Exploring the Wireless LANscape

Linda Dailey Paulson

Traditionally, the word "networking" has evoked images of yards of spaghetti-like wiring in walls, on floors, and hanging from the backs of computers and peripherals.

However, several trends in the computer industry are rapidly driving the development and adoption of newer wireless networking technologies, which link devices to each other and to corporate LANs, primarily via radio-frequency (RF) technology.

These trends include the increase in home networking; the rapidly growing use of networkable portable devices—such as smart phones, personal digital assistants, and laptops—by a mobile work force; and the desire by companies to operate networks in historic, leased, or temporary buildings in which wiring is impractical, prohibited, or expensive.

Moreover, there is a demand for wireless networking by industries, such as medicine, in which employees must communicate with central networks but are too mobile to use wired devices.

Meanwhile, improved radio and networking technologies have increased the performance, reliability, and desirability of wireless networking.

To maximize the usefulness of wireless LANs, vendors want technology based on open standards rather than on proprietary technologies, which have been used during the past 10 years.

With this in mind, the IEEE and two industry consortia have developed three major wireless LAN standards: IEEE 802.11, HiperLAN, and HomeRF.

And another industry consortium has developed Bluetooth, which many experts consider to be wireless PAN (personal area network) technology. (See the sidebar "Bluetooth: The Wireless PAN.")

Major vendors are beginning to develop products using these standards, and a number of vendors are working with more than one of the technologies.

And now, faster and otherwise improved versions of wireless LAN standards are being prepared for release.

"We've been touting wireless LANs for six or seven years, and they just have not taken off," said Eric Thompson, senior analyst with the Gartner Group, a market research firm.

However, said Peter Hortensius, director of technology development for IBM's personal system group, the IEEE 802.11 standard, backed by established companies, has begun to move wireless LANs into the mainstream. Bluetooth and HomeRF are following in a similar path, he said. HiperLAN appears aimed principally at the high-end corporate market, primarily in Europe.

The technologies are not well established yet, though, and they still face such challenges as high costs. Meanwhile, the market has not determined whether one or all of the technologies will succeed.

WIRELESS LAN TECHNOLOGIES

Several companies developed wireless LAN technology about a decade ago. For example, said John Barr, Motorola's director of systems architecture and technology for PANs, Motorola developed Altair, one of the first commercial wireless LAN systems.

Early wireless LANs were expensive, their data rates were low, they were prone to signal interference, and most of them were based on proprietary RF and infrared technologies.

IEEE 802.11b

The recently adopted IEEE 802.11b is the newest IEEE 802.11 wireless LAN standard. IEEE developed the 802.11 standards to provide an Ethernet-like wireless networking technology.

The European Telecommunications Standards Institute (ETSI) is looking into adopting IEEE 802.11 standards, which would enhance the technology's international interoperability.

The technology. The technology permits transmission speeds of up to 11 Mbits per second, which makes it considerably faster than the original IEEE 802.11, which sends data at up to 2 Mbps, and a bit faster even than standard Ethernet.

IEEE 802.11b permits devices to establish either peer-to-peer networks or networks based on fixed access points with which mobile nodes can communicate.

IEEE 802.11 operates in the unlicensed 2.4-GHz so-called industrial, scientific, and medical frequency band, which has become popular for worldwide wireless communications because it is globally available.

On the physical layer, the original IEEE 802.11 uses either FHSS (frequency-hopping spread spectrum) or DSSS (direct-sequence spread spectrum) technologies.

With both technologies, transmissions regularly shift frequencies, which reduces interference and efficiently uses the available bandwidth. However, DSSS sends

Bluetooth: The Wireless PAN

Bluetooth has been one of the hottest stories in computer technology, even though vendors have only just begun releasing products.

Ericsson developed the wireless networking technology in 1994 to replace the cables used to link computers and telephones. The technology has garnered strong industry support, with about 2,000 companies, universities, and other organizations joining the Bluetooth Special Interest Group (http://www.bluetooth.com). And many vendors—including Intel, Lucent Technologies, and Microsoft—have invested in the technology.

Anders Edlund, Ericsson Mobile Communication's marketing director for Bluetooth, said "We don't consider Bluetooth to be a wireless LAN. It is more like a personal network."

Bluetooth personal area networks (PANs) link enabled devices—such as PCs, laptops, smart phones, and personal digital assistants—into mininetworks via radio signals operating in the 2.4-GHz spectrum. Bluetooth can also link mininetworks to form a piconetwork. However, the technology is primarily designed to replace wiring between devices that are close together, rather than create data or voice networks.

Edlund said Bluetooth functions over distances of 10 meters or 100 meters, depending on the power of the radio transceiver being used. The technology permits net throughputs of up to 721 Kbps upstream and 56 Kbps downstream.

Bluetooth works with a wireless system packed onto a chip that can be integrated into computers, phones, and other devices.

Ericsson has released a wireless cellular headset and two types of cellular phones, all equipped with Bluetooth. Meanwhile, other vendors plan to implement Bluetooth in their upcoming cellular phone releases.

transmissions over a wider channel (11 MHz) than FHSS (1 MHz) and thus offers greater transmission speeds over longer distances. However, wider channels also mean that DSSS offers fewer potential channels and less scalability. In addition, DSSS uses more power and is more expensive to build.

IEEE 802.11b uses complementary

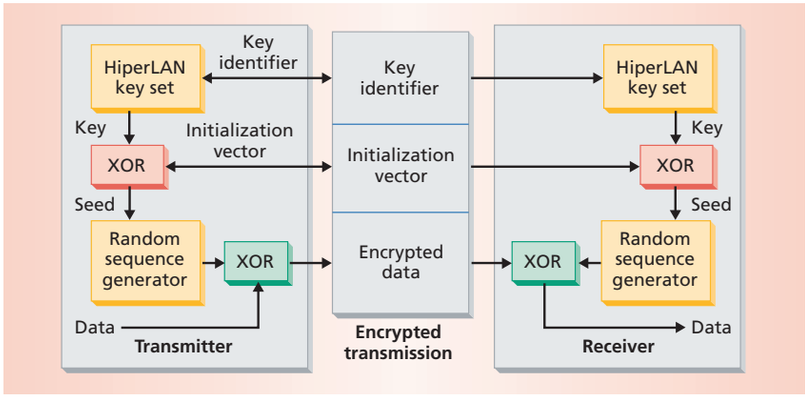

Figure 1. In HiperLAN1's implementation of wired equivalent privacy (WEP) cryptography, a random bit sequence called the initialization vector runs an XOR operation on the encryption key. The resulting value helps produce a stream cipher, which is used to encrypt the data. Packets—which include the key identifier, initialization vector, and data—are then sent to the recipient's system, where decryption takes place.

code-keying DSSS, which permits faster transmission speeds than the original DSSS used in IEEE 802.11.

For security, IEEE 802.11b supports authentication and encryption, including 128-bit wired equivalent privacy (WEP) cryptography.

The market. Apple Computer was the first company to market IEEE 802.11b systems, via its AirPort technology. AirPort is implemented via add-on cards and, in some cases, base stations that let up to 10 devices form networks. Other companies, including Cisco Systems and 3Com, also offer IEEE 802.11b products, such as network cards and chips.

Gartner's Thompson predicts that most wireless LAN vendors will invest in 802.11-based technology. Corporate users like 802.11 because of its range, security, and reliability, he said.

In addition, IEEE 802.11 offers quality-of-service capabilities, according to Barry Davis, Intel's strategic marketing manager for wireless LAN operations.

"The [big] advantage," Thompson said, "is that it has a very strong push from the industry and is standards based. It's absolutely brought vendors together and given them a target for interoperability."

"It is a little more expensive than some of the other wireless technologies today, but the price is coming down," he said.

HiperLAN

ETSI developed the HiperLAN (high performance radio LAN) standard. The HiperLAN Alliance (http://www.hiperlan.com) designed the initial version of the technology, HiperLAN1; the HiperLAN2 Global Forum (http://www.hiperlan2.com) is working on a faster version.

HiperLAN1 offers up to 23.5 Mbps throughput, the highest performance of today's wireless LAN technologies.

The technology. The keys to HiperLAN's high data rate include its efficient power amplifier and its use of the 5-GHz frequency band. Within the 5-GHz band, providers have larger frequency ranges and, therefore, higher bandwidth to work with than providers using technology in the 2.4-GHz band.

On the physical layer, HiperLAN1 uses Gaussian Minimum Shift Keying, a robust technique for modulating data signals by shifting transmitter frequencies.

HiperLAN1 supports quality of service in some implementations. In addition, the technology supports encryption, including the WEP algorithm, as shown in Figure 1.

The market. HiperLAN offers great promise because of its high data rates, according to Jeff Orr, product manager for Proxim, a manufacturer of broadband wireless networking products and a member of the HiperLAN Alliance.

Potential commercial applications of the high-speed technology include medical imaging, video training, or remote surveillance.

However, HiperLAN has not hit the marketplace yet, as vendors have focused more on IEEE 802.11 thus far.

"HiperLAN is fancy and it's new," said Barry Davis, strategic marketing manager for wireless LAN operations at Intel, "but products have never shipped."

Although HiperLAN has been seen as primarily a technology for the European market, it can be used in other areas. For example, the US Federal Communications Commission (FCC) has allocated spectrum for its use.

HomeRF

HomeRF is based on the shared wireless access protocol (SWAP), which the HomeRF Working Group (http://www.homerf.org) adopted in late 1998.

The technology, including a faster Wideband HomeRF currently under development, is designed for use primarily in homes and small offices.

The technology. SWAP lets up to 127 PCs, peripherals, cordless telephones, and other devices with a network stack share and communicate data. SWAP also permits up to six voice connections.

A HomeRF system can operate either as an ad hoc network of devices, which support only data communications, or as a managed network under the control of a central connection point. For transmissions that won't tolerate latency, such as voice communications, a connection point is required to coordinate the system. The connection point can also support power management for prolonged battery life by scheduling device wake-up and polling.

The radio in HomeRF systems has a power amplifier able to transmit at up to 100 milliwatts, which permits the technology to operate over distances up to about 45 meters.

The market. HomeRF products have already been released, including Intel's AnyPoint home networking system, as well as Compaq Computer's Symphony-HRF USB dongle, PC cards for notebook computers, and PCI cards for PCs.

Wideband HomeRF, with its 10-Mbps

data rates, could be particularly appealing in the residential marketplace. In the corporate marketplace, however, it would have to compete with faster versions of other technologies.

THE WIRELESS LAN'S FUTURE

The widespread adoption of wireless LANs has been limited by such issues as relatively low data rates and a lack of quality-of-service capabilities in some technologies.

Interoperability is also a potential issue. However, said Ben Manny, HomeRF Working Group chair and director of residential wireless networking for Intel's Architecture Lab, "in the near future, you'll start to see bridge products."

These products—such as Proxim's Harmony PC cards, access points, and access-point controllers—bridge LANs that use different technologies, such as IEEE 802.11b and HomeRF.

The primary impediment to wider adoption of wireless networking is that costs are still "too high relative to Ethernet," explained Peter Rysavy, president of Rysavy Research (http://www.rysavy.com), a communications-technology consultancy.

"The key new technology here is OFDM (orthogonal frequency division multiplexing), which currently is expensive," said Rysavy, "but vendors are likely to make large strides in reducing product costs."

Observers expect OFDM to be a key component of next-generation, high-speed wireless networks. OFDM divides the available spectrum into multiple transmission channels. The technology permits many channels and thus squeezes considerable performance out of the spectrum. OFDM places channels very close together and positions adjacent channels orthogonal to each other to minimize interference that would otherwise occur.

OFDM is a key component of IEEE 802.11a and HiperLAN2, both of which are planned for release next year with throughputs of up to 54 Mbps.

Meanwhile, the HomeRF Working Group plans to release a 10-Mbps version of its technology, called Wideband HomeRF, early next year. A recent ruling by the FCC will enable the use of wideband frequency-hopping systems in the domestic 2.4-GHz frequency band. This technology permits higher data rates by allowing more signal modulation within each frequency hop, thus using radio frequencies more efficiently with less interference.

Indicating how the wireless LAN market as a whole might grow, Figure 2 shows that Gartner Group/Dataquest predicts that the worldwide revenue from sales of wireless NICs will increase from $187.9 million in 1998 to $648 million in 2004, even as the average product price drops from $340.20 to $180.

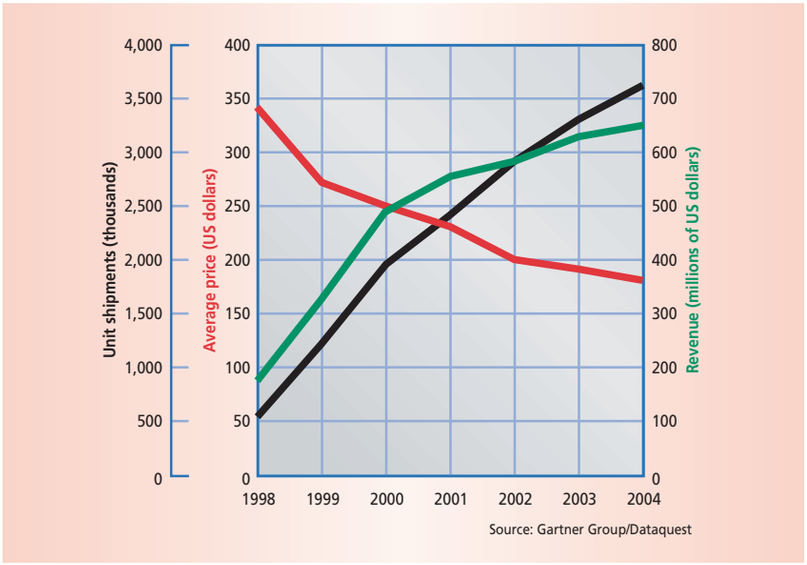

Figure 2. Gartner Group/Dataquest predicts that the number of network interface cards sold and the worldwide revenue they generate will steadily increase through 2004, even though the average product price will steadily fall.

Many industry observers say that HomeRF will be used more in the home and small office, while IEEE 802.11 and HiperLAN will be used more in the enterprise.

However, Thompson said, as prices drop for IEEE 802.11, home-networking users may well adopt this technology.

In the long run, said IBM's Hortensius, "The dilemma is whether you need all three [wireless LAN] technologies, and that's what the marketplace will tell us. There are not enough products [now] to decide. There could be a compelling case for all three, or just one or two." ✸

Linda Dailey Paulson *is a freelance technology writer based in Ventura, California. Contact her at ldpaulson@yahoo.com.*

Editor: Lee Garber, *Computer*, 10662 Los Vaqueros Circle, PO Box 3014, Los Alamitos, CA 90720-1314; l.garber@computer.org