LINKSYS®

November, 2000

Exploring Wireless Technologies

Benefits of Wireless LANs

The widespread strategic reliance on networking among competitive businesses 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, service, 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, adds, 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 allows roaming over a broad area.

Wireless Technologies Overview

The keystone to a wireless LAN is the cell. The cell is the area where all wireless communication takes place. In general a cell covers a more-or-less circular area. Within each cell there are radio traffic management units also known as Access Points (repeaters). The Access Point in turn interconnects cells of a wireless LAN and also connects to a wired Ethernet LAN through some sort of cable connection.

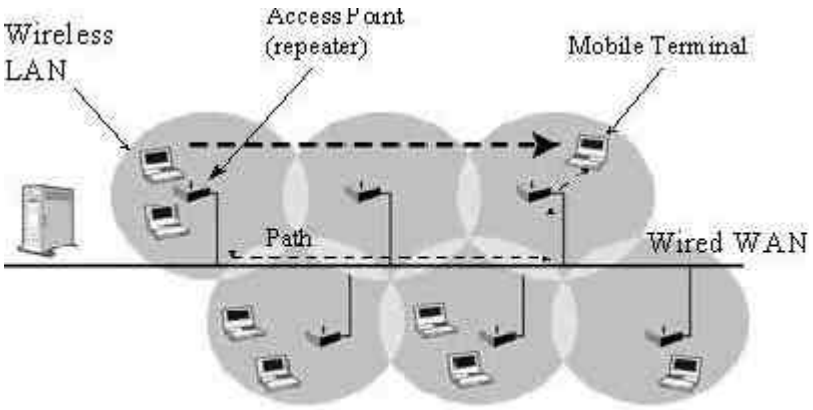


Fig. 1 Configuration of Wireless LAN

The number of wireless stations per cell is dependent on the amount of data traffic (and the type of data traffic). Each cell can carry anywhere from 50 to 200 stations depending on how busy the cell is. To allow continuous communication between cells, individual cells overlap. Cells can also be used in a stand-alone environment to accommodate traffic needs for a small to medium sized LAN between workstations and/or workgroups. A stand-alone cell would require no cabling.

Another option is **wired bridging**. In a wired bridging configuration each access point is wired to the backbone of a wired Ethernet LAN (see figure 1). Once connected to a wired LAN, network management functions of the wired and the wireless LANs can be controlled. **Wireless bridging** is also an option which allows cells to be connected to remote wireless LANs. In this situation networking can stretch for miles if it were linked successively and effectively from access point to access point.

Finally by connecting several Access Points to external directional antennas instead of their built-in omni-directional antennas access points can provide multi-cells. This is useful for areas of heavy network traffic since with this configuration they are able to automatically "choose" the best Access Point to communicate with. Roaming can also be provided for portable stations. Roaming is seamless, and it allows a work session to be maintained when moving from a cell to a cell (there is a momentary break in data flow).

Wireless LAN Technology Options

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.

Spread Spectrum
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.

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.

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. Figure 2 provides an example of how FHSS works.

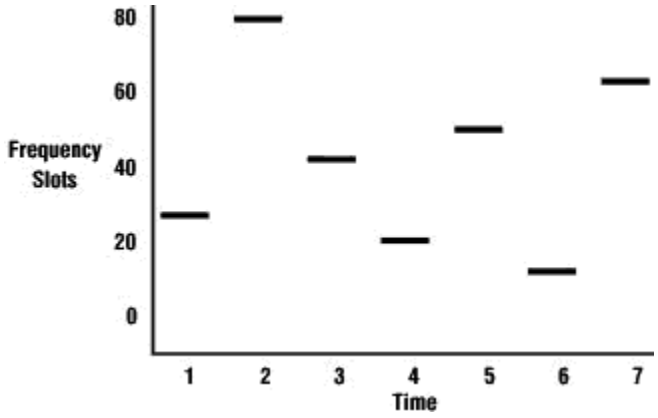


Figure 2. Frequency Hopping Spread Spectrum

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. Figure 3 provides an overview of how this technology works.

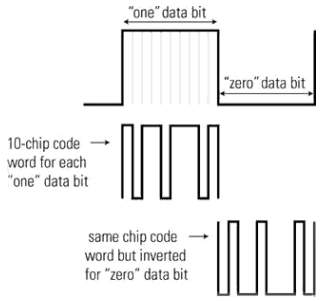
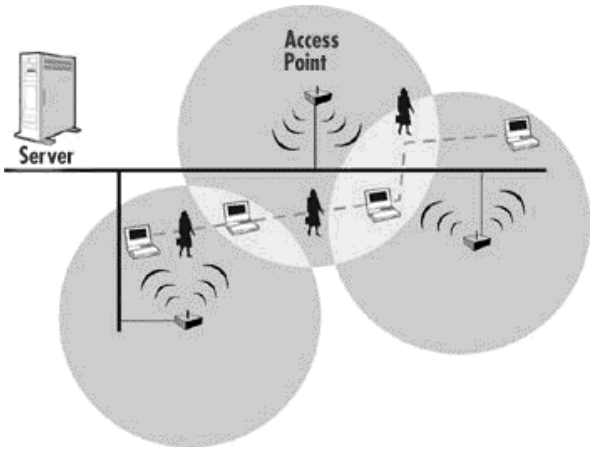


Figure 3: How Direct-Sequence Spread Spectrum Technology

Infrared Technology
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 PANs but occasionally are used in specific WLAN applications. High performance directed IR is impractical for mobile users and is therefore used only to implement fixed subnetworks. Diffuse (or reflective) IR WLAN systems do not require line-of-sight, but cells are limited to individual rooms.

Microcells and Roaming
Wireless communication is limited by how far signals carry for given power output. WLANs use cells, called microcells, similar to the cellular telephone system to extend the range of wireless connectivity. At any point in time, a mobile PC equipped with a WLAN adapter is associated with a single access point and its microcell, or area of coverage. Individual microcells overlap to allow continuous communication within wired network. They handle low-power signals and "hand off" users as they roam through a given geographic area.

Figure 4. Handing off the WLAN Connection Between Access Points



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.

Figure 5: 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.

Figure 6: Client and Access Point

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.

Figure 7: 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.

Figure 8: 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.

Figure 9: The use of directional antennas

Exploring the Linksys Wireless Products

WAP11 - Instant Wireless Network Access Point

Features

- High-Speed Transfer Rate of Up to 11 Mbps
- Interoperable with IEEE 802.11b (DSSS) 2.4GHz-compliant Equipment
- Provides Roaming, Best Access Point Selection, Load Balancing, and Network Traffic Filtering
- Supports up to 32 users/nodes
- Long Operating Range Supports 120m (indoor) and 300m (outdoor)
- Advanced Power Management Features Conserve Valuable Battery Life
- Hardware Wireless Encryption Protocol
- Compatible with Windows 95, 98, 2000, NT v.4 and Millennium
- Technical Support - 24 Hours a Day, 7 Days a Week
- Full 1-Year Warranty

Specs

1. Standards IEEE 802.3 (wired), IEEE 802.11b (wireless)
2. Channels
    i. 11 Channels (US, Canada)
    ii. 13 Channels (Europe)
    iii. 14 Channels (Japan)
3. Ports One 10BaseT/100BaseTX RJ-45 Port
4. Cabling Type
    i. 10BaseT: UTP/STP Category 3 or 5
    ii. 100BaseTX: UTP/STP Category 5 or Better
5. Operating Range
    i. Indoor:
        - 50M (164 ft.) @ 11 Mbps
        - 80M (262 ft.) @ 5.5 Mbps
        - 120M (393 ft.) @ 2 Mbps,
        - 150M (492 ft.) @ 1 Mpbs

    ii. Outdoor:
        - 250M (820 ft.) @ 11 Mbps
        - 350M (1148 ft.) @ 5.5 Mbps
        - 400M (1312 ft.) @ 2 Mbps
        - 500M (1640 ft.) @ 1 Mbps
6. Data Rate up to 11Mbps
7. LEDs Power, Ethernet (Wired - Link/Activity)

WDT11 - Instant Wireless PCI Adapter

Features

When combined with the Network PC Card (WPC11):

- 11 Mbps High-Speed Transfer Rate
- Compatible with Windows 95, 98, 2000, NT and Millennium
- Plug-and-Play Operation Provides Easy Setup
- Works with All Standard Internet Applications
- Utilizes Intersil HFA3841/HFA3842 chip sets
- Interoperable with IEEE 802.11b (DSSS) 2.4GHz-compliant Equipment
- 40-Bit WEP Encryption Protocol
- Free Driver Upgrades
- Free Technical Support—24 Hours a Day, 7 Days a Week for North America Only
- 1-Year Limited Warranty

Specs

8. Model No.: WDT11
9. Standards:
   i. PC97/98/99 SUPPORT
   ii. PCI Local Bus 2.1 compliant
   iii. PC Card-16 bit Standard Specification
10. Channels*:
   i. 11 Channels (US, Canada)
   ii. 13 Channels (Europe)
   iii. 14 Channels (Japan)
11. Operating Range*:
   i. Indoor:
      - 50M (164 ft.) @ 11 Mbps
      - 80M (262 ft.) @ 5.5 Mbps
      - 120M (393 ft.) @ 2 Mbps
      - 150M (492 ft.) @ 1 Mpbs
   ii. Outdoor:
      - 250M (820 ft.) @ 11 Mbps
      - 350M (1148 ft.) @ 5.5 Mbps
      - 400M (1312 ft.) @ 2 Mbps
      - 500M (1640 ft.) @ 1 Mbps
12. Card Type: 32-bit PCI

WPC11 - Instant Wireless Network PC Card

Features

- 11 Mbps High-Speed Transfer Rate
- Compatible with Windows 95, 98, 2000, NT and Millennium
- Plug-and-Play Operation Provides Easy Set Up
- Advanced Power Management Features Conserve Valuable Notebook PC Battery Life
- Rugged Metal Design with Integrated Antenna
- Works with All Standard Internet Applications
- Utilizes Intersil HFA3841/HFA3842 chip sets
- Interoperable with IEEE 802.11b (DSSS) 2.4GHz-compliant Equipment
- 40-Bit WEP Encryption Protocol
- Free Technical Support - 24 Hours a Day, 7 Days a Week for North America Only
- Full 1-Year Warranty

Specs

13. Standards IEEE 802.11b
14. Channels
    i. 11 Channels (US, Canada)
    ii. 13 Channels (Europe)
    iii. 14 Channels (Japan)
15. Operating Range
    i. Indoor:
        - 50M (164 ft.) @ 11 Mbps
        - 80M (262 ft.) @ 5.5 Mbps
        - 120M (393 ft.) @ 2 Mbps
        - 150M (492 ft.) @ 1 Mpbs
    ii. Outdoor:
        - 250M (820 ft.) @ 11 Mbps
        - 350M (1148 ft.) @ 5.5 Mbps
        - 400M (1312 ft.) @ 2 Mbps
        - 500M (1640 ft.) @ 1 Mbps
16. Data Rate up to 11Mbps (with automatic scale back)
17. LEDs Power, Tx/Rx
18. Card Type PCMCIA Type II

Glossary

Access Point – Linksys' wireless-based device for connecting roaming wireless PC cards directly to the Internet. The Access Point is a device that provides the benefits of roaming and mobility from a stationary Internet connection.
ADSL—Asymmetric DSL. A DSL technology providing asymmetrical bandwidth over a single wire pair. The downstream bandwidth going from the network to the subscriber is typically greater than the upstream bandwidth going from the subscriber to the network.
ATM—Asynchronous Transfer Mode.Under ATM, multiple traffic types (such as voice, video, or data) are conveyed in fixed-length cells (rather than the random-length "packets" moved by technologies such as Ethernet and Fiber Distributed Data Interface [FDDI]). This enables very high speeds, making ATM popular for demanding network backbones. With networking equipment that has recently become available, ATM will also support WAN transmissions. This feature makes ATM valuable for large, dispersed organizations.
Backbone—The part of a network that acts as the primary path for traffic moving between, rather than within, networks.
Bandwidth—The "data-carrying" capacity of a network connection, used as an indication of speed. For example, an Ethernet link is capable of moving 10 million bits of data per second. A Fast Ethernet link can move 100 million bits of data per second—10 times more bandwidth.
Bridge—A device that passes packets between multiple network segments using the same communications protocol. If a packet is destined for a user within the sender's own network segment, the bridge keeps the packet local. If the packet is bound for another segment, the bridge passes the packet onto the network backbone.
Cable modem – A class of modem that is used for connecting to a cable TV network, which in turns connects directly to the Internet. Cable-modem based connections to the Internet are typically much faster than dial-up modems, yet have the issue of security, as a cable-based network is comparable to a closed network.
Client—A networked PC or terminal that shares "services" with other PCs. These services are stored on or administered by a server.
Digital Subscriber Line – A digital phone services that provides for voice, video and digital data over existing phone systems at higher speeds than are available in typical dial-up Internet sessions.
DSL modem – A modem that connects a PC to a DSK network, which in turn connects to the Internet.
DSL—digital subscriber line. A public network technology that delivers high bandwidth over conventional copper wiring at limited distances. There are four types of DSL: ADSL, HDSL, SDSL, and VDSL. All are provisioned via modem pairs, with one modem located at a central office and the other at the customer site. Because most DSL technologies do not use the whole bandwidth of the twisted pair, there is room remaining for a voice channel.
Ethernet—A popular LAN technology that uses CSMA/CD (collision detection) to move packets between workstations and runs over a variety of cable types at 10 Mbps. Also called 10BASE-T.

Extranet—A network that provides external users (such as suppliers, independent sales agents, and dealers) access to company documents such as price lists, inventory reports, shipping schedules, and more.
Fast Ethernet—Uses the same transmission method as 10-Mbps Ethernet (collision detection) but operates at 100 Mbps- 10 times faster. Fast Ethernet provides a smooth upgrade path for increasing performance in congested Ethernet networks, because it uses the same cabling, applications, and network management tools. Variations include 100BASE-FX, 100BASE-T4, and 100BASE-TX.
FDDI—Fiber Distributed Data Interface, a LAN technology based on a 100- Mbps token-passing network running over fiber-optic cable. Usually reserved for network backbones in larger organizations.
Frame Relay—Wide-area network service that provides switched ("on-and-off") connections between distant locations.
FTP—File Transfer Protocol, a part of the chief Internet protocol "stack" or group (TCP/IP), used for transferring files from Internet servers to your computer.
Gigabit Ethernet—The latest version of Ethernet. It offers 1000-Mbps (1-gigabit per second [Gbps]) raw bandwidth, that is 100 times faster than the original Ethernet, yet is compatible with existing Ethernets, because it uses the same CSMA/ CD and Media Access Control (MAC) protocols. Gigabit Ethernet competes most directly with ATM and is forcing out FDDI and Token Ring.
Home Phoneline Networking Alliance (HomePNA) – An organization that works to ensure that all products sold into the home networking marketplace adopt a single, unified phoneline networking standard. This is specifically done to bring a unified set of interoperable home networking solutions to the marketplace. Linksys is a member of the HomePNA association.
HTML—Hypertext Markup Language, a simple document formatting language used for preparing documents to be viewed by a tool such as a worldwide Web browser.
HTTP—Hypertext Transfer Protocol, a protocol that governs transmission of formatted documents over the Internet.
Hub – A networking device that enables attached devices to receive data streams that are transmitted over a network. This device also makes it possible for devices to share the network bandwidth available on a network.
Hub—A device that interconnects clients and servers, repeating (or amplifying) the signals between them. Hubs act as wiring "concentrators" in networks based on star topologies (rather than bus topologies, in which computers are daisy- chained together).
IDSL—ISDN digital subscriber line, a DSL technology that is basically a naming convention for an ISDN Basic Rate Interface (BRI), both B channels and the D channels permanently bonded for 144 kbps over a single wire pair. ISDN digital subscriber line (IDSL) uses 2B1Q line coding.
Internet—A massive global network, interconnecting tens of thousands of computers and networks worldwide and accessible from any computer with a modem or router connection and the appropriate software.
Intranet—An internal network that takes advantage of some of the same tools popularized on the Internet (browsers for viewing material, HTML for preparing company directories or announcements, and so on).
IP telephony—IP telephony combines different types of communications-such as data, voice, and video-over a single packet cell-based infrastructure. IP telephony extends the value of the