Metrics to Consider when Choosing a PAN or WAN Interface for Telehealth Applications

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Introduction

Telehealth is becoming a new way of helping people achieve a better quality of life, but the proliferation of wireless technologies has also introduced a personal health and medical device interoperability challenge that has not been seen before. The challenge rests in the need to have several wirelessly equipped devices and end equipments communicate adequately with each other. To do so, it is important that devices function with the same protocols, in order to maintain data integrity. In this article, we discuss interoperability challenges associated with wireless technologies, as well as some metrics that are used to differentiate which wireless standards are appropriate to use in certain situations.

As one of today's fastest-growing, inter-disciplinary areas, telehealth utilizes various technologies to deliver health and medical information through wired and wireless networks, over large and small distances. Telehealth is a catalyst for implementing a new way of delivering this information in the healthcare field. It empowers patients, doctors and other providers in all-new ways, offering a better quality of life at reduced cost with chronic diseases such as cardiovascular diseases, diabetes, chronic respiratory problems, and cancer. With the advent of short-distance wireless connectivity technologies, telehealth also plays a critical role in wellness, fitness and sports markets. Here are two examples that can help better illustrate the impact of the wireless connectivity on telehealth:

1. First, a jogger running with several sensors on his body can have his vital signs (including heart rate, blood pressure, SpO_2) monitored, the humidity of his skin, along with other performance characteristics such as running pace, calories burnt and stride length. These monitored parameters are collected during the run on a mobile device, such as a watch or smartphone, then downloaded or sent to the jogger's personal computer, trainer, or doctor's office. After analyzing the data, the doctor or trainer can suggest changes to the exercise or training regime to improve endurance and performance.

2. The second example could be an ambulance at the scene of an accident. The emergency medical team (EMT) responding to the accident begins treatment and immediately starts monitoring and sending the vital signs and diagnostic details of the critically injured person to the emergency room, while the patient is still a distance away from the hospital. Sending this data in advance allows the nurses and doctors to be better prepared for the patient, saving precious time in applying proper treatments when the

patient arrives, which can result in saving lives.

These two examples illustrate the critical role that wireless connectivity solutions can and are playing in the wide-scale deployment of telehealth by enabling:

- data collection more accurately, frequently and less costly
- a new way to connect patients and health care professionals

Continua Health Alliance

Continua Health Alliance, an international non-profit open industry industrial organization that comprises more than 230 companies, was created to tackle and solve the interoperability issue presented when implementing and deploying telehealth products and services. it is their mission to establish an ecosystem of interoperable personal health systems that empower people and organizations to better manage their health and wellness." The Alliance does not aim specifically at developing new communication standards, but rather starts by selecting preexisting standards and sets out guidelines for interoperability. To successfully take on this challenge, the work is segmented into three major domains:

- chronic condition management;
- health and wellness; and
- living longer independently.

Figure 1 shows the architecture that has been defined by Continua Heath Alliance.

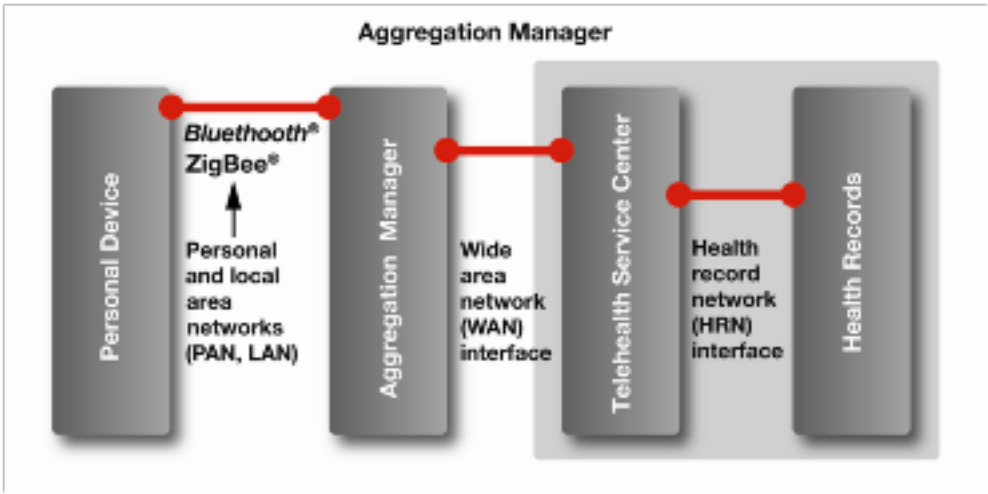

Figure 1. Continua telehealth end-to-end system architecture.

This end-to-end system architecture comprises four main areas:

-Personal healthcare devices: Monitors basic vital signs such as blood pressure, weight, pulse, oxygen level and blood sugar values, and transmits this data in a wired or wireless connection.

-Aggregation manager: Enables personal health devices to log data in a remote electronic health record (EHR) for family and or clinical review. The aggregation manager can take the form of a smartphone, a personal computer, or other dedicated device.

-Health Service Center: Stores and analyzes a patient's information in a centralized area. It can be the doctor's office, the home, or another type of healthcare-related facility.

-Health record: Serves as a repository for collected data. Can take the form of a personal health record (PHR) or electronic health record (HER)

While four types of network have been defined in this aggregation management architecture, here we focus on two: personal area networks (PAN) and wide area networks (WAN).

Since PAN is characterized by the need for low (and typically battery) power, *Bluetooth*® and ZigBee® technologies have been selected as the wireless standards to be used in future generations of Continua-compliant telehealth systems. *Bluetooth* technology is used typically for interfacing between a mobile aggregation manger (a smartphone, for example) and sensors or medical devices; whereas ZigBee is used for wirelessly networked low-power sensors such as those enabling independent living. The connections in a PAN network are generally limited to less than one meter up to 10-20 meters of range, and most devices using PAN connections are battery powered.

For transmitting data over longer distances (greater than 30 meters), and with greater bandwidths, a wide area network (WAN) connection may be beneficial. Continua has selected the w3c standards for WAN, which can be implemented over any IP-based network. This allows solutions such as Wi-Fi and most 3G services to deliver the data from managers/hubs to the back-end software.

It is important to note that selecting a specific choice of connectivity standard is mandated only when designing a product which is intended to carry the Continua Health Alliance certification. If the Continua certification is not a requirement, the system/product architect has the choice between several other connectivity standards such as IEEE 802.15.4, ANT, 6lowPAN, or even proprietary radios in the 2.4 GHz or 900 MHz frequency bands.

Key metrics to consider when choosing a wireless connectivity standard

The choice of a particular connectivity standard or technology is the result of a series of tradeoffs and optimizations. Wireless standards can be compared based on parameters such as required data rate, network topology, transmission range, and others. These parameters serve as selection metrics. **Figure 2** illustrates the most considered parameters when comparing wireless standards for telehealth and medical applications. Not all metrics listed below are relevant for a given

application, and the number or type of metrics both depend on the specific end application.

Table 1 illustrates a summary of data rate required for acquiring physiological information or vital signs for applications such as chronic disease management, or heath and wellness. A data rate between 1 and 10 kbps may be required for blood pressure monitoring. On the other hand, 2 Mbps maybe be required, if the application involves sending still images. The product developer needs to know which technology is able to support the data rate that the application will be transmitting.

Operating frequency is another important metric to consider. The frequency spectrum which can be used to transmit data depends on the prevailing governmental regulating body, such as the Federal Communications Commission (FCC) or European Telecommunications Standard Institute (ETSI). Frequency spectrum requirements and constraints vary according to geographical region and market (in-hospital vs. consumer, for example) that the product is targeting. Moreover, the network topology will likely have an impact on the software stack size, as well as current consumption. This is certainly the case for applications which use protocols that require a full mesh topology such as ZigBee.

Biological signs being monitor	Data Rate (Kbps)
Blood Pressure	0.01 – 10 (40 – 200 Hz sample)
Pulse / Heart Rate	0.01 – 10
Temperature	0.01 – 10 (40 – 80 Hz sample)
Respiration	0.01 – 10
Glucose	0.01 – 10
SpO2	0.01 – 10
EEG	10 – 200 (500 Hz sample, 12-bit ADC up to 32 channels)
ECG	10 – 200 (500 Hz sample, 12-bit ADC up to 32 channels)
EMG	10 – 200 (500 Hz sample, 12-bit ADC up to 32 channels)
Still Images	1000 – 2000

Table 1: Data rate for different monitored biological signals

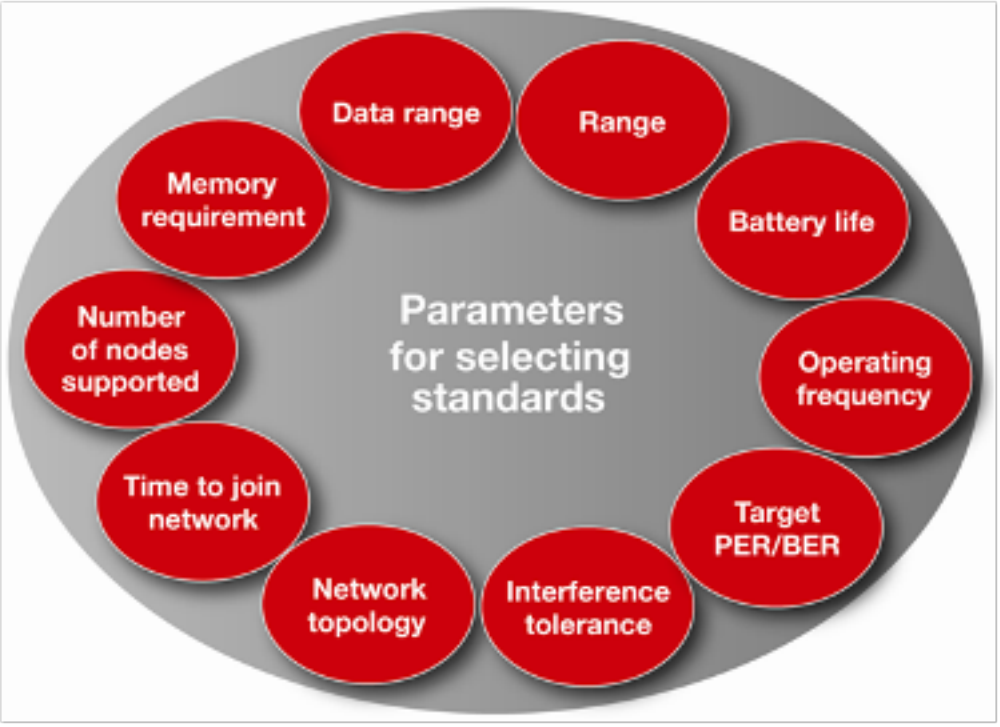

Figure 2. Parameters to consider when comparing different connectivity standards.

Figures 3, 4 and 5 compare several wireless connectivity standards using transmission range and throughput metrics. **Figure 3** shows that *Bluetooth* technologies and the ANT protocol are the most suitable, non-proprietary standards for body area networks (BAN), which require very short distances and low power. On the other hand, **Figure 4** shows that for high throughput, Wi-Fi is perhaps the most appropriate connectivity standard. **Figure 5** shows the type of battery needed for the different standards. From these graphics, it is clear that Wi-Fi requires more power than the other connectivity options.

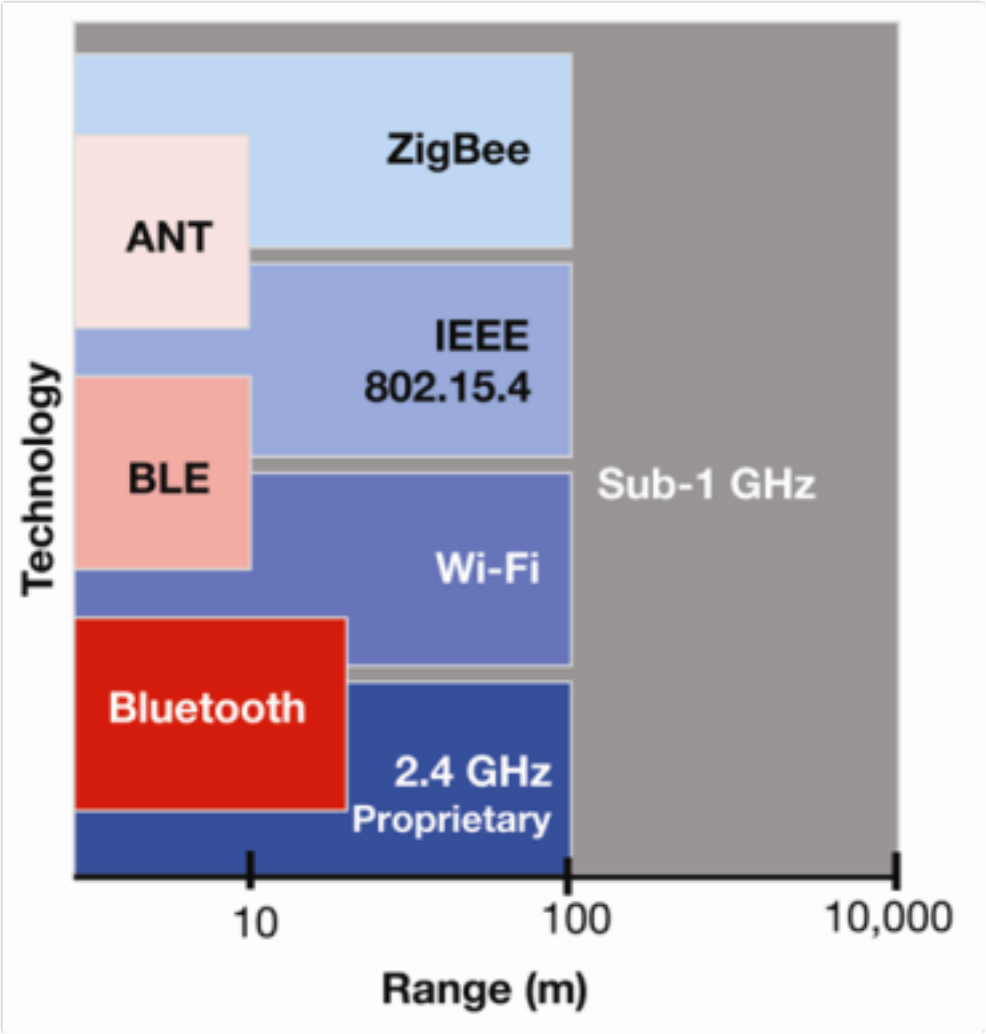

Figure 3. Technologies vs. range.

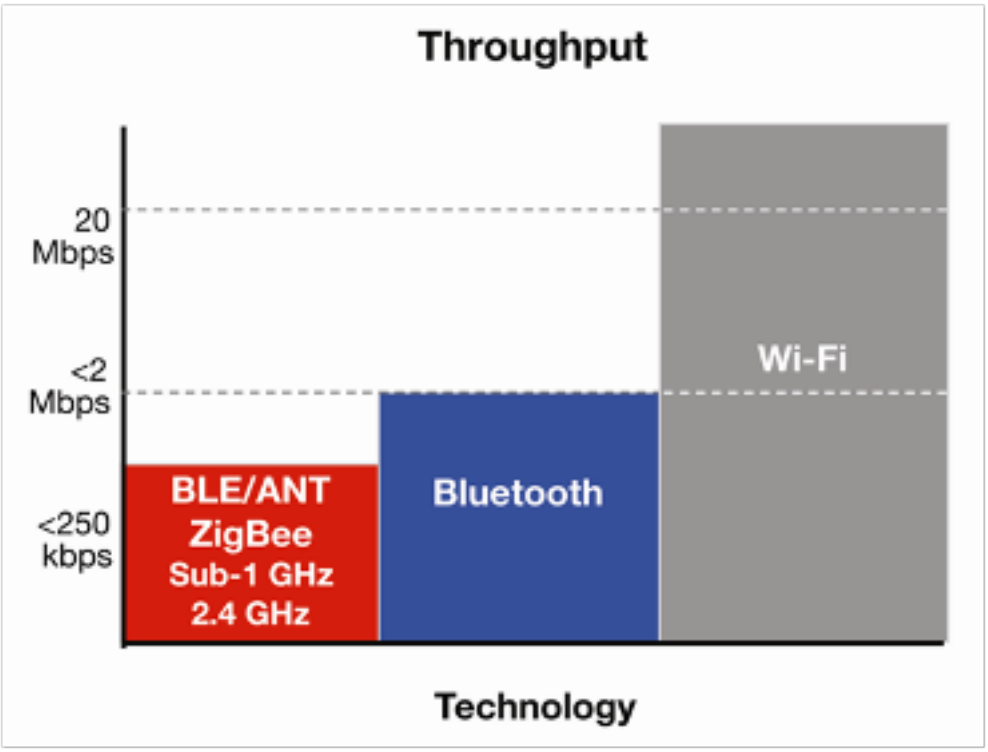

Figure 4. Technologies vs. throughput.

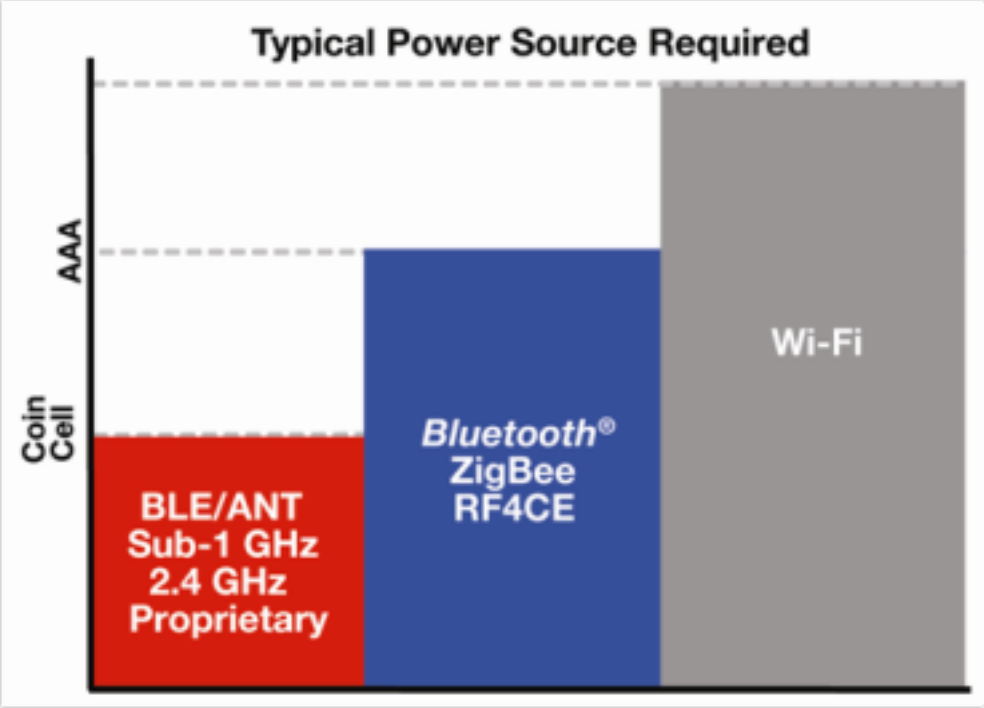

Figure 5. Technologies vs. required power source.

Conclusion

Without doubt, telehealth is one sector that benefits greatly from the proliferation of wireless technologies, which are revolutionizing the way healthcare is delivered. However, along with the proliferation comes the challenge of interoperability between different wireless devices and equipments, as well as the process of choosing the appropriate wireless standard. Various standards are available for telehealth applications, and it's important for engineers and developer to choose the one that best fits specific end applications. In the process, capabilities will emerge that truly make life easier for patients, doctors, care givers and all other players of the healthcare ecosystem.

References

- More information on TI's telehealth solutions: www.ti.com/telehealth-ca [1].
- TI's medical selection and solutions guide: www.ti.com/medicalguide-ca [2].

About the Author

Iboun Sylla currently manages business development for Telehealth and Medical Wireless products at Texas Instruments. Prior to this position, Iboun was a senior RF design engineer. Iboun received his bachelor's degree in telecommunications

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Links:
[1] http://www.ti.com/telehealth-ca
[2] http://www.ti.com/medicalguide-ca
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