Wireless Technologies Build Momentum for Telehealth Systems

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According to the Centers for Medicare and Medicaid Services (CMS, www.cms.gov [1]), in 2006 the cost for healthcare in the United States rose to $2.1 trillion, which represents 16 percent of the gross domestic product (GDP). These numbers have increased throughout the years due to a combination of several factors such as an aging population and the increase of chronic diseases like diabetes and hypertension. In order to be able to control these costs and their negative impact on states' budgets, new methods of delivering healthcare need to be implemented. One possibility is the use of wireless technologies in the medical field, which is commonly called telehealth or telemedicine. Telehealth can help provide healthcare in rural areas where it can be difficult to access medical care, especially when a specialist is required. In such cases, broadband and telehealth applications can connect doctors and patients via high technologies. In this article, we discuss telehealth and applicable wireless technologies such as Bluetooth classic, Bluetooth low energy (BLE), and ANT. We also will discuss the key differences between these technologies and what makes them applicable for medical applications.

Telehealth System Overview

Telehealth can be defined as a health system that can transmit biometric data, like blood pressure, glucose levels, temperature, and heart rate, from home to a healthcare professional by use of telecommunications (wired or wireless) technologies. Figure 1 illustrates the block diagram of a basic telehealth system.

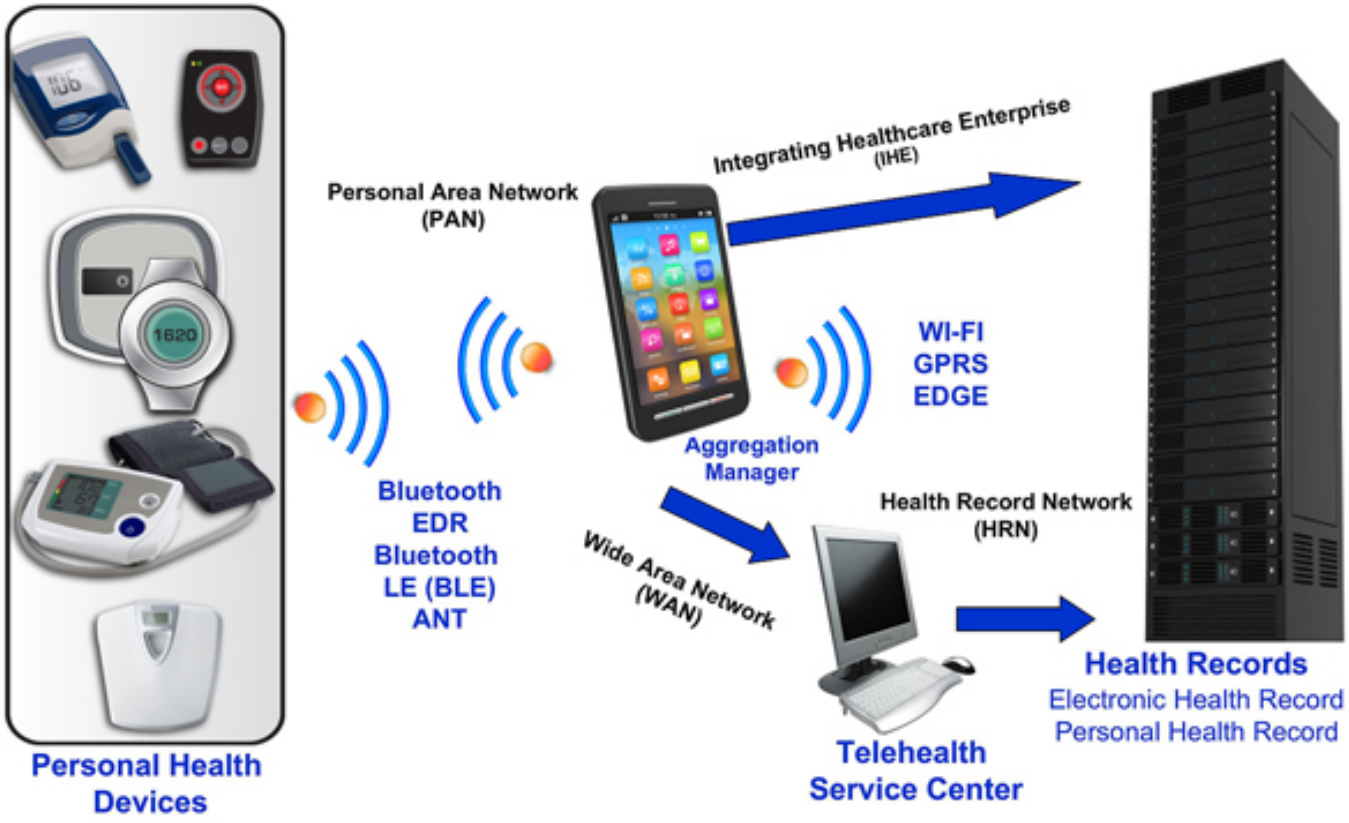

Figure 1. Basic telehealth system.

A telehealth system comprises three basic blocks:

1. **Personal health devices** that monitor basic vital signs such as blood pressure, weight, pulse, oxygen level and blood sugar values to measure and transmit data in a wired or wireless connection. A typical personal health device usually comprises these four elements: a sensing unit, processor unit, connectivity, and power and battery management unit

2. The **aggregation manager** is an essential device in the connected health system, enabling personal health devices to log data in a remote electronic health record (EHR) for family and clinical review. The aggregation manager collects data from personal health devices and transmits this data to a server via a wired or wireless connection. The aggregation manager can take the form of a cell phone, a personal computer; or a dedicated device. The aggregation manager usually presents the following key components: processors, connectivity, power management, and battery management.

3. The **health service center** is a physical location where the patient's information is being analyzed or stored. It can be the doctor's office, the home of a family member, or another type of healthcare-related facility.

Telehealth Wireless Connectivity
The connection between personal health devices, the aggregation manager and the health care center can be wired or wireless. In recent years, the Continua Health Alliance has taken the lead to regulate these connections for the sake of

interoperability between vendors. Several different wireless platforms are being offered today for telehealth solutions. Figure 2 shows a personal area network (PAN) connection between the personal health device and the aggregation manager. Wireless standards used in PAN are operating in the industrial, scientific, and medical (ISM) bands. The personal health devices that connect to the aggregation manager usually operate in the 2.4 GHz frequency and in most cases use Bluetooth classic, Bluetooth low energy, or ANT. In other cases, standards such as ZigBee/IEEE 802.15.4 are being used. It is also common to find a few proprietary solutions for personal health devices that operate in sub-1 GHz frequency band. The devices operating in the PAN are characterized by low-power, long battery life, and short range with a typical range varying between 10 m to 100 m.

For the wide area network (WAN) interface that connects the aggregation manager and the health service center, platforms such as Wi-Fi are commonly used, but GSM, GPRS or EDGE also can be options (Figure 3). Standards used in the WAN are commonly high power and can help achieve long range connection.

Figure 2. Personal area network connectivity.

Figure 3. Wide area network connectivity.

Bluetooth Classic and Bluetooth Low Energy

Bluetooth classic is based on the IEEE 802.15.1 standard. It is a wireless technology that enables devices to communicate in the 2.400 GHz to 2.4835 GHz band. This band is divided into 79 channels with each channel a width of 1 MHz. Bluetooth allows devices such as mobile phones, PDAs, printers, laptops and headsets to exchange data. It uses the Gaussian frequency shift keying (GFSK) type of modulation along with frequency-hopping spread spectrum (FHSS). Three output power levels are available in the Bluetooth standards. Classes 1, 2 and 3 devices deliver 20 dBm, 4 dBm, and 0 dBm of output powers respectively. Bluetooth is a packet-based protocol with a master-slave structure. One master may communicate with up to seven slaves in a piconet; all devices share the master's clock. Originally, Bluetooth operated with a maximum throughput of 1 Mbps. However, with the enhanced data rate feature, a maximum throughput up to 3 Mbps can now be achieved.

Recently, another variant of Bluetooth, called Bluetooth low energy (BLE), has been introduced by the Bluetooth Special Interest Group (SIG). BLE targets data exchange using lower power consumption than Bluetooth classic. It operates within

the same spectrum range (2402 MHz to 2480 MHz) as classic Bluetooth, but with a different set of channels. BLE has 40 channels with 2 MHz wide channels, while Bluetooth classic has 79 channels with 1 MHz wide channels. The power reduction in BLE can be explained by the reduction of the synchronization word, as well as connection mechanism. The duration of a BLE link does not exceed 3 ms.

ANT
ANT is a wireless personal network protocol, with small size, reasonable cost and very low-power requirements. ANT provides short-range wireless communication in point-to-point or more complex network topologies. Suitable for many applications, today ANT is a proven and established technology for collection, automatic transfer and tracking of sensor data within sports, wellness management and home health monitoring applications. Like Bluetooth, ANT radios operate in the 2.4-GHz ISM band and work particularly efficiently in embedded systems that use a peer-to-peer or star network topology. ANT transceivers use coin cell-type batteries and could operate up to three years in low use applications.

ZigBee
Built on top of the IEEE 802.15.4 PHY layer, ZigBee uses the 802.15.4 standard. The 2.4 GHz band remains the most used frequency band as of today. To resolve the range and interference problem faced in the 2.4 GHz, some companies are exploring the design of 915 MHz ZigBee products. Unlike IEEE 802.15.4, ZigBee allows full mesh networks. This difference can be noticed when comparing the IEEE 802.15.4 and the ZigBee stacks. ZigBee has established a strong momentum within the metering industry as well as in the home automation sector.

Wi-Fi
As of today, Wi-Fi represents the most prominent technology for wireless connectivity for computers and the Internet. Wi-Fi technology integrates most personal computers, personal digital assistants (PDAs) and other devices such as gaming and portable audio. The Wi-Fi term is applicable to wireless devices that utilize the suite of IEEE 802.11 standards. Except 802.11b, the Wi-Fi standard operates in the 2.4 GHz band (2.4 GHz – 2.4835 GHz) and uses FHSS and direct sequence spread spectrum (DSSS) techniques.

Conclusion
With the ubiquity of wireless technologies and the emergence of new standards, the healthcare industry is experiencing a revolution in the way healthcare is being delivered. With the support of wireless technologies, telehealth offers the potential to help control the cost of healthcare while enabling patients to maintain a good quality of life.

References

* For more information on these and other telehealth solutions, visit: www.ti.com/telehealth-ca [2].

* Download your medical selection and solutions guide here: www.ti.com/medicalguide-ca [3].

About the Author

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Links:
[1] http://www.cms.gov
[2] http://www.ti.com/telehealth-ca
[3] http://www.ti.com/medicalguide-ca
[4] mailto:ti_ibounsylla@list.ti.com