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ANALYSIS OF VARIOUS PROTOCOLS IN WIRELESS BODY AREA NETWORKS (WBAN)

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ABSTRACT:

A Body Area Network is a system of computing devices located in close proximity to the human body which coordinates and cooperates for the benefit of the user. Body Area Networks have evolved out of sensor network technology and biomedical engineering. In this paper we discuss various aspects of Body Area Networks, introduction section deals with various concepts associated with computer networks and some supporting technologies of Wireless Body Area Networks (WBANs). Section 2 deals with the various definitions of Body Area Networks (BANs) followed by the types of BAN in section 3 and system architecture in section 4. Section 5 gives the draft guidelines by IEEE 802.15.6 for a communications standard for BAN, the next two sections list out the applications and current research trends of BAN followed by the conclusion.

Key words: Body Area Network, Types of BAN, applications, research trends.

1. INTRODUCTION

A computer network aka as a data network is an interconnection of a group of computing devices via a physical cable or wireless media to share files, information and other peripherals. Devices that are able to share information or other peripherals are said to be networked devices. The most common example of a data network is the internet. For devices to be able to transmit and accept data efficiently and effectively certain protocols have to be implemented. A protocol is a set of rules that control the communication between computers on a network. For example the message signal will have a header block of digits giving information about the sender, recipient and the length of the message. It will also have a termination block of digits that indicate the end of the message and further information toverify the accuracy of the message. Protocols are designed according to the standards decided by International Organization for Standards (ISO) with principles to Open Systems Interconnection (OSI).In any communication network a node is defined as an interconnection point. In a computer network a node is defined as a device that starts and terminates the data. A node can also be a gateway. A schematic description of the nodes and connecting cables in a computer network is called the topology of the computer network. Topologies can be

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defined as physical topology and signal Topology. Examples of physical topologies include ring, bus, star, mesh. Bluetooth Low Energy and Zigbee are being commonly used for Body Area Networks (BANs).

Bluetooth is a short range wireless radio system which operates in the frequency band of 2.4GHz at a maximum signal rate of 1 Mb/s. Its operating range is 10m with a transmission power of 0-10dBm and channel BW of 1MHz. Topologies defined in Bluetooth are piconet and scatternet. A piconet is a Wireless Personal Area Network (WPAN) formed by 2 Bluetooth devices, one serving as a master and the other slave. A scatternet is formed by connecting 2 piconets. A Bluetooth device may interact with several piconets at the same time. A scatternet can be a slave in many piconets but master in only one of them. Zigbee is a low rate WPAN operating in the frequency band 868/915 MHz and 2.4GHz with a maximum signal rate of 250Kb/s, operating in the range of 10-100m with a transmission power of 0dB. It is designed to support devices that consume minimal power.

Device types that can participate in a low rate WPAN network are Full Function device (FFD) and Reduced Function device (RFD). An FFD can operate as a device, coordinator or a PAN coordinator. An RFD is used for extremely simple applications. An FFD can talk to another FFD or RFD whereas an RFD can talk only to an FFD.

2. BODY AREA NETWORK (BAN)

IEEE 802.15 formally defines a Body Area Network as, "a communication standard optimized for low power devices and operation on, in or around the human body(but not limited to humans) to serve a variety of applications including medical, consumer electronics/personal entertainment and other.[1]"

As Erik Karulf puts it in more simpler terms, "in more common terms, a Body Area network is a system of devices in close proximity to a person's body that cooperate for the benefit of the user.[1]" BAN has evolved out of existing sensor network technology and Biomedical engineering. Professor GuangZhong Yang was the first person to coin the phrase Body Sensor Network in his book Body Sensor Network in 2006.

A Ban consists of several smart, extremely tiny and self powered sensors that can be attached or implanted into subjects to monitor body parameters like ECG, ENG, blood pressure or to monitor the subjects posture, location etc., this information is either stored for further data processing or decision making by reporting it to a BAN coordinator. A BAN coordinator can connect the BAN sensors to external networks like wireless sensor network, Wi-Fi access points or Broadband cellular network(GSM, GPRS, 3G etc)

3. TYPES OF BAN

According to the node position BANs can be categorized into 4 different types.

ON-Body

All the nodes involved in the communication are placed on the subject either by stitching it on the skin or integrating it into a wearable or portable object carried by the user.

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OFF-Body

Here at least one node is placed outside the subject and is made to act as a router, the communication takes place between the external node and one of the devices on the body.

Body to Body

Both transmitter and receiver are placed on two different subjects [2].

IN-Body

At least one node is located inside the subject and it communicates with devices either inside, on, or outside the subject.

4. SYSTEM ARCHITECTURE

4.1. Physical Layer

PHY is the undermost layer in the BANs communication stack. It defines the mechanism for sending and receiving information bits over a wireless medium.

4.2. Medium Access Control (MAC) Layer

The nodes in a BAN have a common wireless channel for data transmission. Access to this common channel is controlled by a common MAC. MAC protocols can be classified as schedule-based MAC protocol and contention-based MAC protocol. In schedule-based MAC protocol a coordinator to avoid packet collision in the commonly shared wireless medium regulates the nodes channel access by assigning different time slots, frequency bands or spreading code. In contention-based Mac protocol a predefined channel sharing mechanism is employed and multiple nodes determine when, which and how to access the channel in a distributed manner. Due to their distributed nature contention-based MAC protocols are more feasible than schedule-based MAC protocols in most applications.

4.3. Network Layer and Topology

The network layer protocol is responsible for effective and efficient packet delivery from source to destination, often through a number of intermediate nodes [3]. The principal job of a network layer protocol is to locate, establish and maintain routes. There are a number of routing protocols developed for various wireless sensor networks. Some of them include

- Sensor protocols for Information via Negotiation(SPIN)
- Threshold sensitive Energy Efficient sensor network(TEEN)

4.4. Middleware and Operating System

An operating system acts as an administrative program that effectively and efficiently manages the hardware and software resources of the BAN.

The main functions of an operating system are as follows [3]

- Manages multiple processes and provides concurrency support
- Handles communication devices, sensors, memory and peripherals.
- Facilitates the efficient development of software applications by providing convenient and secure abstraction of hardware resources.

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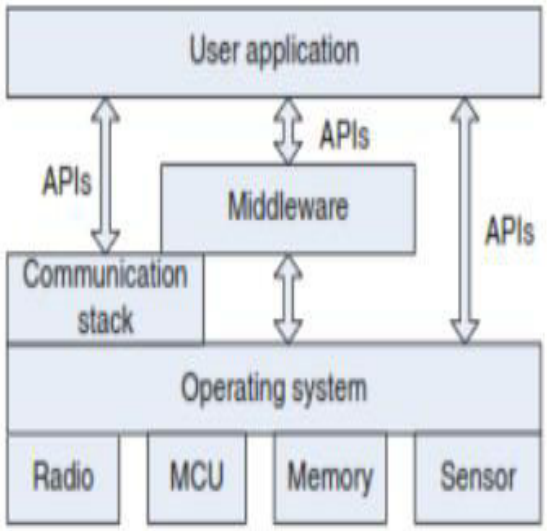

Figure 1 Generic architecture of a BAN Node [3].

Figure1 portrays the generic architecture of a BAN node. While providing an abstraction of system resources and Application Programming Interfaces (APIs) the operating system manages the nodes hardware resources and other peripherals. Certain advanced operating systems can provide concurrency mechanism thus allowing for multi-tasking and multithreaded programming. The middleware subsystem lies between the user application and operating system and often provides communication, localization, Quality of service and data management services for user applications. The communication stack is a simplified version of the ISO seven-layer open systems interconnection model (ISO OSI 7-layer Model) and typically consists of a PHY layer, a MAC layer and a network layer [3]. Each of the layers has a significant role in communication link establishment, communication medium sharing, route discovery and management. Compared to a general operating system, the operating system developed for a wireless sensor network should be light weight, less complex, operate on low power and be flexible in terms of the number of devices ported. Several operating systems have been specifically developed for wireless sensor network. Some of them are

- TinyOS
- Contiki
- ScatterWeb
- MANTIS
- T-kernel
- LiteOS

5. BAN PROTOCOL

Several BAN devices have been implemented using already existing communication standards, but they only meet a partial list of specific needs. Moreover they offer limited solutions and cannot communicate with the outside world. The IEEE 802.15.6(TG6) task group has been entrusted to come out with a specific communication standard for low power devices and operating in, on, or around a human body. It is still in the development stage and the communication standard has not been finalized yet. Several proposals for the standard have been submitted to the task group. Various technical requirements were used to assess proposals for the IEEE 802.15.6 BAN standard. Those guidelines particularly related to propagation and the physical layer includes [4]:

BANs should be scalable up to 256 nodes. A BAN link should support bit-rates between 10 kb/s and 10 Mb/s. The packet error rate (PER) should be $\leq$ 10% for a 256 octet payload (i.e., 256× 8 bits of data) for the 95% best-

performing links according to PER . Maximum radiated transmitted power should be 0 dBm and all devices should be able totransmit at −10 dBm. Nodes should be able to be added and removed to and from the network in less than 3 seconds. Reliability, latency and jitter should be supported for those BAN applications that need them. Latency in medical applications should be less than 125 ms, and should be less than 250 ms in non-medical applications. Jitter should be less than 50 ms. Power saving mechanisms should be provided. The physical layer should support co-located operation of at least 10 randomly distributed BANs in a 6 × 6 × 6 m volume. In-body BAN and on-body BAN should coexist in and around the body

6. APPLICATIONS OF BAN

- Remote health monitoring for humans and animals
- Security
- Sports and fitness
- Entertainment
- Rescue operations
- Consumer electronics

7. CURRENT REASEARCH TRENDS

- Medium Access Control
- Antennas and Propagation on or near the surface of the body
- Networking protocols
- Security
- Localization
- Radiated power
- Consumed power
- Device size
- Interference susceptibility
- Electromagnetic field absorbed by the user

8. CONCLUSION

This paper gives information about the various aspects of a Body Area Network including system architecture, applications, communication protocol draft specifications and current research trends.

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