and monitoring physiological parameters such as Electrocardiogram (ECG), blood pressure, Electromyography (EMG) etc. These devices could be wearable or could be implanted inside the body. that communicate wirelessly to a monitoring station known as the Base Station. The limited number of nodes in a WBAN environment gives us an opportunity to relax constraints in routing protocols. Considering these constrains in mind, existing have tried to improve the network life-time of the network; energy of the network as well as the path loss of the link being established between the nodes.

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Author Profile

Kiran received the B.Tech (Computer Science) from Matu Ram Engineering and Management College in 2013 and M.Tech degree in Computer Science and Engineering from R. N. College of Engineering & Management in 2015, respectively.