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BODY AREA NETWORKS: AN INTRODUCTION

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ABSTRACT

This paper provides an introduction to body area networks (BANs). A BAN is a communication network between humans and computers through wearable devices. BANs are commonly used in medical healthcare monitoring. They constitute a growing research area in medical healthcare applications.

INTRODUCTION

The body area network has recently received increasing attention due to its promising applications in medical healthcare systems, personal entertainment, and military communication. A body area network (BAN) may be regarded as a network of wearable computing devices which may be embedded or implanted in the body or located on or around the human body. BANs are made feasible by advances on lightweight, small-size, and intelligent wearable sensors. Typically, BAN tiny nodes are placed on the human body or hidden under clothing. Thus, a BAN consists of sensor/actuators nodes located on the human body. For this reason, it is also known as body area sensor network (BASN).

BANs can be wired or wireless. Using a wired connection turns out to involve a high cost for deployment and maintenance. The wires may limit the patient's activity and level of comfort. The use of a wireless BAN (or WBAN) is more cost effective. It allows the patient with BAN to have greater mobility and is not compelled to a fixed location. WBAN can be connected to local, metropolitan, and wide area networks by several wired and wireless communication technologies. A typical patient monitoring in a WBAN is shown in Figure 1.

CHARACTERISTICS OF WBAN

WBANs have the following characteristics [1-3].

Architecture: A WBAN consists of in-body and on-body nodes that continuously monitor a patient's vital information. It has two types of nodes: sensors/actuators on or in a human body and router nodes functioning as an infrastructure for relaying data. Star and star-mesh hybrid topologies show promise for WBAN. Figure 2 shows the relationship between a WBAN and other types of wireless technologies, such as wireless personal area network (WPAN), WLAN, and WAN [4].

Density: WBANs do not require high node density. The number of nodes deployed by the user depends on different factors. Unlike regular wireless sensor networks, BANs do not employ redundant nodes to cope with different kinds of failures.

Data rates: Most WBANs are employed in monitoring physiological activities, which may vary in a periodic manner. The sensors need to transmit at a wide range of data rates from 1kps to 10 Mbps. 10 Mbps is expected in some applications, and low data rate of 10 kbps should be supported in some medical applications.

Latency: This requirement is dictated by the applications. For healthcare applications, latency resulting from WBANs should be minimized.

Mobility: WBAN allows nodes to move around. Nodes belonging to the same wearer move together in the same direction

APPLICATIONS

BANs have a wide range of applications. They are enabling medical applications that were previously not practical. In medical and healthcare applications, BAN is connected to sensors that monitor vital body parameters and movements. BAN can be used for continuous health monitoring with real-time update of medical records via Internet. BAN with the Internet can provide a more patient-centric care model. With a BAN on a diabetic patient, insulin can be automatically injected when the insulin level goes low. Sensors embedded in suits of firefighters and mine workers are being used to monitor their health conditions. A set of physiological sensors may include the following [5]:

- An ECG (electrocardiogram) sensor for monitoring heart activity

- An EMG (electromyography) sensor for monitoring muscle activity
- An EEG (electroencephalography) sensor for monitoring brain activity
- A blood pressure sensor
- A breathing sensor for monitoring respiration

The ECG/EMG/EEG sensors measure potential differences across electrode attached to corresponding parts of the body.

Other applications of BAN include sports, fitness, security, entertainment, military, interactive gaming, virtual reality, and consumer electronics.

CHALLENGES

BANs introduce various challenges for implementation [6-9]. Researchers on BANs must address such challenges before BANs can become widespread.

System devices: BANs have problems such as physical size, low storage capacity, limited energy, and limited processing capability. One constraint is power consumption since power supply is limited. For most devices it is impossible to recharge or change the batteries. Hence, the energy resources and the computational power of such devices are limited.

Security: Because WBAN systems are geographically distributed, they present a challenge in terms of throughput, data integrity and data security. Strict security mechanisms are needed to ensure private and confidential character of the information. Considerable effort is needed to make WBAN secure and reliable. Information between sensors should be encrypted for privacy and confidentiality. Security measures such as user authentication will prevent unauthorized access or manipulation.

Interference: External interference from other networks nearby presents another challenge, especially for large scale deployment. At high frequencies, in the range of several GHz, the human body introduces high radio wave attenuation in the propagation channel. Another issue is compatibility. BAN nodes need to interoperate with other BAN nodes and other wireless technologies without undue interference. Compatibility addresses how well the wireless devices can operate in close proximity to each other.

Standards: The success of any wireless technology is driven by standardization. Standards will guide industry efforts by making it easier to fulfill the promise of interoperability and compatibility of the wireless technology. The international standard for BANs is the IEEE 802.15.6 [10]. In May 2012, the Federal Communication Commission (FCC) voted to allocate 40 MHz of spectrum in the 2360-2400 band for BAN [11].

CONCLUSIONS

This paper has presented a brief introduction to BANs. Most BANs are wireless and are applied in medical healthcare monitoring [12]. A BAN extends the range of wireless network technologies to an ultra-low range, ultra-low power network solution optimized for a human body to monitor a wide range of physical quantities. WBANs are affordable health monitoring systems, which may be used to collect health information at home and facilitate disease management. In WBAN, patients suffering from chronic diseases such as diabetes can have precise treatment.

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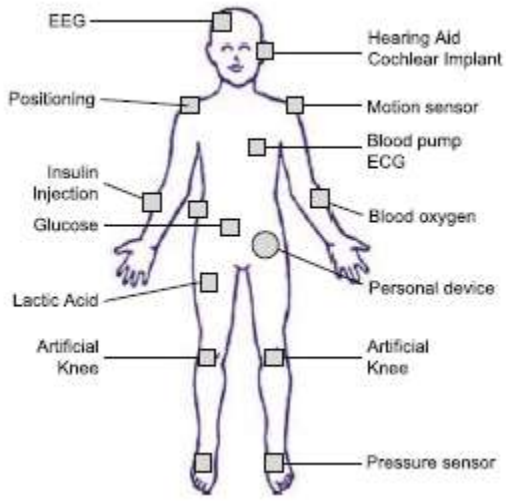

Figure 1 A typical potential monitoring in a WBAN [1].

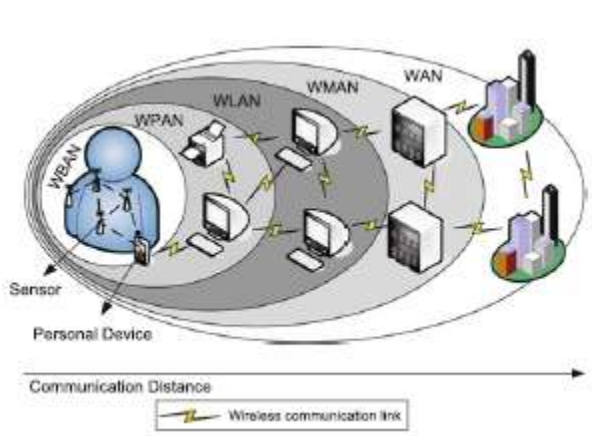

Figure 2 Relationship between WBAN and other wireless networks [1].