RADIO COMMUNICATIONS: COMPONENTS, SYSTEMS, AND NETWORKS

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Computer networking in the 1970s and 1980s meant exactly that: interconnecting large timesharing systems to exchange information, principally email and files. As computing became more pervasive, however, it ultimately resulted in the personal data devices we carry around with us (also known as smartphones), and networking moved from a computer-centric focus to a people-centric focus. By some estimates, more than 3 billion people today, or about 40 percent of the world's population, are connected to the global Internet in one way or another. Clearly, the majority of these users must be networked via their personal devices; for most people the Internet represents a direct personal communications facility rather than anything to do with a "computer" in the traditional sense of the word.

In the last five years, however, the "Internet of Things" has started to gain momentum. This refers to the concept of endowing inanimate objects with Internet connectivity, hooking them up to a data center — typically in the cloud — and then harvesting data from them, directing commands to them, or both. The concept is not new; apparently a Carnegie Mellon University vending machine could display its status on the Internet as far back as 1982. However, the Internet of Things is now a commercial reality applied to several different areas, and it is now predicted that there could be 20 to 30 billion devices connected to the Internet by 2020. Current applications for the Internet of Things (customarily abbreviated as IoT) exist in transportation infrastructure management, energy management (the Smart Grid), home automation, and healthcare systems, and the technology is being applied to new areas every day.

It is relatively straightforward to expect that the IoT is actually a wireless IoT, as it would be patently absurd to run cables to these billions of devices: quite apart from being cost-prohibitive, many of these devices are not even stationary. Thus, radio communications will play a large role in facilitating the development of the IoT. However, the wireless links that serve well for IoT communications differ considerably from those that support human to Internet connectivity. The latter are optimized for very high bandwidth — up to 7 Gb/s for the recently ratified IEEE 802.11ac standard — and long-duration traffic, such as streaming video, sent to a relatively small number of stations. IoT links, on the other hand, must cope with thousands of stations, each of which may transfer short bursts of small packets with data rates in kilobits or even bits per second. On top of that, many IoT applications demand extremely low power consumption, which severely constrains the wireless radios and protocols that can be used.

This issue of the Radio Communications Series contains an article presenting a tutorial overview of key elements of the IEEE 802.11ah draft standard, which is specifically designed to support key use cases important to IoT applications. The article focuses on those aspects of IEEE 802.11ah that are pertinent to IoT systems, linking individual aspects of the medium access control (MAC) and physical (PHY) layers to specific IoT needs. For example, IoT devices such as sensors or meters can profitably trade off occupied channel bandwidth for range; 802.11ah takes advantage of this trade-off by shifting the PHY into the sub-1-GHz spectrum (e.g., 915 MHz in the United States), where the available bandwidth is low, but considerable range improvement accrues from the lower path loss.

The article particularly calls out the various power-saving aspects of the IEEE 802.11ah MAC. Power saving is critical for IoT devices that may not only need to run on battery power for years, but are also likely to have space constraints that limit the size of battery that can be integrated. Even more constrained are energy harvesting IoT devices that may not even have batteries at all, but have to subsist on tiny amounts of energy harvested from the surrounding environment. Such devices necessarily must spend virtually all their time sleeping, and only wake up at long intervals to exchange data in short but highly efficient bursts. This forms a particular challenge for IEEE 802.11 carrier sense multiple access (CSMA-CA) MAC protocols, and the article capably illustrates the new 802.11ah MAC functions that were introduced to deal with the challenge.

We would like to continue to place similar articles before you, in future issues, to cover topics of current interest. However, for this to happen we need contributions from our community of authors! We therefore encourage you to submit articles discussing emerging trends in wireless communications. We also thank our reviewers for their time and attention to helping us create a quality Series.