

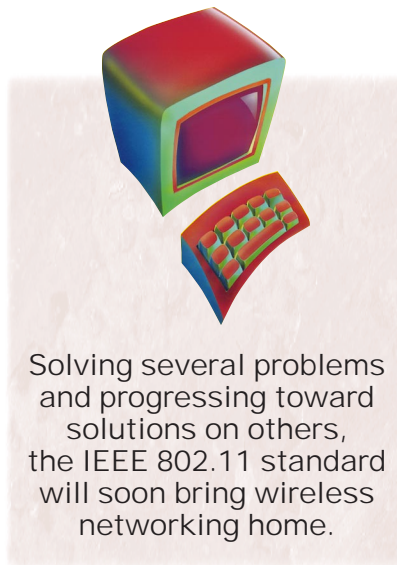
IEEE 802.11: Wireless Is Coming Home

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I can hardly wait. Yet another IEEE standard is on its way to my home. Please don't tell my wife—I want to surprise her. With her newly minted BA in business, she now has a much greater need for computer access than before, so I'm getting ready to buy her an iMac portable with AirPort wireless networking. This will let her work anywhere in the house anytime she wants. Somehow our windowless basement "machine room" proved less than optimal as an environment for her writing projects, and my son was getting tired of her camping in his room to use his machine. We already have a LAN, firewall, and full-time Internet connection, and her iMac will easily fit right into our home net.

The iMac AirPort is based on technology from Lucent Technologies (<http://www.wavelan.com>) using the IEEE 802.11 standard for wireless networking. In my opinion, by integrating wireless networking into its base product, Apple has (again) thrown down the gauntlet to the rest of the computing industry to match its innovation.

Home, office, and traveling users have been waiting for the wireless data networking revolution to take off. As the



number of homes with more than one computer increases (our family of four will soon have six machines), wireless networking will be recognized as an attractive alternative to hiring a contractor to run a bunch of Category-5 wiring into each home. Right now, most people are staying on the sidelines until the wireless market shakes out, but I believe this will all soon change—in part as a result of standardization.

IEEE 802.11 WIRELESS NETWORKING

When devices cooperate and stay out of each other's way, the 2.4-GHz spectrum area can act like an efficient network switch. Without cooperation, the addition of a single "rogue" device might

take all the others off the air. The IEEE 802.11 effort has produced a standard for data networking in the unlicensed 2.4-GHz frequency range. Approved in 1997, the standard has stimulated a wide range of products from companies such as Raylink, Aironet, Breezecom, Proxim, and Lucent Technologies.

Wireless networking faces many challenges, and 802.11 addresses them from the bottom up. Physical-media issues (frequencies and how they're used) are at the bottom.

Given that the spectrum areas are unlicensed, it is important for devices to cope with other unlicensed devices that might be close enough to interfere. The physical-access standard solves this problem by publishing "rules of the road" for the use of the frequencies in the range. There are two basic approaches.

The simplest is "frequency hopping," which divides the spectrum into 79 separate 1-MHz bands. Communicating devices switch between these frequencies 50 times per second using one of several predefined patterns. If a device encounters interference at a particular channel, it will attempt to use another channel. Over time, the device will transfer data, even if it must do so more slowly in the presence of other communicating devices or general interference.

The other approach to maintaining communications in the presence of other devices or background interference is "direct sequence," a technique that breaks the spectrum into 11 separate (wider) channels. Instead of sending a full power signal through the entire channel, direct sequence sends a lower power signal that uses redundant coding so that the receiver (a card in the receiving station—either a base station, or a portable unit) can reassemble the data in case of interference.

In addition to the physical-media layer, 802.11 specifies the media access layer (MAC), which covers the basic structure of the packets being sent over the wireless infrastructure, including definition of the basic packet framing and headers. In addition, like Ethernet, the basic header includes fields for protocol type to allow multiple, as-yet-unimagined protocols to coexist in this space. Much as Ethernet

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allows TCP/IP, Novell IPX, and Apple-Talk to coexist transparently on a single system, 802.11 allows these protocols and others such as wireless voice and video to coexist. An important aspect of any standard is to build in expansion for future unanticipated use.

STILL TO COME: CROSS-VENDOR INTEROPERABILITY

Although 802.11 addresses the challenges in the physical and media access layers, it does less in the area of multi-vendor interoperability. Many difficult interoperability issues reach all the way into the operating systems of wireless devices. A large unsolved interoperability issue is handling mobile users. As a system moves from one base station to another (say 100 meters), some type of handoff must occur. Like a cellular telephone, one base station must cease transmitting the data and the other must begin sending it. It is as if a PC were disconnected from one Ethernet LAN and reconnected to another. Not only must the base stations make the handoff, but the rest of the network must also properly route packets to the new location.

For example, as a TCP/IP user walks down the hallway of a building, his IP address may change three or four times. Today's operating systems cannot handle these address changes either on the client end or the server end.

Because of this situation, interoperability is left to individual vendors and trade associations. The University of New Hampshire runs a wireless interoperability lab (<http://www.iol.unh.edu/consortiums/wireless/>) that tracks vendor progress toward full interoperability and other issues in wireless networking.

NON-802 SOLUTIONS

Although several exciting, emerging technologies use the 2.4-GHz range, not all the devices based on them comply with the 802.11 specifications. The RangeLAN2 technology from Proxim is very well established and based on specifications developed by the OpenAir consortium (<http://www.wlif.org>). RangeLAN2 is a frequency-hopping protocol. Its primary advantages are lower power

consumption and a very broad installed base. Though most 802.11 cards are aimed at Windows-based portable computers, RangeLAN2 is available for Windows CE-based portables (the driver is included in Windows CE 3.0) and a wide range of industrial equipment such as bar code scanners.

Proxim also has an 802.11-based product called the RangeLAN802. Although a long-term contributor to the 802.11 working group, Proxim is clearly focused primarily on the OpenAir-based RangeLAN2 in the short term. Proxim (<http://www.proxim.com>) and Mobilstar (<http://www.mobilstar.com>) recently announced a limited nationwide Internet service based on RangeLAN2 technology. This service is targeted at airports and hotels that cater to business travelers.

I commend the IEEE 802.11 group for its dedication. A look at the tutorials on its Web page (<http://grouper.ieee.org/groups/802/11/index.html>) will give you an idea of just how many challenges the group has solved to produce standards at the physical and media access levels.

FUTURE DIRECTIONS

The horizon looks bright for wireless networking. Possibilities abound for the development and extension of this standard into as-yet-undeveloped areas. A single solution for both data and voice using the 2.4-GHz spectrum with a single base station may not be far off. Several features like 1- to 20-Mbps delivery capability, low power output, freedom from license requirements, and limited range make the 2.4-GHz band ideal for home networking. Because its range doesn't extend much further than the boundaries of an average home, this technology will have fewer problems arising from interference between neighbors. New 900-MHz and 2.4-GHz phones provide quality and range on a par with their nonwireless counterparts. A recent cooperative agreement (between Motorola and Proxim) and a trade organization (HomeRF, <http://www.homerf.org>) that coordinates efforts in this area are both indications of the potential for this convergence.

In addition to wireless convergence, the future could lead to an expansion

into a whole new frequency. The 2.4-GHz spectrum is a battleground of competing standards, but the 5-GHz frequency is up for grabs. This new frequency promises better bandwidth and the chance for standards makers to have a new start. With the existing 2.4-GHz standard in place and fewer existing commercial products in the 5-GHz area, 802.11 is in a position to produce standards early enough to ensure that the majority of products will follow the standards. Given the maturity of the 802.11 effort right now, it's in a good position to influence the 5-GHz field.

It may not be all that long before you move into a new neighborhood and see a sign saying, "This neighborhood is 802.11 compliant." And if you start using your noncompliant wireless phone, neighbors might drop by to politely recommend that you upgrade your phone. Every home, jogger, and automobile in the neighborhood will have high-speed data and voice connectivity.

For my part, perhaps I should convince my wife to go back to school for her master's degree. Just about the time she graduates, I should be able to buy her a nice 5-GHz data/telephony IEEE 802.11 solution as a graduation present. But please don't tell her: I want it to be a surprise. ❖

Resources

- <http://grouper.ieee.org/groups/802/11/index.html>. The home page for the IEEE 802.11 working group.
- <http://www.wavelan.com>. The home page for the Lucent WaveLAN project.
- <http://www.apple.com/airport/>. This page provides more information on the Apple wireless networking solution.

For an excellent explanation of wireless networking and 802.11, read *Wireless LANs: Implementing Interoperable Networks*, Jim Gier, Macmillan Technical Publishing, Indianapolis, Ind., 1999.