An Overview of Wireless LANs

In this report:

Editor's Note

One of the hottest topics in the communications industry today is wireless communications. Eliminating costly and space-consuming cabling from their premises is a priority for many users. With the local area network (LAN) market booming, many vendors are introducing wireless LANs, eliminating the need for coaxial, twisted-pair, and fiber optic LAN cabling. This report examines the varied technologies being used to implement cabling and presents guidelines on why or why not to consider wireless LANs. Also included, in tabular form, is a comparison of eight wireless LAN products currently offered by vendors including BICC, Motorola, and NCR.

Report Highlights

Wireless LANs are local area networks that operate without traditional cabling techniques. To most, wireless LANs are local area networks which use radio frequencies to transmit signals generated by electromagnetic sources. A few consider wireless LANs to encompass transmission of signals through AC power outlets.

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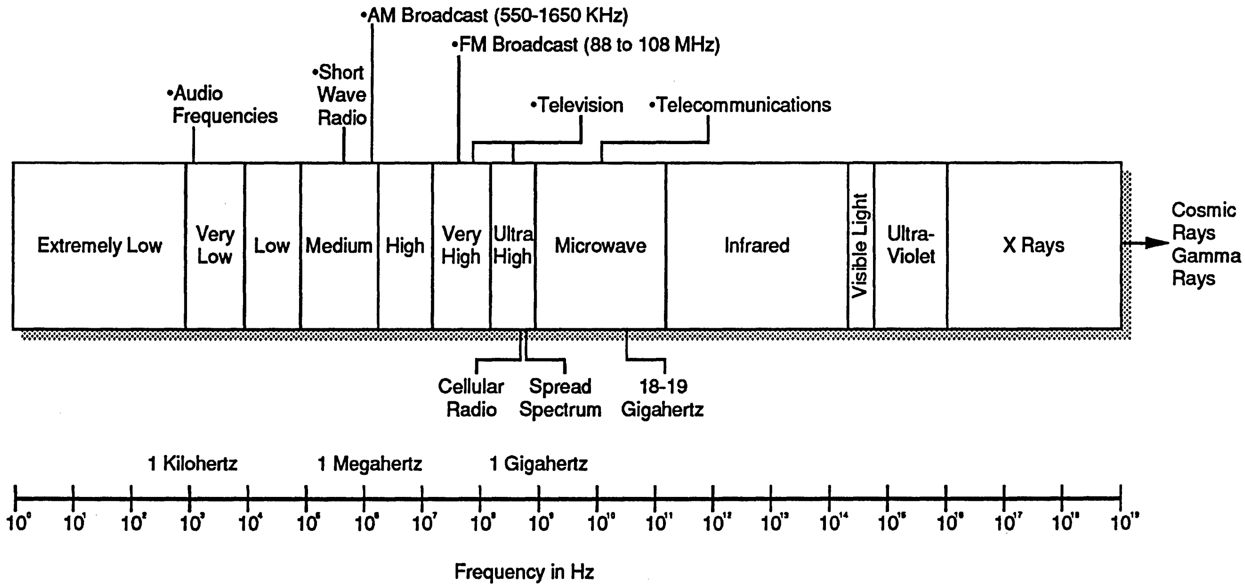
Figure 1.
The Electromagnetic Spectrum



The electromagnetic spectrum is made up of energy which includes heat (infrared), light, X rays, and radio, all of which travel invisibly at the speed of light as waves. The characteristics of the waves are physical length (measured in meters) and the frequency at which they oscillate (measured in hertz, or cycles per second).

Source: Motorola, Inc.

Wireless Technologies

The basis of what is traditionally referred to as wireless LAN technology is radio. Radio uses a broad portion of the lower end of the electromagnetic spectrum as a vehicle to encode and ship information from one place to another. The electromagnetic spectrum is made up of energy which includes heat (infrared), light, X rays, and radio, all of which travel invisibly at the speed of light as waves. The characteristics of the waves are physical length (measured in meters) and the frequency at which they oscillate (measured in hertz, or cycles per second). These two attributes determine the way in which waves behave. Actually, there is an inverse correlation between wavelength and frequency; as wavelength increases, frequency decreases.

As the frequency of waves increases, the electromagnetic radiation becomes known first as infrared, then light, then ultraviolet radiation, then X rays. The increase in wave frequency takes us across the electromagnetic spectrum (see Figure 1).

The strength of radio waves is a function of amplitude, which is the strength of their oscillation and not their frequency. Radio uses a carrier frequency—a certain fixed, constant frequency—where it encodes an information signal by modulating or varying the amplitude (AM, or amplitude modulation) or frequency (FM, or frequency modulation) of the carrier frequency in direct proportion to the signal. The encoded radio frequency signal is radiated into the air, after it has been amplified, through an antenna. Once the signal hits the antenna of the receiving radio, it converts it back into electrical form. The receiving radio then takes the information signal from the carrier frequency and separates and reconstructs it through a process called demodulation. The signal is then amplified, and the decoded information is sent to the output device (most commonly a speaker).

Information can be carried in analog (natural waveforms of information) and digital (information in discrete, discontinuous, usually binary bit) form.

Wavelengths vary considerably and can react very differently to different items in the environment—they can bounce off rocks, be absorbed by wood, and even react differently to changes in atmospheric pressures. All radio frequencies exhibit their own characteristics. For instance, low-frequency, long-wavelength radio frequencies (RFs) can pass through earth, water, and even human-made structures.

UHF Radio Systems or Spread-Spectrum Technology

The first wireless devices used the ultrahigh frequency component of the electromagnetic spectrum. This technology became known as spread-spectrum.

The essence of spread-spectrum technology is that it is spread across a range of radio frequencies instead of being sent on one specific frequency. The result of this spreading is a unique "waveprint" which can only be intercepted by a device that understands the spreading which has taken place by the sending device; data is therefore difficult to intercept. The spreading effect in spread-spectrum technology leaves this option with improved security—no one frequency can be readily tapped to siphon data.

The technology was developed during World War II for military applications which were based on antieavesdropping and antijamming properties. In 1985 the Federal Communications Commission (FCC) set aside selected bandwidths for commercial data transmission by radio waves. These three bands of frequencies are 902MHz to 928MHz, 2400MHz to 2483.5MHz, and 5725MHz to 5850MHz. In setting these frequencies aside, the FCC limited commercial installations to a low power level of one watt, which results in a transmission that can only travel 800 feet.

These bandwidths are essentially the upper end of the UHF band. The upper end of the UHF band is not only used for spread-spectrum radio technology but also for television, FM radio, and cellular radio. They all use several small, narrow bands, within a general region of the spread-spectrum bands, as carrier frequencies. As a consequence, there really is not a lot of available bandwidth for spread-spectrum technology.

Spread-spectrum technology (also called SST) operates on a non-exclusive spectrum of radio frequencies. There are other radio signals being sent across these frequencies, and the signals are therefore susceptible to interference. The maximum speed or signaling rate which the data can travel is 230K bps.

Wireless In-Building Networks (WINs)

At the highest level of UHF frequencies, frequencies exist within the electromagnetic spectrum which are virtually interference free. Spectrum reuse is therefore more easily done here, than at a lower, more crowded frequency.

These frequencies (18GHz to 19GHz) are in essence a blend of UHF frequencies and infrared characteristics. At these higher bandwidths, transmission speed is much quicker. Presently, transmission speeds of 15M bps are being achieved while 80M to 100M bps are attainable. Due to the uncrowded nature of these bandwidths, there is enough bandwidth available to handle these higher speeds that will be found in future computer systems.

This higher bandwidth is to be licensed by the FCC. The FCC will also assign frequencies on which signals may travel. The FCC now calls the 18GHz to 19GHz frequencies the Digital Termination Service (DTS) band. Motorola coined the name Wireless In-Building Networks (WINs) as the vendor applied it to this bandwidth. One problem with this frequency is that signals are often blocked by large structures. While it is a high enough frequency that it does not interfere with other electronic equipment, signals can only pass through drywall surfaces. Motorola has developed a lot of technology around the wireless use of this DTS band. It includes the following.

Six-Sector Intelligent Antenna: This antenna is set up to continuously select the best signal for each individual data transmission.

High-Performance RF Digital Signal Processor: This processor is a radio frequency digital signal processor which is used for data synthesis and recovery. Motorola embedded this technology in CMOS technology, which incorporates specialized modulation and demodulation techniques with a bit error rate of 10^{-8}.

GaAs MMIC Module: Gallium Arsenide Monolithic Microwave Integrated Circuit (GaAS MMIC) technology enables the DTS technology to be miniaturized so that a system module is the size of a deck of cards. This module contains five GaAs integrated circuits which both transmit and receive the 18GHz RF energy.

Packet Switch and Network Interface on a Chip: This chip has a three-level switching architecture which is intended to manage, organize, route, and ensure the integrity of the high-speed datastream. One million connections per second can be processed through its on-chip switching capability.

Infrared

Infrared wireless LANs operate at an even higher frequency on the electromagnetic spectrum. Infrared is immune to electrical interferences and is quite available in terms of various frequencies. The technology is line of sight (even though it is invisible to the human eye) in that it cannot penetrate dense surfaces. However, it can be reflected off some common point for linking transmissions together. The speed of infrared transmissions is currently 1M bps, but in the future it is anticipated such transmissions could travel at 10M bps through products on the market.

Carrier Current Radio

Wireless alternatives must include a mention of carrier current radio. The basis of this technology is to send low-frequency radio signals over AC power lines. The technology is inexpensive but constrained to a narrow bandwidth. It has the same distance constraints as does RS-232 cabling. Its maximum signaling rate is 115.2K bps.

Why Use Wireless LANs?

Why should you use wireless local area networks? There are a host of reasons. The most commonly cited ones are:

Issues of Inflexibility of Cabling. When cable has been laid in a building, it is often difficult and expensive to change the configuration of that cabling—walls have been closed off and they must be opened again to rewire, or no wiring diagram had been constructed and now there is a lot of guesswork involved in figuring out what cabling is where. Today, there is frequent addition or reconfiguration of personal computers or local area networks, which adds to the need to create additional flexibility.

Expense of Cabling. The expense of cabling can be as great as the cost of computer hardware and software. If the installer is fortunate enough to be working with a new building, drywall may not have been placed in the structure so that cabling is not only easier but less expensive. If the structure is complete, cabling can be quite expensive. Especially in older structures where stone forms the base of the construction, it can be a difficult environment in which to pull cable. These expenses are increased anytime that a move of a personal computer or a local area network takes place.

Physical or Regulatory Limitation on Cabling. Many types of cable will not guarantee signal strength if the cable length is over 1,000 feet. While repeaters (devices to "repeat" or push the signal further) can be used, there are still many limits on the physical distance which a signal can travel over coaxial, twisted-pair, or fiber optic cabling can travel.

Limitations of Speed of Cabling. Cabling configurations can limit the speed at which the signal can travel. While token-ring configurations can support speeds of 4M and 16M bps and Ethernet networks can support 10M bps, sources in the wireless LAN market claim that it could easily achieve network speeds of 100M bps. Since the bandwidth of cabling determines the speeds at which signals can travel, physical limitations of bandwidth may constrain wired systems far below this level.

Need to Easily Form Workgroups of People Using PCs. Local area network workgroups often need to be put together very quickly, and often for short-term situations (such as a field audit performed by accountants). The cabling involved in quickly and economically constructing a workgroup, especially on a short-term basis, does not always make economic sense. While one could argue that cabling does not need to be concealed in the wall for short-term projects of this nature, others would argue that security and professional reasons mandate that the cabling be concealed. These scenarios are those for which wireless local area networks are ideal.

In fact, wireless LAN industry observers claim that the ideal local area network configuration can be best achieved through wireless techniques in the future. Network attributes commonly cited in this ideal wireless configuration are:

- easy to install and move
- can coexist with wire, cable, and future optical fiber
- easy to operate

- universally applicable
- can provide similar speeds to what it replaces
- secure
- reliable
- cost effective

Why Not to Use Wireless LANs

Conversely, there are a number of reasons to *not* use wireless LANs. They include the following:

Wireless LANs are Radio Devices. Are the electronic emissions from these devices necessary and safe?

Cost. With wireless technology in its early stages, some of the technology is still not cost effective.

Speed. With spread-spectrum, carrier current, and infrared technologies, speed can be slower than what can be achieved with comparable wired systems. The WIN technology is the main area where we see potential for great improvements in speed over wired systems.

Line-of-Sight Issues. Line-of-sight restrictions cause the technology to have physical limits.

Distance/Range Issues. Coupled with line of sight are the issues which surround the distance that a signal can travel. Especially in spread-spectrum technology, this distance may be adversely affected by weather.

Interference. Spread-spectrum technology, which is shared, is susceptible to interference from assorted household equipment including microwave ovens, garage door openers, and industrial meat cookers. Burglar alarms have even been found to emit and sense reflected radio waves blanketing out wireless signals.

Newness of Technology. As is the case with many new technologies, many users perceive wireless LAN technology to be untried. While this perception may not be valid, it is an issue which must be addressed.

Need for Special Software Drivers and Proprietary Components. Many wireless LANs require special software drivers and proprietary components in order to function. This requirement, by definition, locks the user into the vendor from which he or she purchased this proprietary technology.

AC Power-Line Product Restrictions. AC power-line products must be located on the same AC transformer due to the fact that low-frequency signals will not go through transformers.

Products and Services

Products

We have compiled a list of eight wireless LAN products currently available. This list, in Table 1, is by no means exhaustive but is intended to provide an overview of some products which are now being offered as wireless LANs.

Services

Advanced Radio Data Information Service (ARDIS)
ARDIS is a joint venture cellular-radio network between IBM and Motorola which is presently operating in 8,000 cities. It charges users for access to a slice of the radio spectrum which they are licensing from the FCC. An electronic mail and telecommunications program called MacKDT has been developed by Apple Computer to use ARDIS.

Data Personal Communications Services (PCS)
This proposed service is a bandwidth (1.7GHz to 2.3GHz) which Apple Computer has recommended that the FCC set aside for the free use of wireless LANs. The network would be accessible anywhere and would be free, yet it would carry only data.

Table 1. Wireless LAN Product Comparisons

Product	**Motorola Altair Wireless Ethernet**	**Telesystems SLW Arlan 440/450**	**Carrier Current Technologies CarrierNET Series**	**BICC InfraLAN**
Technology	Wireless In-Building Network (WIN)/microwave	Spread-spectrum	AC power line	Infrared light
Applications	Wireless networking of PCs (with Ethernet cards), printers, terminals, other Ethernet devices	Wireless PC LANs; mixed combination of wireless and cable LANs; PC-to-host connections; network-to-network bridges	With Manylink software, file transfer, E-Mail, printer sharing via low-power, low-frequency radio signal; software does not support virtual drives	Traditional LAN applications
Protocols Supported	All running over IEEE 802.3 10M bps Ethernet	None identified	None identified	Ties into token-ring networks
Configuration	1 Control Module per Microcell; maximum of 32 User Modules per Microcell; maximum of 32 users per Microcell; maximum of 6 users per User Module	Arlan 440: wireless communications card with at least 1 Arlan 010 Transceiver over Arlan NCBus; up to 16 additional communications devices; Arlan 450: wireless communications card with attached or optional antenna; Requirements: 128K RAM per PC, Advanced NetWare 286 2.1 or ELS NetWare II	Requires 256K RAM and RS-232 serial port for each PC, DOS 2.0 or higher, 110/220 V AC, 50/60 Hz; 255 nodes on a power line up to 1 mile long	6-port repeater/multiaccess unit (MAU) for attaching PCs and bridges; 2 optical nodes transmit incoming and outgoing data signals
Frequency	18-19GHz	915MHz	200kHz	Optical wavelength: 870 nanometers
Range/Site Coverage	5,000 square feet (with 32 Ethernet devices); 40 feet between control and user modules	Indoor/office: 500 feet diameter; open factory: 3,000 feet diameter; building to building: 6 miles directional (line of sight)	Up to 1 mile	80 feet between nodes
Transmit Power	25 mW	1 watt, peak	5 watts	Not applicable
Signaling Rate	15M bps	230K bps	38,400 bps	4M/16M bps
Pricing	$3,995 (Control Module/32 users); $3,495 (User Module/daisy-chained 6 workstations, each with thin Ethernet adapter); net cost: $780 per port	$1,500 per node	CarrierNET: $199; CarrierNET Plus and CarrierNETPlusl: $399	$2,995 per node; under $500 per user
FCC License	Required	Not required but FCC certified under part 15.126	Not required	Not required
Strengths	Potential speed to 100M bps; security ensured due to data encoding; higher frequency leads to lower interference	Supports up to 100 PCs per network	Inexpensive	Minimal interference; inexpensive
Limitations	Proprietary technology not compatible with other network management packages; proprietary directional antenna required because signals fade rapidly; uses FCC-licensed frequency which costs the end user on an ongoing basis	Speed of network	Speed and distance constraints	Uses line-of-sight technology; cannot transmit through walls or partitions; relatively expensive at $2,995 per node

Table 1. Wireless LAN Product Comparisons (Continued)

Product	O'Neill Communications Local Area Wireless Network (LAWN)	Photonics Photolink	California Microwave RadioLink	NCR WaveLAN
Technology	Spread-spectrum	Infrared light	Spread-spectrum	Spread-spectrum—differential quadrature phase shift keying (DQPSK)
Applications	File transfer, peripheral sharing, E-Mail	All traditional LAN applications	All traditional LAN applications	Runs on MS-DOS and Novell NetWare
Protocols Supported	AX.25 (X.25 standard for radio)	Compatible with TOPS (Sitka), PhoneNET, LocalTalk, or RS-232 links (4 computers)	RS-232-C (asynchronous/synchronous), RS-485, V.35, X.21 bis, IEEE 802.3, AppleTalk	Ethernet-type (CSMA/CD)
Configuration	LAWN transceiver unit; software requires 110K RAM (TSR program within software requires 40K); each PC requires 512K RAM and RS-232 serial port, DOS 2.0 or later; hard disk recommended	Infrared Photolink transmitter/receiver attaches to PC and desk or wall divider; 32 Photolinks at same target area; maximum of 128 computers on 1 Photolink network; Infrared Transceiver allows portable computers to be tied into Photolink network	RadioLink transceiver	Network interface card for ISA PC platforms, including network drivers and installation tools; external omnidirectional antenna module; optional DES encryption socket
Frequency	902-928MHz	Below visible light	902-928MHz; 2,400-2,483.5MHz	902-928MHz
Range/Site Coverage	1,000 square feet (coverage inside buildings); 500 feet (unobstructed in space); can extend another 500 feet using repeater (which works like microwave repeater tower that receives and resends telephone calls)	70-600 feet	Line-of-sight up to 5 miles; office building: 800 feet; dense building: 500 feet	Open environment: 800 feet; semi-closed environment: 250 feet; closed environment: 100 feet
Transmit Power	20 mW	25 mW	1 watt, peak	250 mW
Signaling Rate	38,400 bps	1M bps	250K bps	2M bps
Pricing	$499 per transceiver	4 Macintosh transmitter/receivers: $1,195; Infrared Transceiver: $20 (OEM qty.)	Not available	Network interface card including Novell drivers and omnidirectional antenna: $1,390; DES (Data Encryption Standard) security feature: $90
FCC License	Not required	Not required but has Class A FCC certification	Not required (FCC Part 15.247)	Not required
Strengths	Inexpensive; 1-year warranty	Potential speed to 10M bps; secure; easy to install	Secure; easy to install	Fully compatible with Industry Standard Architecture (ISA); DES encryption socket allows for enhanced security; transmission not blocked by office partitions (except thick concrete or metal); can be connected to wired network via single PC on wired network
Limitations	Incompatible with NetWare and other LANS; can communicate with only one other network at same time	Supports only LocalTalk; relatively low speed; affected by weather; requires direct line of sight to operate	Speed constraints; interference possibilities	Relatively slow speed; signal may interfere with other spread-spectrum devices

Vendors

Listed here, for your convenience, are the addresses and telephone numbers of the vendors whose products are listed in Table 1.

BICC Technologies
1800 W. Park Drive
Westborough, MA 01581 (508) 898-2422

California Microwave, Inc.
985 Almanor Avenue
Sunnyvale, CA 94086 (408) 732-4000

Carrier Current Technologies Inc.
6505 Pharr Mill Road
Harrisburg, NC 29075 (800) 835-2402

Motorola, Inc.
3209 Wile Road
Arlington Heights, IL 60004 (800) 233-0877

NCR Corp.
1700 S. Patterson Blvd.
Dayton, OH 45479 (513) 445-5000

O'Neill Communications, Inc.
8601 Six Forks Road
Raleigh, NC 27615 (800) 624-5296

Photonics Corp.
200 E. Hacienda Avenue
Campbell, CA 95008 (408) 370-3033

Telesystems SLW, Inc.
85 Scarsdale Road, Suite 201
Don Mills, ON, Canada M3B 2R2 (416) 441-9966 ■