Diversifying the IoT with Sub-1 GHz technology

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Overview

As the Internet of Things (IoT) has evolved, one of its most notable aspects has been its diversity. From a somewhat modest beginning of connecting home appliances or water/electrical meters to the Internet, the IoT is now casting a much wider shadow, reaching into retail and industrial markets such as electronic shelf labels, logistics, search and rescue, agriculture and other new application areas. Some experts expect that by **2020 50 billion devices** will be a part of the worldwide IoT.

But with every new IoT use case comes a unique set of technical operating characteristics. Fortunately, the wireless connectivity technology, Sub-1 GHz, is satisfying many of the most demanding requirements currently challenging IoT system designers. Of course, it's not any one advantage of Sub-1 GHz technology that makes it such a powerful solution for many of these applications, but rather, the combination of its considerable capabilities and their adaptability to the specific needs of the application. This paper will look at four benefits of the Sub-1 GHz technology including long range, spectrum, low power and software flexibility.

The long range of Sub-1 GHz transceivers and wireless microcontrollers (MCU) are already making possible new types of IoT applications. Some tests have shown that Sub-1 GHz transmissions have an effective range up to more than 100 kilometers (km). In addition, by occupying the ISM bands in the wireless spectrum below 1 GHz, Sub-1 GHz communications avoids the much more crowded band at 2.4 GHz, where Wi-Fi®, *Bluetooth*® Smart, ZigBee® and other wireless protocols operate. On a less-busy band, IoT networks will be more robust and able to scale to cover larger areas. The added efficiency of operating in an uncrowded band, as well as several other factors, also reduce the power consumed by Sub-1 GHz devices. In fact, some end nodes will be able to operate for up to 10 years on a coin-cell battery. Another critical characteristic is the software flexibility and compatibility of Sub-1 GHz wireless technology. Developers can quickly differentiate their products with features that bring a competitive advantage in the marketplace.

In the final analysis though, Sub-1 GHz technology is becoming one of the chief driving forces behind the IoT of the future, not just because of its unique feature set, but also because each feature is adjustable to the unique requirements of every application.

Long range wireless connectivity

The longer signaling range of wireless transceivers and integrated MCUs has set Sub-1 GHz apart from alternative technologies. This can be especially critical in IoT networks which may be quite diverse, covering entire homes or multistory office buildings, or even an entire city or region.

The effective radio frequency (RF) range of a Sub-1 GHz network will be determined by the nature of the application, which dictates the data transfer speed and the amount of data communicated. At lower data rates the range will be greater. Generally, the most advanced Sub-1 GHz end node transceivers and integrated MCUs have been empowered with critical characteristics that enable long-range operations. For example, a recently introduced advanced wireless MCU can sense Sub-1 GHz signaling at –110 dBm at data rates of 50 kbps or, at an even slower speed of 0.625 kbps, down to –124 dBm. Interference from other wireless communications can be overcome with 90 dB of blocking and output power levels up to +14 dBm ensure robust signaling for longer range communications.

The diversity of today's Sub-1 GHz transceiver technology has reached a point where the specific range requirements of an IoT application can be met with a certain device. For example, narrowband and ultra-narrowband Sub-1 GHz transceivers have become a mainstay technology in applications like flow meter monitoring, police radios, alarm systems and others where the data rate can be fairly low in order to achieve longer range and the added intelligence of an MCU is not needed. In Europe, the wireless M-Bus (wM-Bus) standard for metering applications is based on narrowband Sub-1 GHz technology.

In addition to the long range qualities of narrowband and ultra-narrowband Sub-1 GHz transceivers, some advanced Sub-1 GHz wireless MCUs have an integrated long range mode of operation so the end node device can take advantage of the greater processing capabilities of an MCU and still achieve long range.

Narrowband Sub-1 GHz

- 25-kHz bandwidth
- 12.5-kHz channel spacing
- 10-kHz channel bandwidth
- Typical applications: Meter monitoring, SIGFOX and wireless sensor networks

The architectural flexibility of Sub-1 GHz networks can also affect signaling range. Sub-1 GHz networks can be configured in any of several architectures to meet the range requirements of the applications (see Figure 1). For example, a relatively confined network with a central control point such as a home building automation system might adopt a star architecture based on wM-Bus or 6LoWPAN. A mesh architecture with multiple gateways could be employed as the basis for a larger network covering a factory campus or an agricultural operation. Additionally, another configuration is a point-to-point architecture, which might be used to communicate a small amount of data like a temperature or some other sensor measurement back to a central control element.

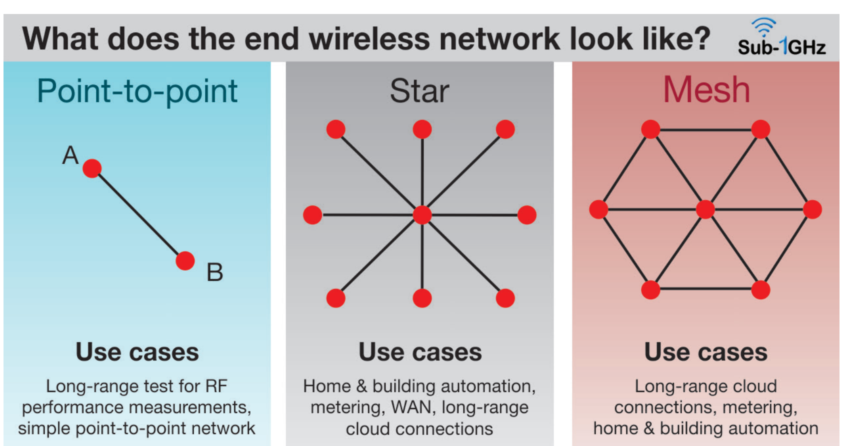


Figure 1: Examples of end wireless networks

Less crowded spectrum

Sub-1 GHz networks avoid the pitfalls of the 2.4-GHz band that are caused by overcrowding. Much of today's most popular wireless equipment operates in the 2.4-GHz band, including Wi-Fi hot spots and home wireless routers, ZigBee, Bluetooth, some cordless phones, even baby monitors. Excessive traffic in any band of the wireless spectrum will cause problems for equipment operating in that band. Interference and conflict among many wireless signals in the 2.4-GHz band can corrupt the payload or header information in communications packets, slowing down throughput by triggering a high level of retransmissions or denying connectivity altogether. If the wireless technology is based on a collision detection protocol, like Wi-Fi, too many signal collisions caused by an overcrowded band could deny access to the airwaves or erode the performance of all wireless communications in the vicinity.

Adding 50 billion IoT devices to the 2.4-GHz band by 2020 would only make matters even worse (see Figure 2). In addition, the fundamental nature of a high percentage of the IoT traffic in the future will be quite different from much of the data-intense traffic in the 2.4-GHz band where video streaming, phone conversations, Internet downloads and other high-priority connections can tie up channels for extended periods of time. A considerable amount of IoT traffic will be short bursts of data at slower speeds to optimize signal range. Therefore, it makes sense to segregate different types of applications in different bands of the wireless spectrum.

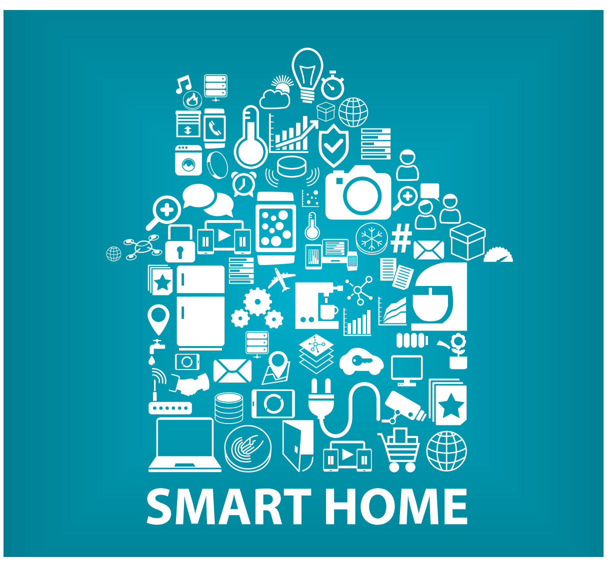


Figure 2: Crowded 2.4 GHz network with many household devices

Besides, less signal congestion allows Sub-1 GHz networks to expand more easily, quickly scaling upward in the number of devices supported on any one network and outward to cover larger distances. With less crowding there will be less data loss on Sub-1 GHz networks and this is critical for a number of important applications like emergency communications or transferring imperative sensor information.

Ultra-low power

Ultra-low power consumption will be another requisite for many IoT applications. In fact, just powering 50 billion IoT devices will be a major challenge. Fortunately, many Sub-1 GHz end-node devices consume an amazingly small amount of power. Many devices, like sensor nodes or flow meter monitors, can operate for up to 10 years on a coin-cell battery or longer through some sort of energy-harvesting system like a solar panel. Low power is particularly important for hard-to-reach or inaccessible installations because changing a battery on a sensor node, for example, could be quite expensive or dangerous for the person changing the battery, or virtually impossible if the node were installed on a weather satellite, for instance.

In addition, the ultra-low power consumption of Sub-1 GHz end nodes is achieved without sacrificing signal range or output power. For example, a recently introduced Sub-1 GHz wireless MCU has peak power consumption of as little as 5.5 milliamps (mA) when receiving and 22.6 mA when transmitting at +14 dBm. In addition, this

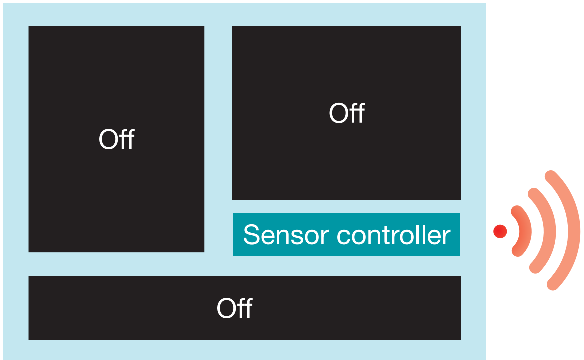


Figure 3: Sophisticated power management on some Sub-1 GHz wireless MCUs can shut down most of a sensor node to make coin-cell batteries last up to 10 years.

MCU's ARM® Cortex®-M3 core consumes as little as 51 µA of power per megahertz of processing capabilities. Moreover, the device has been integrated with sophisticated power management algorithms that will place portions of the system in a sleep mode where as little as 0.6 microamps of power is consumed while retaining the contents of memory.

Software flexibility

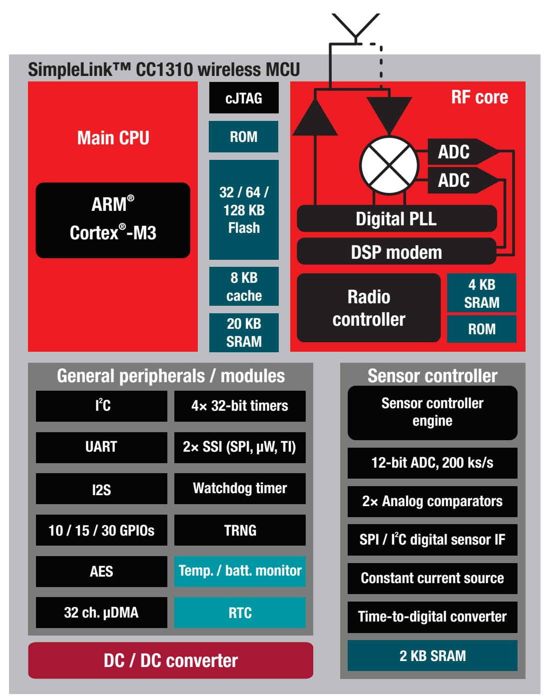
The software environment surrounding Sub-1 GHz networking is particularly conducive to creative innovation. Conformance to the IEEE 802.15.4g standard has given developers off-the-shelf solutions that by and large perform as expected right out of the box. In addition, open industry standards always encourage the growth of a support ecosystem of tools and development aids. For Sub-1 GHz networking these factors have accelerated the deployment of new wireless networking topologies like 6LoWPAN, wM-Bus and others.

Now, newly introduced wireless Sub-1 GHz MCUs are highly programmable and resource rich, enhancing the software flexibility of end-node devices even further (see Figure 4). Unlike simple transceivers, wireless MCUs incorporate a processing engine, such as a low-power ARM Cortex-M3 core, for application processing. The ease with which these wireless MCUs can be programmed allows end-node device designers and equipment manufacturers to rapidly integrate differentiating functionality into their products, functionality that will make their products stand apart in competitive situations.

The most advanced of such wireless MCUs have been empowered with a full complement of resources that simplify software development. The

TI's ultra-low power wireless MCU

The extremely adaptable SimpleLink™ Sub-1 GHz **CC1310 wireless MCU** includes an ARM® Cortex®-M3 core, ultra-low power RF, peripherals and an integrated sensor controller engine that saves power by waking up the rest of the device only when needed.



inclusion of a real-time operating system, drivers, peripheral interfaces and, at least in one case, a sensor controller means that software developers can concentrate on developing innovative new features and not worry about how they are going to integrate basic resources into the device.

In addition, this sort of software environment is also a tremendous benefit to networking equipment suppliers who wish to deploy their own proprietary software. Programming tools, development platforms, libraries of intellectual property and other support features will accelerate the time-to-market for new proprietary systems.

Conclusions

The IoT of the future will be an exciting place. Every day creative developers are generating ideas for innovative new IoT applications, causing a groundswell of demand for wireless connectivity technology with new capabilities and feature sets. And Sub-1 GHz is responding. Sub-1 GHz transceivers and wireless MCUs provide the capabilities needed by next-generation IoT systems and, just as importantly, this functionality is adaptable to the one-of-a-kind requirements of each and every application.