Body Area Networks: A way to improve remote patient monitoring

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With today’s aging population, monitoring healthcare systems represents an important element of the healthcare issue, especially in countries where the limits of the system are being tested. Monitoring the health condition of elderly people and sharing information with remote care providers or hospitals is increasingly in great demand, especially as more and more senior citizens are choosing to live by themselves. The ability to monitor the medical conditions of a patient living in a remote location lifts a huge pressure off the system in term of cost and logistics. One technology that is expected to play a key role in the patient monitoring arena is body area networks (BANs). BANs are highly localized wireless networks that potentially can support a wide variety of medical applications, from monitoring how an implant is functioning, to tracking the health of senior citizens, to performing state-of-the-art endoscopic exams.

Body area network technology

Previously, patient monitoring typically consisted of various sensors connected to the body as well as a processing unit through unwieldy wires. With a multitude of wires, the patient activity and level of comfort, not to mention the measured results, are most often negatively impacted. With the advancement of wireless technology, BANs have increased in efficiency. Figure 1 illustrates a typical wireless BAN. A network of sensors is placed close to the human body or implanted in some tissues to enable the collection of specific physiological data. This allows the medical specialist to continuously monitor physiological data of a patient’s health, regardless of the geographical location.

The sensed signal can monitor several types of medical measurements such as electroencephalography (EEG), electrocardiography (ECG), electromyography (EMG), skin temperature, skin conductance, or electrooculography (EOG). Each of these sensors transmits the collected information wirelessly to an external processing unit, which instantly transmits all information in real time to the doctor’s facility, or to a specific server. The sensors used in the BAN require accurate sensing, a certain level of signal processing, as well as some wireless features. These sensors can be transceivers or receivers only, which is a defining factor for this network’s characteristics.

Sensors used in BAN are classified by two main categories:

• A wearable BAN is located within the vicinity of the body. It consists of inexpensive, lightweight and miniature sensors that allow long term ambulatory health monitoring, thus, providing a periodic update of the patient’s health status. Wearable BANs are mostly used for physiological monitoring.

• An implantable BAN is located within the tissues of the human body. Implantable BANs use biosensors and, unlike wearable BANS, are used for more than just monitoring. Implantable BANs represent a highly desirable proposition for health issues like diabetes management, which currently relies on data obtained by pricking the patient’s finger to obtain blood that is applied to test strips. In addition to being a painful procedure, this method is incapable of reflecting the overall direction, trends, and patterns associated with the patient’s daily habits. Implantable BANs are widely used in applications such as drug delivery through a micro-pump or micro-port, insulin, etc.

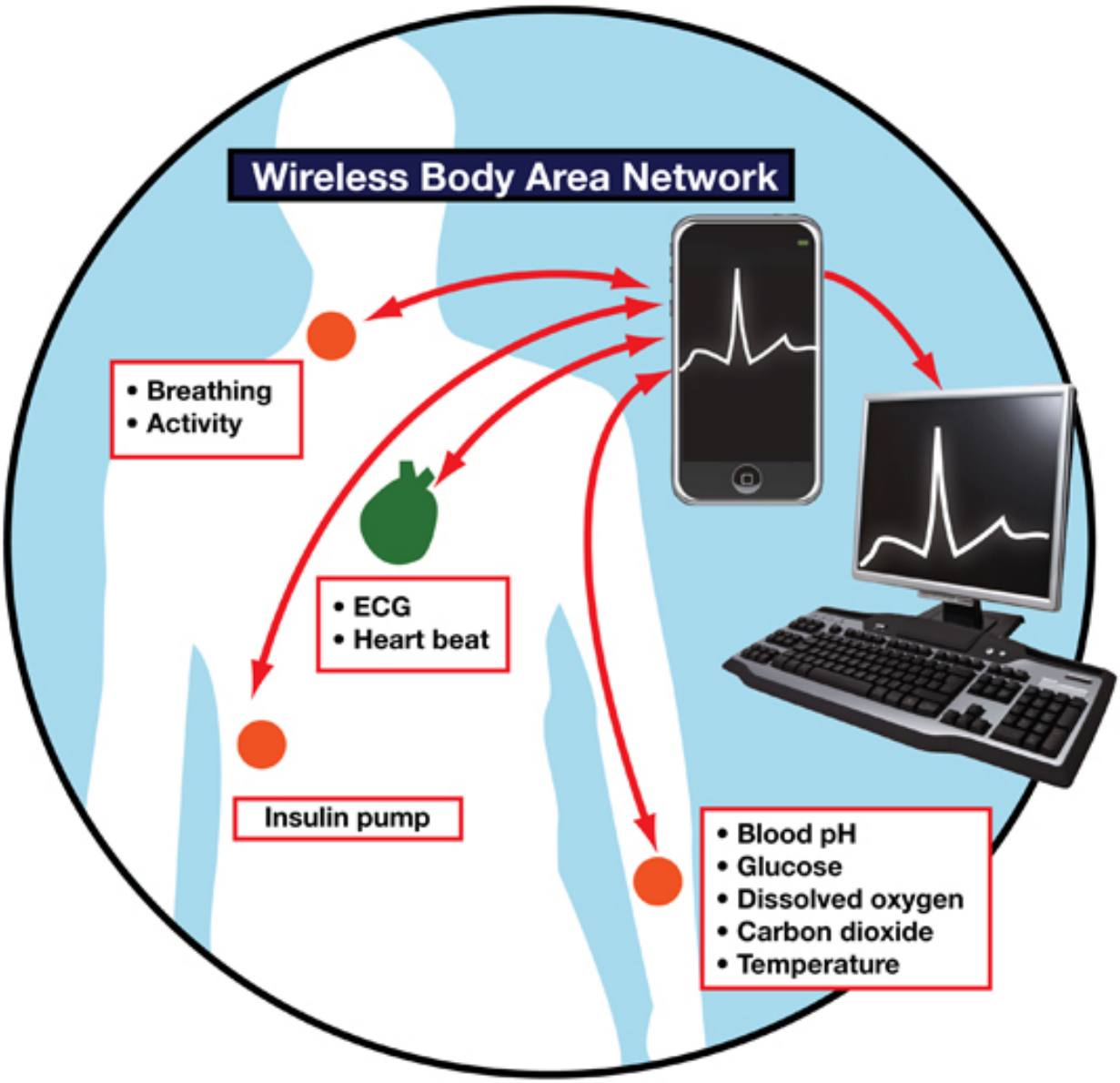

Figure 1: Illustration of a typical body area network.

BAN node requirements

The challenges of designing BANs can be summarized as follow:

• Form factor: Size and weight are very pivotal for BAN sensors, as they directly impact the patient's level of comfort. The smaller and less visible a node is, the less likely it is that it will introduce restrictions in the patient's activities. Considering the population types being targeted by BANs, user friendliness is a very important factor for BAN technology adoption.

• Current consumption: Current consumption represents a critical challenge when designing BAN nodes. The need to replace or recharge batteries is undesirable for wearable nodes, and is totally unacceptable for any implantable nodes.

• Reliability: When dealing with medical applications, it is imperative that a system provide great data accuracy and reliability in order not to endanger the patient.

Therefore, accuracy and reliability are both addressed at the sensing and wireless transmission level.

• Security: To protect a patient's privacy and prevent hacking into the network, BAN nodes also need to be secured.

• Intelligence: The level of signal processing capability is determined by how much intelligence the node can display. Nodes are becoming more and more intelligent with the use of advanced processor and high integration.

Body area networks nodes standards

A BAN can be implemented using several existing wireless standards such as Bluetooth, ZigBee, Wi-Fi, ANT or BLE. These existing standards, however, have not been optimized for BAN applications. They carry significant overhead as they were designed with other applications in mind. Therefore, they generally don't meet the peak-power consumption requirements. Table 1 describes the different useable standards and applications for which they have been optimized:

Standards	Optimization
Bluetooth	Voice links
ZigBee	Industrial sensors, smart grids, smart energy
Wi-Fi	Data networks
ANT	Low-current consumption, but still with high-peak current
BLE	Low-current consumption, but still with high-peak current

BAN systems also can be implemented using proprietary solutions from different vendors. However, different systems use different operating frequencies and may not be interoperable. While lacking interoperability, proprietary solutions do allow solutions tailored to one's needs.

To develop a communications standard that is optimized for low-power devices suitable for BAN applications and operations, IEEE has launched the IEEE 802.15 Task Group 6 (BAN), known as IEEE 802.15.5 standard. IEEE 802.15.6 presents several advantages compared to existing standards. While focusing on short distance and low cost, it has low complexity and low current consumption. The IEEE 802.15.6 standard defines the PHY layer, the MAC protocol, and the security layers.

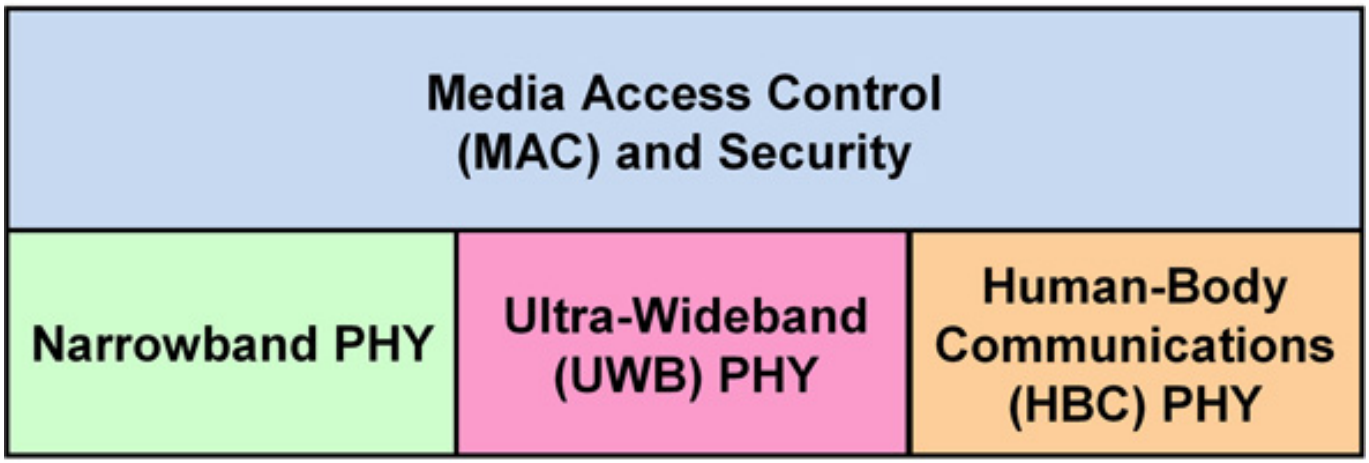

Figure 2: High level overview of the IEEE 802.15.6 architecture.

Figure 2 describes the overview of the IEEE 802.15.6 architecture. It comprises a PHY layer, a common MAC, and security layer. The PHY layer is divided into three frequency bands in order to address the diverse data rate require¬ments imposed by med¬ical and con¬sumer applications. These include narrowband, ultra-wideband, and the human-body communication band. It targets a distance of three meters while supporting data rates varying between 100 kbps and 1 Mbps, with a peak power consumption of 3 mA. The MAC protocol is defined to control access to the channel. The standard also defines three levels of security: level 0, unsecured communication; level 1, authentication only; and level 2, for both authentication and encryption.

Conclusion

Wireless body area networks have gained momentum in the last few years for several factors. With the emergence of the IEEE 802.15.6, the medical BAN market is expected to grow significantly. The key drivers will be applications such as patient monitoring, and some other non-medical applications such as home automation, agriculture or infrastructure monitoring.

References

• For more information about medical BANs, visit: www.ti.com/consumermed-ca [1]

About the Author

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