IEEE 802.11b High Rate Wireless Local Area Networks

Networks as Mobile as the People Who Use Them

Contents

Executive Summary

With the release of an Ethernet-equivalent standard, Wireless Local Area Network (WLAN) technology is now on the threshold of widespread deployment and accelerated development of low-cost, interoperable products. Providing the flexibility to rapidly and wirelessly transfer large data files and high-resolution images, access the Web, support wireless videoconferencing, and rapidly reconfigure high-bandwidth sites, high-rate wireless technology promises to take Local Area Networks (LANs) to new heights unimaginable with a wired infrastructure.

This paper examines the state of wireless networking technology, including standards development, deployment methods, and business and educational applications, as well as networking trends that are likely to shape the future of Wireless Local Area Networks. At the end of the paper is a short description of Intel's involvement in the wireless world, and sources for further information.

Wireless Technology Today

What is Wireless Networking?

A Wireless Local Area Network is a flexible data communications system that can either replace or extend a wired LAN to provide added functionality. Using Radio Frequency (RF) technology, WLANs transmit and receive data over the air, through walls, ceilings and even cement structures, without wired cabling. A WLAN provides all the features and benefits of traditional LAN technologies like Ethernet and Token Ring, but without the limitations of being tethered to a cable. This provides greatly increased freedom and flexibility.

The importance of WLAN technology, however, goes far beyond just the absence of wires. The advent of the WLAN opens up a whole new definition of what a network infrastructure can be. No longer does an infrastructure need to

be solid and fixed, difficult to move and expensive to change. Instead, it can move with the user and change as fast as the organization does.

For example, business people can stay connected as they move throughout the corporate campus, easily tapping into the resources of the wired network. Students and instructors can wirelessly access instant information during field trips or lab projects. Organizations leasing temporary office space can set up a WLAN and then easily take the infrastructure with them when they move.

Just as wired LANs use copper or fiber optic cable, WLANs also use a medium: radio frequencies. Data is superimposed onto a radio wave through a process called modulation, and this "carrier wave" then acts as the transmission medium, taking the place of a wire.

A WLAN can be configured in two basic ways:

- *Peer-to-peer* (*ad hoc mode)* – This mode consists of two or more PCs equipped with wireless adapter cards, but with no connection to a wired network (Figure A). It is principally used to quickly and easily set up a WLAN where no infrastructure is available, such as at a convention center or offsite meeting location.

- *Client/server (infrastructure networking)* – Offering fully distributed data connectivity, this mode typically consists of multiple PCs linked to a central hub that acts as a bridge to the resources of the wired network (Figure B).

How can multiple wireless users operate at the same time, without getting someone else's messages? The same way that commercial radio stations stay separated. The carrier waves transporting the data will not interfere with each other, as long as they are sent out on different frequencies. At the other end of the communication, a radio receiver tuned to a specific frequency will "hear" only the messages on that frequency. All other signals will be treated as noise and ignored.

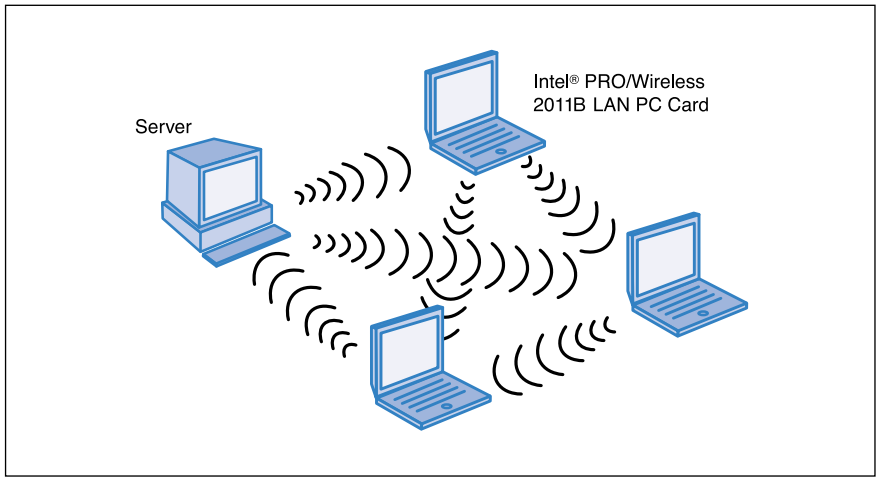

Figure A, Peer-to-Peer Wireless Configuration.

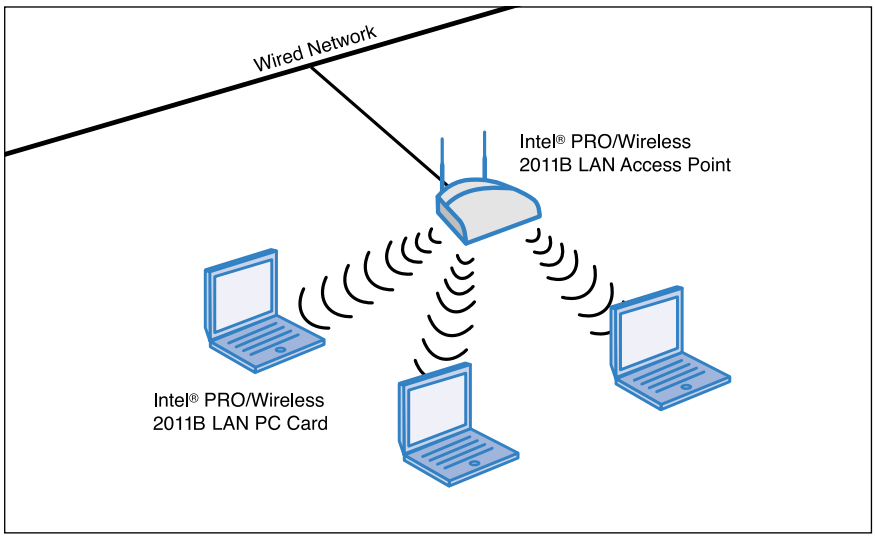

Figure B, Client/Server Wireless Configuration.

Most WLANs use the 2.4 Gigahertz (GHz) frequency band. Countries around the world have set aside this portion of the airwaves for unlicensed devices.

WLAN Equipment

There are three main links that form the basis of the wireless network.

- *LAN adapters*

  Wireless adapters are made in the same basic form factors as their wired counterparts – PCMCIA, Cardbus, PCI and USB. They also serve the same function, enabling end users to access the network. In a wired LAN, adapters provide the interface between the

network operating system and the wire. In a WLAN, they provide the interface between the network operating system and an antenna, to create a transparent connection to the network.

- *Access Points*

  Essentially, the Access Point is the wireless equivalent of a LAN hub. It receives, buffers and transmits data between the WLAN and the wired network, supporting a group of wireless user devices. An Access Point is typically connected with the wired backbone through a standard Ethernet cable, and communicates with wireless devices by means of an antenna. The Access Point, or the antenna connected to it, is generally mounted high on a wall or on the ceiling. Like the cells in a cellular phone network, multiple Access Points can support hand-off from one Access Point to another as the user moves from area to area (Figure C).

  Access Points have ranges from under 20 meters to 500 meters, and a single Access Point can support between 15 and 250 users, depending on the technology, configuration and use. It is relatively easy to scale WLANs by adding more Access Points. This decreases network congestion and enlarges the coverage area. Large facilities requiring multiple Access Points deploy them to create overlapping cells for constant connectivity to the network. A wireless Access Point can track movement of clients across its domain and permit or deny specific traffic or clients from communicating through it.

- *Outdoor LAN bridges*

  Outdoor LAN bridges are used to connect LANs in different buildings. When the cost of burying a fiber optic cable between buildings is considered, especially if there are barriers such as highways or bodies of water in the way, a WLAN bridge can be an economical alternative. A bridge can also provide a less expensive alternative to recurring leased-line charges. WLAN bridge products support fairly high data rates and ranges of several miles with the use of line-of-sight directional antennas. Some Access Points can also be used as a bridge between buildings of relatively close proximity.

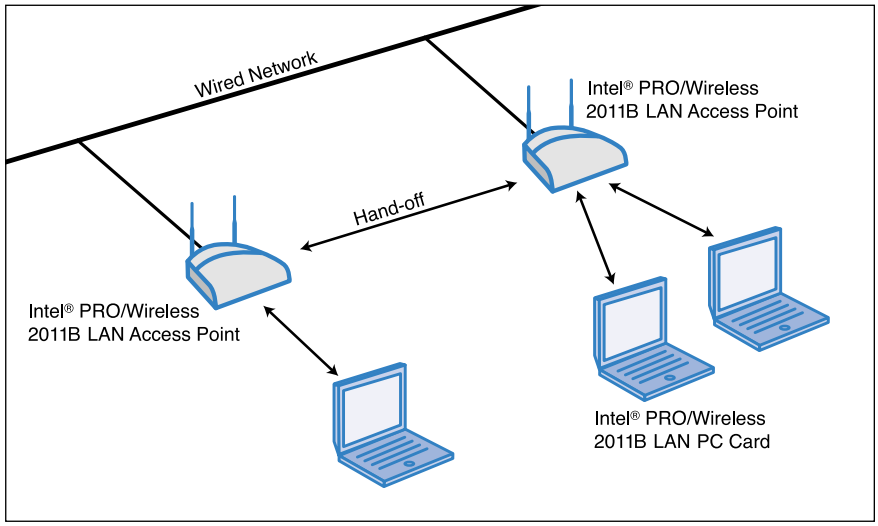

Figure C, Multiple Access Point Hand-Off.

The High Rate Standard

Just as IEEE 802.3 Ethernet has evolved to become the predominant wired LAN technology, the IEEE 802.11 standard has emerged in the realm of WLANs. Like all IEEE 802 standards, the 802.11 standard focuses on the bottom two levels of the ISO model, the physical layer and data link layer. Any LAN application, network operating system or protocol, including TCP/IP, will run on 802.11 compliant WLANs as easily as they run over Ethernet.

The 802.11 standard allows for two types of transmissions: Frequency Hopping Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS). Spread spectrum was initially developed by the U.S. military. Both forms of spread spectrum consume more bandwidth than a typical narrowband transmission, but this enables a louder signal that is easier for the receiver to detect than a narrowband signal.

Military use of these methods stemmed from the fact that they were hard for a third party to intercept or jam. With FHSS, the signal hops from one frequency to another at a predetermined rate known only to the transmitter and receiver. With DSSS, a redundant “chipping code” is sent with each signal burst, and only the transmitter and receiver know the chipping sequence.

Of importance for today’s wireless uses, DSSS has much greater range characteristics and higher throughput potential. The recent evolution of the High Rate wireless standard, 802.11b, provides for a full Ethernet-like data rate of 11Mbps over DSSS and has become the predominant WLAN standard. Products based on the 802.11b High Rate (11Mbps) standard interoperate with older products based on the 1 and 2Mbps 802.11 DSSS standard.

FHSS systems are primarily used for low-power, low-range applications such as 2.4GHz cordless phones, and do not interoperate with DSSS products.

Extensions to the Standard

For WLANs to be implemented in corporate environments, they must have similar reliability and security characteristics as the wired LANs to which they connect. Roaming schemes allow clients to seamlessly traverse across different Access Points, providing reliable LAN access on the move. Advanced roaming techniques offered by some WLAN vendors, such as preemptive roaming, assure connection with a new Access Point before the current connection is lost, thus enabling IT managers to meet their network availability goals.

The 802.11b standard specifies optional encryption using a shared-key RC4 algorithm. Additionally, some WLAN vendors provide access control features to authenticate clients and Access Points before granting entry to the network. Because wireless technology was originally designed for military use, security has long been a design criterion for wireless devices.

Besides reliability and security extensions, the 802.11b High Rate standard supports two power-utilization modes, called Continuous Aware Mode and Power Saving Polling Mode. In the former, the radio is always on and drawing power, while in the latter, the radio enters a sleep state to extend battery life of portable devices. The associated Access Point will hold data in buffers and signal clients who have traffic waiting for them.

Poised for Growth

Until recently, the WLAN market segment has been vertically focused by industry. Early adoption has been limited chiefly to industries where workers need to be mobile throughout the day. This includes retail and warehousing, where mobile workers use handheld devices for data collection and inventory management. However, several changes are taking place to move wireless networking from vertical market adoption to mainstream deployment.

- *Widely supported standard* – Since its 1999 release, the 802.11b High Rate standard has been adopted by almost all of today's wireless vendors.
- *Interoperability* – To ensure cross-vendor interoperability, WLAN purchasers can look for the Wi-Fi* symbol (Wireless Fidelity.) WECA (Wireless Ethernet Compatibility Alliance) is the organization behind Wi-Fi that certifies products meeting the 802.11b specification through compatibility testing. www.wirelessethernet.org
- *Cost* – Wireless network adapter card prices dropped an average of 200 percent in a recent 12-month period.
- *Performance* – Since data rates have crossed the 10Mbps barrier, Ethernet-equivalent speeds are now a reality.
- *OS support* – Microsoft Windows* 95 and Windows 98 are better able to support a wireless environment than previous releases. Windows 2000 promises to provide an even more fluid environment for WLAN products.
- *Internet economy* – With the growing importance of the Internet and e-Business applications, access to real-time data without being confined to one's desk is fueling the WLAN segment.

Most analysts agree that the WLAN market segment is set to take off in 2000 and 2001, reaching $1.6 to $2.2 billion by 2005.

- Gartner Group, an analyst firm specializing in the computer industry, characterized it best when it stated that, "Investments at the desktop are idle, because people are spending less time at their desks."
- Wireless voice is common, while wireless data is not. Yet, more than 90 percent of all communications traffic consists of data and not voice – this represents a huge reservoir of potential growth.
- Laptops now make up about 25 percent of corporate purchases (Intel Corporate Market Research, 2000).
- 75 percent of large organizations are evaluating WLANs (Campbell DeLong Resources, Inc., 1/2000).

Wireless connectivity is moving from the back office to the front office, from workers who must communicate while traversing warehouses, to marketing personnel who need to take their productivity tools down the hall or across the campus. Wireless networking is a natural extension to a company's wired network. High-performance, wireless solutions can greatly increase an employee's productivity by providing real-time access to e-Business applications and valuable networked data. Additionally, wireless networking allows teachers to more easily integrate student-empowered discovery into the educational environment. Networking resources, including the Internet, are changing the way students learn, affording them more control and interaction in their learning experience.

Looking Ahead

The 802.11b High Rate standard is not yet two years old. In many ways, wireless has only begun to stretch the boundaries of the network. In other ways, the future is practically here. Along with the growth spurred by price/performance and standards development, several other trends are acting as catalysts in the WLAN arena.

Networking Trends

- *Proliferation of networking accessories*

  A wide variety of new devices such as Internet phones and handheld computers are continually adding to the usefulness of the network. This trend enlarges people's notions of what is possible and helps create a well-founded desire for the increased mobility that WLANs bring. Tomorrow, there will be additional devices, many with combined capabilities. Interoperability will provide investment protection for users. The list includes:

  – Laptops and Desktop PCs with wireless NICs

  – PDAs and handheld computers with built-in radio devices

  – Internet access appliances

  – Voice over IP (VoIP) phones

  – Scanners

  – Wireless gateways

- *Growth of the Internet economy*

  An even more basic trend is the rapid and global acceptance of the Internet as a preeminent communications medium. Both the number of web users and the amount of web content accessed are continuing to accelerate. The Web is becoming a major center for transactions of all types, with an increasing proportion of traffic taking the form of e-Business. The projected value of this rapidly expanding Internet economy is enormous (Figure D).

  This value is driving demand for more powerful and easy-to-use Internet access methods, including wireless technology. The growing importance of the Web also means that the web browser is rapidly earning the status of *de facto* universal interface, forming a common basis for new generations of business and personal communications devices.

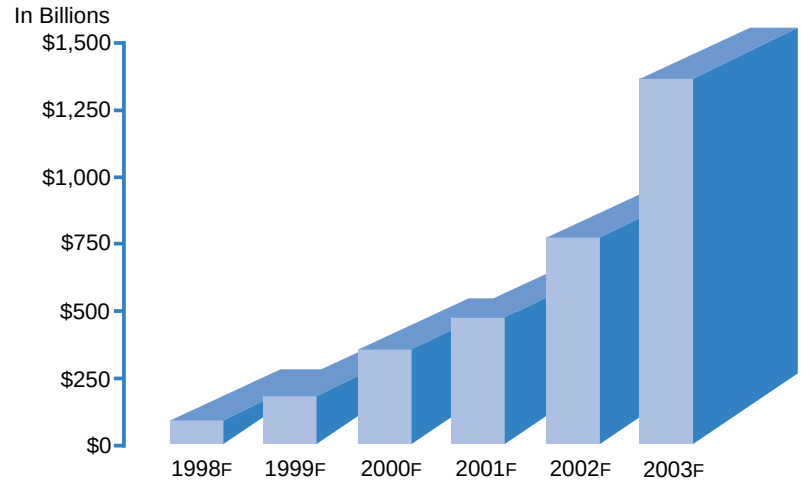

Figure D, Projected Value of the Internet Economy.

In order for companies to participate in the Internet economy, they must set-up a system infrastructure that allows e-Business activities to take place. For example, suppliers must be networked to customers for inventory management, multiple companies must have access to collaborative design documents, or electronic systems must be put in place for real-time account ledger updates. To achieve optimal efficiencies, companies must enable employees to access this data anytime, from anywhere. Wireless networked devices make this access possible.

- *Use of technology in education*

  Wireless technology is spreading from higher education to K-12, as more and more schools are making technology investments top priority. Middle schools are leasing laptops to students, so they can take them from classroom to classroom and then home at night. In order for the students to connect to the Internet, printers, and other network resources, wireless Access Points are being placed in classroom ceilings or along hallways, eliminating the need for each student to connect to an Ethernet port. WLAN products are a less expensive and environmentally safe alternative to retrofitting buildings with cable, especially older buildings that may contain asbestos materials.

  As another example, some schools do not have the funding to put a PC in every classroom or in every science lab, so they are utilizing Computers-On-Wheels or COWs. The school can schedule a COW to be in different rooms throughout the day, an hour at a time. In this way, the maximum number of students can benefit from the school's technology investment. WLANs enable the computer and cart to roam seamlessly from Access Point to Access Point throughout the school, to portable classrooms, and onto the playground, eliminating the time spent shutting it down between sessions.

- *Voice and data convergence*

  Another trend emerging today is the prospective growth of voice/data convergence. Traditionally, voice and data networks have been separate because no single technology has been able to meet the reliability and performance requirements of both.

That, too, is rapidly changing, with the advent of 802.11b High Rate WLAN products.

The focus of most converged network strategies is Voice over IP (VoIP), a technology which can transmit telephone conversations over any packet-switched IP network, whether a LAN or the Internet. The H.323 standard provides the necessary functionality. Quality of Service is another key requirement for successful VoIP communications, whereby traffic management techniques can now deliver QoS over LANs. With wireless connectivity now a reality, the stage is set for seamless, end-to-end voice/data solutions.

Benefits to the User

A fully evolved wireless environment has brought significant efficiencies in vertical market segments, and will now bring substantial benefits to users in educational and business-to-business settings, including:

- *Small businesses*

  WLANs can help a small business inexpensively network its PCs and peripherals. There is no money or time spent on installing space-consuming network cable. For example, an orthodontist can carry his laptop between patient rooms and use a virtual imaging application to project what a patient's teeth will look like after braces. This can be done over a wireless network, eliminating the need for a PC and network connection in each patient room. And at the touch of a button, the dentist can send a copy of the image to the front desk printer for the patient to grab on the way out the door.

- *Higher education*

  At colleges and universities, it is increasingly common for students to carry and use laptop computers. Institutions are responding with wireless Access Points located in libraries, student lounges and even dormitories. The result: students can have 24-hour access to the Internet and the institution's network, without the need to be connected to wires.

- *Large Enterprises/Primary and Secondary Schools*

  Organizations can enable wireless mobility throughout a campus, or connect LANs together for a fraction of the cost of traditional Wide Area Network (WAN) technologies. Wireless LANs also make it much easier to add or move workstations, and to provide connectivity in areas where it is difficult to lay cable. An additional benefit is the entire wireless network can be managed from one location, anywhere in the world and it has enhanced security/access control to thwart hackers or intruders. There are as many potential applications as there are organizational categories. Securities traders already use WLANs for transactions as they roam the stock exchange floor. Corporate employees use WLANs to keep up with e-mail, and access real-time data in conference rooms to make critical business decisions. Students access shared software housed on district servers to prepare for standardized testing.

Conclusion

The recent emergence of high-rate WLAN communications is enabling a wide range of new capabilities for enterprises and institutions across a number of industries. These capabilities can offer many organizations a key competitive advantage. IT managers and others involved in network communications will want to be familiar with this technology.

As the widespread deployment of WLAN technology moves forward, what should organizations look for in a solution? In addition to price/performance, Intel believes it is most important that a solution provides end-to-end connectivity, from mobile users to wired workers. In short, the wireless network must integrate with the wired network to form a seamless entity.

A common set of advanced features such as security, manageability, VoIP, and QoS should be part of this end-to-end solution, enabling IT managers to deploy a universal bandwidth management strategy across their organizations. This can save them vast amounts of time and money configuring, maintaining and building out their networks. Advanced software, including a GUI interface and support for popular enterprise management applications, is also essential.

Intel and Wireless Networking

Intel announced a joint development agreement and investment in Symbol Technologies Inc. in February 2000. Symbol is widely regarded as a foremost mobile communications expert, contributing decades of wireless experience, innovation and standards leadership. Intel, as a world leader in high-performance Ethernet connections, contributes in-depth networking silicon expertise as well as world-class manufacturing capabilities.

"Combining Symbol's leading wireless LAN technology with Intel's recognized silicon expertise will accelerate the mass production of high-speed, low-cost wireless LAN chipsets," said Tom Razmilovic, Symbol's president and chief operating officer.

On June 5, 2000, Intel announced the first products resulting from the joint development agreement with Symbol. The new Intel® PRO/Wireless LAN PC Cards and Access Points provide high-speed, secure and reliable network connectivity without wires. There's no easier way to provide real-time LAN access away from the desk, enabling freedom to work, teach, or study wherever one can be most productive.

For More Information

To learn more about Intel's networking technologies and products, please visit
http://www.intel.com/network/products

0302/MCD/PP/PP/HB/1.5K

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