What is a Wireless LAN?

White Paper

Introduction

A wireless local area network (LAN) is a flexible data communications system implemented as an extension to, or as an alternative for, a wired LAN. Using radio frequency (RF) technology, wireless LANs transmit and receive data over the air, minimizing the need for wired connections. Thus, wireless LANs combine data connectivity with user mobility.

Wireless LANs have gained strong popularity in a number of vertical markets, including the health-care, retail, manufacturing, warehousing, and academia. These industries have profited from the productivity gains of using hand-held terminals and notebook computers to transmit real-time information to centralized hosts for processing. Today wireless LANs are becoming more widely recognized as a general-purpose connectivity alternative for a broad range of business customers. Business Research Group, a market research firm, predicts a sixfold expansion of the worldwide wireless LAN market by the year 2000, reaching more than $2 billion in revenues.

Why wireless?

The widespread reliance on networking in business and the meteoric growth of the Internet and online services are strong testimonies to the benefits of shared data and shared resources. With wireless LANs, users can access shared information without looking for a place to plug in, and network managers can set up or augment networks without installing or moving wires. Wireless LANs offer the following productivity, convenience, and cost advantages over traditional wired networks:

- *Mobility: Wireless LAN systems can provide LAN users with access to real-time information anywhere in their organization. This mobility supports productivity and service opportunities not possible with wired networks.*
- *Installation Speed and Simplicity: Installing a wireless LAN system can be fast and easy and can eliminate the need to pull cable through walls and ceilings.*
- *Installation Flexibility: Wireless technology allows the network to go where wire cannot go.*
- *Reduced Cost-of-Ownership: While the initial investment required for wireless LAN hardware can be higher than the cost of wired LAN hardware, overall installation expenses and life-cycle costs can be significantly lower. Long-term cost benefits are greatest in dynamic environments requiring frequent moves and changes.*
- *Scalability: Wireless LAN systems can be configured in a variety of topologies to meet the needs of specific applications and installations. Configurations are easily changed and range from peer-to-peer networks suitable for a small number of users to full infrastructure networks of thousands of users that enable roaming over a broad area.*

How wireless LANs are used in the real world

Wireless LANs frequently augment rather than replace wired LAN networks-often providing the final few meters of connectivity between a wired network and the mobile user. The following list describes some of the many applications made possible through the power and flexibility of wireless LANs:

- *Doctors and nurses in hospitals are more productive because hand-held or notebook computers with wireless LAN capability deliver patient information instantly.*
- *Consulting or accounting audit teams or small workgroups increase productivity with quick network setup.*
- *Students holding class on a campus greensward access the Internet to consult the catalog of the Library of Congress.*
- *Network managers in dynamic environments minimize the overhead caused by moves, extensions to networks, and other changes with wireless LANs.*
- *Training sites at corporations and students at universities use wireless connectivity to ease access to information, information exchanges, and learning.*
- *Network managers installing networked computers in older buildings find that wireless LANs are a cost-effective network infrastructure solution.*

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- *Trade show and branch office workers minimize setup requirements by installing pre-configured wireless LANs needing no local MIS support.*
- *Warehouse workers use wireless LANs to exchange information with central databases, thereby increasing productivity.*
- *Network managers implement wireless LANs to provide backup for mission-critical applications running on wired networks.*
- *Senior executives in meetings make quicker decisions because they have real-time information at their fingertips.*

Wireless LAN Technology

Manufacturers of wireless LANs have a range of technologies to choose from when designing a wireless LAN solution. Each technology comes with its own set of advantages and limitations.

Narrowband Technology

A narrowband radio system transmits and receives user information on a specific radio frequency. Narrowband radio keeps the radio signal frequency as narrow as possible just to pass the information. Undesirable crosstalk between communications channels is avoided by carefully coordinating different users on different channel frequencies.

A private telephone line is much like a radio frequency. When each home in a neighborhood has its own private telephone line, people in one home cannot listen to calls made to other homes. In a radio system, privacy and noninterference are accomplished by the use of separate radio frequencies. The radio receiver filters out all radio signals except the ones on its designated frequency.

From a customer standpoint, one drawback of narrowband technology is that the end-user must obtain an FCC license for each site where it is employed.

Spread Spectrum Technology

Most wireless LAN systems use spread-spectrum technology, a wideband radio frequency technique developed by the military for use in reliable, secure, mission-critical communications systems. Spread-spectrum is designed to trade off bandwidth efficiency for reliability, integrity, and security. In other words, more bandwidth is consumed than in the case of narrowband transmission, but the tradeoff produces a signal that is, in effect, louder and thus easier to detect, provided that the receiver knows the parameters of the spread-spectrum signal being broadcast. If a receiver is not tuned to the right frequency, a spread-spectrum signal looks like background noise. There are two types of spread spectrum radio: frequency hopping and direct sequence.

Frequency-Hopping Spread Spectrum Technology

Frequency-hopping spread-spectrum (FHSS) uses a narrowband carrier that changes frequency in a pattern known to both transmitter and receiver. Properly synchronized, the net effect is to maintain a single logical channel. To an unintended receiver, FHSS appears to be short-duration impulse noise.

Direct-Sequence Spread Spectrum Technology

Direct-sequence spread-spectrum (DSSS) generates a redundant bit pattern for each bit to be transmitted. This bit pattern is called a chip (or chipping code). The longer the chip, the greater the probability that the original data can be recovered (and, of course, the more bandwidth required). Even if one or more bits in the chip are damaged during transmission, statistical techniques embedded in the radio can recover the original data without the need for retransmission. To an unintended receiver, DSSS appears as low-power wideband noise and is rejected (ignored) by most narrowband receivers.

Infrared Technology

A third technology, little used in commercial wireless LANs, is infrared. Infrared (IR) systems use very high frequencies, just below visible light in the electromagnetic spectrum, to carry data. Like light, IR cannot penetrate opaque objects; it is either directed (line-of-sight) or diffuse technology. Inexpensive directed systems provide very limited range (3 ft) and typically are used for personal area networks but occasionally are used in specific wireless LAN applications. High performance directed IR is impractical for mobile users and is therefore used only to implement fixed sub-networks. Diffuse (or reflective) IR wireless LAN systems do not require line-of-sight, but cells are limited to individual rooms.

How wireless LANs Work

Wireless LANs use electromagnetic airwaves (radio or infrared) to communicate information from one point to another without relying on any physical connection. Radio waves are often referred to as radio carriers because they simply perform the function of delivering energy to a remote receiver. The data being transmitted is superimposed on the radio carrier so that it can be accurately extracted at the receiving end. This is generally referred to as modulation of the carrier by the information being transmitted. Once data is superimposed (modulated) onto the radio carrier, the radio signal occupies more than a single frequency, since the frequency or bit rate of the modulating information adds to the carrier.

Multiple radio carriers can exist in the same space at the same time without interfering with each other if the radio waves are transmitted on different radio frequencies. To extract data, a radio receiver tunes in one radio frequency while rejecting all other frequencies.

In a typical wireless LAN configuration, a transmitter/receiver (transceiver) device, called an access point, connects to the wired network from a fixed location using standard cabling. At a minimum, the access point receives, buffers, and transmits data between the wireless LAN and the wired network infrastructure. A single access point can support a small group of users and can function within a range of less than one hundred to several hundred feet. The access point (or the antenna attached to the access point) is usually mounted high but may be mounted essentially anywhere that is practical as long as the desired radio coverage is obtained.

End users access the wireless LAN through wireless-LAN adapters, which are implemented as PC cards in notebook or palmtop computers, as cards in desktop computers, or integrated within hand-held computers. wireless LAN adapters provide an interface between the client network operating system (NOS) and the airwaves via an antenna. The nature of the wireless connection is transparent to the NOS.

Wireless LAN configurations

Wireless LANs can be simple or complex. At its most basic, two PCs equipped with wireless adapter cards can set up an independent network whenever they are within range of one another. This is called a peer-to-peer network. On-demand networks such as in this example require no administration or preconfiguration. In this case each client would only have access to the resources of the other client and not to a central server.

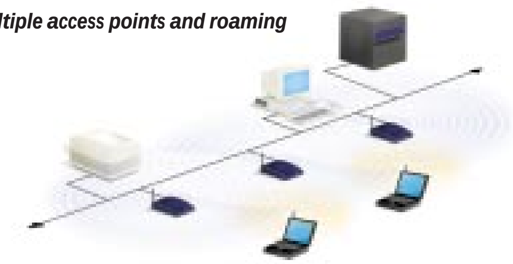
A wireless peer-to-peer network

Installing an access point can extend the range of an ad hoc network, effectively doubling the range at which the devices can communicate. Since the access point is connected to the wired network each client would have access to server resources as well as to other clients. Each access point can accommodate many clients; the specific number depends on the number and nature of the transmissions involved. Many real-world applications exist where a single access point services from 15-50 client devices.

Clients and Access Points

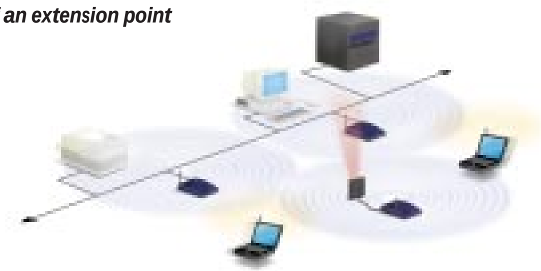
Access points have a finite range, on the order of 500 feet indoor and 1000 feet outdoors. In a very large facility such as a warehouse, or on a college campus it will probably be necessary to install more than one access point. Access point positioning is accomplished by means of a site survey. The goal is to blanket the coverage area with overlapping coverage cells so that clients might range throughout the area without ever losing network contact. The ability of clients to move seamlessly among a cluster of access points is called roaming. Access points hand the client off from one to another in a way that is invisible to the client, ensuring unbroken connectivity.

Multiple access points and roaming



To solve particular problems of topology, the network designer might choose to use Extension Points to augment the network of access points. Extension Points look and function like access points, but they are not tethered to the wired network as are APs. EPs function just as their name implies: they extend the range of the network by relaying signals from a client to an AP or another EP. EPs may be strung together in order to pass along messaging from an AP to far-flung clients, just as humans in a bucket brigade pass pails of water hand-to-hand from a water source to a fire.

Use of an extension point



One last item of wireless LAN equipment to consider is the directional antenna. Let's suppose you had a wireless LAN in your building A and wanted to extend it to a leased building, B, one mile away. One solution might be to install a directional antenna on each building, each antenna targeting the other. The antenna on A is connected to your wired network via an access point. The antenna on B is similarly connected to an access point in that building, which enables wireless LAN connectivity in that facility.

The use of directional antennas

Customer Considerations

While wireless LANs provide installation and configuration flexibility and the freedom inherent in network mobility, customers should be aware of the following factors when considering wireless LAN systems.

Range and coverage

The distance over which RF and IR waves can communicate is a function of product design (including transmitted power and receiver design) and the propagation path, especially in indoor environments. Interactions with typical building objects, including walls, metal, and even people, can affect how energy propagates, and thus what range and coverage a particular system achieves. Solid objects block infrared signals, which imposes additional limitations. Most wireless LAN systems use RF because radio waves can penetrate most indoor walls and obstacles. The range (or radius of coverage) for typical wireless LAN systems varies from under 100 feet to more than 300 feet. Coverage can be extended, and true freedom of mobility via roaming, provided through microcells.

Throughput

As with wired LAN systems, actual throughput in wireless LANs is product- and set-up-dependent. Factors that affect throughput include the number of users, propagation factors such as range and multipath, the type of wireless LAN system used, as well as the latency and bottlenecks on the wired portions of the LAN. Data rates for the most widespread commercial wireless LANs are in the 1.6 Mbps range. Users of traditional Ethernet or Token Ring LANs generally experience little difference in performance when using a wireless LAN. Wireless LANs provide throughput sufficient for the most common LAN-based office applications, including electronic mail exchange, access to shared peripherals, Internet access, and access to multi-user databases and applications.

As a point of comparison, it is worth noting that state-of-the-art V.90 modems transmit and receive at optimal data rates of 56.6 Kbps. In terms of throughput, a wireless LAN operating at 1.6 Mbps is almost thirty times faster.

Integrity and reliability

Wireless data technologies have been proven through more than fifty years of wireless application in both commercial and military systems. While radio interference can cause degradation in throughput, such interference is rare in the workplace. Robust designs of proven wireless LAN technology and the limited distance over which signals travel result in connections that are far more robust than cellular phone connections and provide data integrity performance equal to or better than wired networking.

Compatibility with the existing network

Most wireless LANs provide for industry-standard interconnection with wired networks such as Ethernet or Token Ring. Wireless LAN nodes are supported by network operating systems in the same fashion as any other LAN node: thought the use of the appropriate drivers. Once installed, the network treats wireless nodes like any other network component.

Interoperability of wireless devices

Customers should be aware that wireless LAN systems from different vendors might not be interoperable. For three reasons. First, different technologies will not interoperate. A system based on spread spectrum frequency hopping (FHSS) technology will not communicate with another based on spread spectrum direct sequence (DSSS) technology. Second, systems using different frequency bands will not interoperate even if they both employ the same technology. Third, systems from different vendors may not interoperate even if they both employ the same technology and the same frequency band, due to differences in implementation by each vendor.

Interference and Coexistence

The unlicensed nature of radio-based wireless LANs means that other products that transmit energy in the same frequency spectrum can potentially provide some measure of interference to a wireless LAN system. Microwave ovens are a potential concern, but most wireless LAN manufacturers design their products to account for microwave interference. Another concern is the co-location of multiple wireless LANs. While wireless LANs from some manufacturers interfere with wireless LANs, others coexist without interference. This issue is best addressed directly with the appropriate vendors.

Licensing issues

In the United States, the Federal Communications Commission (FCC) governs radio transmissions, including those employed in wireless LANs. Other nations have corresponding regulatory agencies. Wireless LANs are typically designed to operate in portions of the radio spectrum where the FCC does not require the end-user to purchase license to use the airwaves. In the U.S. most wireless LANs broadcast over one of the ISM (Instrumentation, Scientific, and Medical) bands. These include 902-928 MHz, 2.4-2.483 GHz, 5.15-5.35 GHz, and 5.725-5.875 GHz. For wireless LANs to be sold in a particular country, the manufacturer of the wireless LAN must ensure its certification by the appropriate agency in that country.

Simplicity/Ease of Use

Users need very little new information to take advantage of wireless LANs. Because the wireless nature of a wireless LAN is transparent to a user's NOS, applications work the same as they do on wired LANs. Wireless LAN products incorporate a variety of diagnostic tools to address issues associated with the wireless elements of the system; however, products are designed so that most users rarely need these tools.

Wireless LANs simplify many of the installation and configuration issues that plague network managers. Since only the access points of wireless LANs require cabling, network managers are freed from pulling cables for wireless LAN end users. Lack of cabling also makes moves, adds, and changes trivial operations on wireless LANs. Finally, the portable nature of wireless LANs lets network managers preconfigure and troubleshoot entire networks before installing them at remote locations. Once configured, wireless LANs can be moved from place to place with little or no modification.

Security

Because wireless technology has roots in military applications, security has long been a design criterion for wireless devices. Security provisions are typically built into wireless LANs, making them more secure than most wired LANs. It is extremely difficult for unintended receivers (eavesdroppers) to listen in on wireless LAN traffic. Complex encryption techniques make it impossible for all but the most sophisticated to gain unauthorized access to network traffic. In general, individual nodes must be security-enabled before they are allowed to participate in network traffic.

Cost

A wireless LAN implementation includes both infrastructure costs, for the wireless access points, and user costs, for the wireless LAN adapters. Infrastructure costs depend primarily on the number of access points deployed; access points range in price from $1,000 to $2000. The number of access points typically depends on the required coverage region and/or the number and type of users to be serviced. The coverage area is proportional to the square of the product range. Wireless LAN adapters are required for standard computer platforms, and range in price from $300 to $1,000.

The cost of installing and maintaining a wireless LAN generally is lower than the cost of installing and maintaining a traditional wired LAN, for two reasons. First, a wireless LAN eliminates the direct costs of cabling and the labor associated with installing and repairing it. Second, because wireless LANs simplify moves, adds, and changes, they reduce the indirect costs of user downtime and administrative overhead.

Scalability

Wireless networks can be designed to be extremely simple or quite complex. Wireless networks can support large numbers of nodes and/or large physical areas by adding access points to boost or extend coverage.

Battery Life for Mobile Platforms

End-user wireless products are designed to run off the AC or battery power from their host notebook or hand-held computer, since they have no direct wire connectivity of their own. wireless LAN vendors typically employ special design techniques to maximize the host computer's energy usage and battery life.

Safety

The output power of wireless LAN systems is very low, much less than that of a hand-held cellular phone. Since radio waves fade rapidly over distance, very little exposure to RF energy is provided to those in the area of a wireless LAN system. Wireless LANs must meet stringent government and industry regulations for safety. No adverse health affects have ever been attributed to wireless LANs.

Summary

Flexibility and mobility make wireless LANs both effective extensions and attractive alternatives to wired networks. Wireless LANs provide all the functionality of wired LANs, without the physical constraints of the wire itself. Wireless LAN configurations range from simple peer-to-peer topologies to complex networks offering distributed data connectivity and roaming. Besides offering end-user mobility within a networked environment, wireless LANs enable portable networks, allowing LANs to move with the knowledge workers that use them.

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