Wi-Fi Races into a Faster Future

Lee Garber

Two new faster Wi-Fi versions appear ready to make the technology suitable for a broader range of applications.

Until recently, most users relied on Wi-Fi networks simply to access webpages and e-mail, activities that don't require much bandwidth.

Now, the technology can be utilized in some cases for more demanding applications such as multimedia streaming and audioconferencing.

Today, however, users want more from their wireless technologies, such as the ability to smoothly stream video, download music or large data files, videoconference, participate in multiplayer games, and remotely or automatically control thermostats or other systems.

The demand for using Wi-Fi for such purposes is driving dramatic changes to the technology.

IEEE is developing two faster Wi-Fi versions, both with theoretical maximum speeds of more than 1 Gbit per second. This level of performance has been a longtime goal of Wi-Fi proponents, noted Todd Antes, vice president of product management for the Networking Business Unit at Qualcomm, a provider of wireless technology and services.

IEEE isn't expected to finish its standardization until the second half of next year, according to Rahul Patel, semiconductor vendor Broadcom's vice president of marketing. However, industry observers say most of the important work on the standards is already done. Vendors thus have started releasing new products, such as access points (APs), based on one of the technologies.

The Wi-Fi Alliance and WiGig Alliance, both trade associations, are developing programs to guarantee that certified products will comply with the current state of the IEEE standards and interoperate with one another.

Industry observers say the new technologies mark another important step in the development of Wi-Fi technology. However, the new approaches face several important challenges to future success.

WI-FI 101

Wi-Fi is a radio technology that works via a chip that contains a transmitter, receiver, and one or more antennas.

NCR Corp. developed an early Wi-Fi-like approach in the mid-1980s as a wireless alternative to wireline network technologies such as Ethernet.

IEEE released the first Wi-Fi standard in 1997 and has since adopted 802.11a, b, g, and n versions. 802.11n, approved in 2009, operates in the 2.4- and 5-GHz frequency bands and offers a theoretical maximum throughput of 150 Mbits per second per data stream.

Although IEEE 802.11n was released more than two years ago, Wi-Fi equipment has not advanced enough to use all of the approach's capabilities.

Multiple data streams

802.11n is designed to work with multiple-input, multiple-output technology. MIMO increases throughput by using multiple antennas on both transmitters and receivers, enabling more than one data stream.

IEEE 802.11n allows up to four data streams at a time by enabling the use of four antennas on the transmitter and four on the receiver, a configuration known as 4 × 4. This would yield a theoretical maximum data rate of 600 Mbps per chip (150 Mbps per data stream), and increase the maximum transmission range.

Vendors such as Qualcomm have announced chips that enable 4 × 4 but haven't shipped any products yet, noted Craig Mathias, founder of the Farpoint Group, a wireless communications advisory firm.

Numerous vendors, such as Hewlett-Packard, have released 3 × 3

0018-9162/12/$31.00 © 2012IEEE Published by the IEEE Computer Society

NEW WI-FI APPLICATIONS AND PRODUCTS

IEEE's development of two dramatically faster Wi-Fi versions will let various types of applications use the technology for the first time. Wi-Fi was too slow to work with these types of applications in the past.

New applications

IEEE 802.11ac will be effective for the same applications that Wi-Fi is already useful for: device connection and Ethernet replacement, according to Matthew Gast, director of product management for Wi-Fi vendor Aerohive Networks.

However, he added, the technology's higher performance will also make it appropriate for demanding applications that couldn't previously use Wi-Fi, such as videoconferencing. He said it will also improve voice communications by reducing latency, as well as upgrade the performance of wireless sensor networks that connect to the Internet to make their data available to users.

In addition, 802.11ac could be suitable for real-time, peer-to-peer applications such as gaming, storage, and device synchronization, said Todd Antes, vice president of product management for the Networking Business Unit at Qualcomm, a provider of wireless technology and services.

Other new potential uses include multiplayer gaming; wireless I/O; high-speed data networking; machine-to-machine communications in, for example, smart grids for efficient energy distribution; and public-safety applications such as security-camera monitoring.

Commercial applications could include the control and monitoring of Internet-connected home and business infrastructure systems like those providing heating and air conditioning. Public utilities could employ 802.11ac to control energy consumption during periods of heavy usage and potential system overloads.

Eventually, said Craig Mathias, founder of the Farpoint Group, a wireless communications advisory firm, manufacturers could design 802.11ac APs so that they could function as extensions to 3G and 4G cellular networks. "Many smartphones can work with Wi-Fi, so consumers could use the technology in some cases for calls," he explained. This could improve phone connections indoors, where cellular systems sometimes have problems, and also offload traffic from cellular networks.

Because of its short range and inability to penetrate walls, proponents say, 802.11ad would be ideal for use in small rooms within homes or in open office areas. For example, said Rahul Patel, semiconductor vendor Broadcom's vice president of marketing, the technology could replace the many wires frequently used to connect parts of home-entertainment systems.

It could also enable short-range uncompressed-video transfers and other point-to-point applications, said William S. Kish, cofounder and chief technology officer of wireless-equipment vendor Ruckus Networks.

Products

According to Kelly Davis-Felner, marketing director for the Wi-Fi Alliance trade association, consumer and enterprise products—ranging from laptops, tablets, and printers to TVs, home appliances, and smartphones—will use 802.11ac.

Networking infrastructure equipment—including routers, gateways, and adapters—will also include the technology. "Our APs will support 802.11ac and 802.11ad once baseband and radio chipsets supporting these standards are readily available, probably in late 2012 or 2013," said Ruckus' Kish.

Aerohive Networks plans to release 802.11ac-based APs for consumer products later this year, and equipment for large-scale networks in 2013, said Matthew Gast, the company's director of product management. He said Aerohive isn't concerned about releasing products before the formal IEEE standard is finished because the IEEE's work is very far along, small changes could be easily added to products via firmware, and there is strong user demand for faster Wi-Fi products now.

Early 802.11ac products will also work with 802.11n, and customers will probably use them to provide the slower technology until they are ready to commit completely to the faster version. For example, Broadcom's Patel said, his company plans to release 5G Wi-Fi chips that will work in the 2.4- and 5-GHz frequency bands and be backward-compatible with earlier Wi-Fi technologies.

systems already, though, for use in products such as APs. These chips let the APs either offer 50 percent more bandwidth or handle 50 percent more clients at the same bandwidth than products offering just two data streams.

Beam forming

802.11n enables Wi-Fi to use *beam forming* to improve performance. With this technique, the Wi-Fi infrastructure sends out multiple signals and analyzes client feedback to determine the optimal path that signals should take to reach the client. It then shapes the signal beam appropriately.

Vendors are selling equipment for large corporations that use beam forming, said Mathias, but the approaches are typically proprietary.

TOMORROW'S WI-FI

As the "New Wi-Fi Applications and Products" sidebar describes, one of the most important visions for Wi-Fi is for it to become faster and thus applicable for handling more tasks. Several forces are driving this development.

"We'll see Wi-Fi become a pervasive technology, most notably in personal mobile devices: handsets, tablets, smartphones, notebooks," stated Qualcomm's Antes. He said this has created a need for faster wireless technologies because "clients will put increasing demands on mobile networks."

This trend will be exacerbated by the growing amount of traffic, including an increasing proportion of video and other data-intensive multimedia. Also, Antes added, more consumers are gaining broadband Internet access, which means they could take advantage of faster Wi-Fi versions.

IEEE 802.11ac

IEEE is working on a new technology, 802.11ac, that would be used in the 5-GHz frequency band. This band is not as heavily used as—and thus experiences less interference than—the 2.4-GHz band.

How it works

The approach provides higher speeds primarily by doubling the size of the channels—to 80 MHz from 802.11n's 40 MHz—over which data is transmitted. In the future, depending on government regulations, 802.11ac could allow 160-MHz-wide channels.

802.11ac would also increase throughput by using MIMO to allow up to eight data streams at a time, compared to the four that 802.11n permits.

The new approach would enable multiuser MIMO. Whereas basic MIMO enables communications from one AP to a single client, each with multiple antennas, MU-MIMO enables communications via separate streams from a single AP to multiple clients. This improves performance by serving clients in parallel rather than serially, as has been the case.

802.11ac also utilizes 256 quadrature amplitude modulation, which uses frequency and amplitude changes to encode data onto a radio signal. This enables encoding four times as dense as the 64 QAM that IEEE 802.11n uses.

Thus, 802.11ac would offer data rates up to 1.3 Gbps on 3 × 3 MIMO systems, based on 433 Mbps per channel. The speeds vary based on the numbers of antennas used on the chips and the distance over which transmissions must travel.

The technology also works with orthogonal frequency-division multiplexing, a popular technique that increases a transmission channel's capacity by dividing a radio signal into multiple subsignals that are transmitted simultaneously at different frequencies to the receiver.

By enabling fast downloads and transmissions, 802.11ac reduces the amount of time that batteries must spend powering such activities, which extends battery life, said Broadcom's Patel. In the past, he noted, "Wi-Fi has been one of the largest drains on batteries in smartphones and tablets."

Wi-Fi Alliance

The Wi-Fi Alliance is already designing a Wi-Fi Certified program for 802.11ac products, even before the IEEE completes work on the standard, noted Kelly Davis-Felner, the organization's marketing director.

The alliance is determining which features of the standard's current version should be included in its certification program. The organization plans to issue its first certifications "in very late 2012 or early 2013," according to Davis-Felner.

Today, users want more from their wireless technologies.

IEEE 802.11ad

IEEE is working on specifications for implementing Wi-Fi in the 60-GHz frequency band. The 60-GHz band offers more spectrum, providing a wider pipe that enables fast speeds that could smoothly transmit uncompressed high-definition video. IEEE 802.11ad will provide a theoretical maximum throughput of 7 Gbps.

However, Mathias noted, the physics of signal propagation in the 60-GHz band mean the signals remain strong only over short distances and generally don't penetrate solid objects. This could make it suitable for applications such as replacing wires in home entertainment systems.

The WiGig Alliance is developing a compliance program and specifications that would let vendors start developing interoperable products based on 802.11ad now, even before IEEE finishes its work.

Few devices currently use the 60-GHz frequency band, which means communications would experience less interference.

As is the case with 802.11ac, early chips implementing 802.11ad might also support transmissions of earlier Wi-Fi technologies that work in the 2.4- and 5-GHz frequency ranges, enabling the use of the faster approach when necessary but slower, more energy-efficient technologies when appropriate, Mathias said.

CHALLENGES

Despite the enormous promise, the new Wi-Fi technologies also face challenges.

For example, because the technologies are new, some consumers might wait to see how well products work initially before adopting them. However, said Farpoint's Mathis, that shouldn't be a big problem, as Wi-Fi has a long history, and 802.11ac and ad are evolutionary, not revolutionary, changes to the technology.

Nonetheless, noted Matthew Gast, director of product management for Wi-Fi vendor Aerohive Networks, "It's a new technology. There are always bugs." Also, vendors may find developing drivers and other types of software necessary to make 802.11ac function properly to be a complex process.

In some cases, users will need a faster backbone network to work with the technology. And many won't know exactly how they can use the approach until they find out how much the throughput declines over increasing distances.

Another challenge, is that 802.11ac operates in the 5-GHz band only and can't interact with legacy 2.4-GHz Wi-Fi networks such as those using 802.11b, g, and n.

Because 802.11ad has such a short range and is the first Wi-Fi version to work in the 60-GHz frequency band, Gast stated, vendors will have to "relearn a whole set of skills." Those include identifying the interference

issues in that part of the spectrum and determining the number of APs needed to handle longer-range transmissions.

Gast said cost shouldn't be a major issue for 802.11ac and ad adoption. The technologies will be more expensive initially, he explained, but the cost will drop over time. In fact, Farpoint's Mathias predicted, by December 2012, 802.11ac-based products' prices should be comparable to those using 802.11n.

Dave Favreau, vice president of product management for Qualcomm's Consumer Business Unit, said the move from 802.11n to 802.11ac should be faster and smoother than earlier Wi-Fi transitions.

The advent of 802.11ac and ad will lead to continued growth in the sale of Wi-Fi-enabled products, the Wi-Fi Alliance's Davis-Felner predicted. "The total volume of products shipping globally is expected to rise to 2 billion annually by 2015, up from just over 1 billion in 2011," she said.

"We anticipate the majority of Wi-Fi shipments starting in 2014-15 being 802.11ac based," added Broadcom's Patel.

A driving force will be the ability of 802.11ac "to enable us to do things with Wi-Fi that we haven't been able to do before," said Aerohive's Gast. According to Gast, "This is another step in the process of wireless technology replacing wired technology."

"The future of Wi-Fi remains very strong," said Jay Botelho, director of product management at WildPackets, a vendor of network-monitoring hardware and software. "It is already way beyond critical mass, and it will remain the go-to solution for the last 100 yards of any data network. Users are now dependent on Wi-Fi, and there's nothing even close in the market that's ready to take its place."

Editor: Lee Garber, *Computer*; l.garber@computer.org

Selected CS articles and columns are available for free at http://ComputingNow.computer.org.