



CISCO NETWORKING ESSENTIALS

FOR EDUCATIONAL INSTITUTIONS

Table of Contents

WHAT THIS GUIDE CAN DO FOR YOU	2	Margin Note: The Universal Service Fund, or E-Rate	13
The Building Blocks: Basic Components of Networks	3	Margin Note: Fund-Raising for Networking Projects	13
Clients and Servers	3	Margin Note: Remote Access Servers	13
Wiring and Cable	4	Which Service Is Right for You?	14
Network Interface Cards	4		
Hubs	5	Education Networking Examples	15
Access Points	5	Small School Local-Area Network	15
Margin Note: Network Management	5	As the Campus Network Grows	16
Margin Note: Modems	5	A Wide-Area Network for a Small District	17
Margin Note: Cable Modems	5	A Community College WAN	17
Switches	6		
Routers	6	Making the Right Connection: Network How-Tos	18
IP Telephony	7	How to Connect to the Internet	18
Margin Note: Uninterruptible Power Supplies	7	How to Choose an Internet Service Provider	20
Margin Note: Bridges	7	How to Create Your Own Web Site	21
		Margin Note: Security	21
Networking Technologies Overview	8		
Ethernet, Fast Ethernet, Gigabit Ethernet, and Wireless	8	Basic Network Design: Considerations	22
Remote Access and Wide-Area Networks	10	A Problem Solvers' Guide to Relieving Congestion	22
Analog Lines	10	How to Spot Network Congestion	22
Margin Note: Token Ring	10	Good Network Design: The 80-20 Rule	24
Margin Note: High-Speed LAN Technologies	10	Giving Your Network a Performance Boost	25
ISDN	11	Dedicated Bandwidth to Workgroups and Servers	26
Margin Note: Analog vs. Digital	11	Margin Note: Types of Ethernet Traffic	26
DSL	12	Making the Most of Your Existing Equipment	
Cable Modem	12	as Your Network Evolves	27
Margin Note: Modems vs. Routers	12		
Leased Lines	13	Networking Basics Checklist	28
		For Building a Small LAN	28
		For Connecting Buildings on a Campus	28
		For Connecting to Another Campus or District	29
		For Wireless Networking	29
		Margin Note: Training and Support	29
		GLOSSARY	30
		Who Is Cisco Systems?	32



What This Guide **Can Do for You**

Most people wouldn't use the terms "networking" and "basic" in the same sentence. However, while the underlying principles of networking are somewhat complex, building a network can be very simple given the right tools and a basic understanding of how they work together.

With networks, starting small and planning to grow makes perfect sense. Even a modest network can pay large dividends by saving time; improving communication between faculty, students, and parents; increasing productivity; and opening new paths to learning resources located anywhere in the world. In this respect, networks are like cars. You don't have to know the details about how the engine works to be able to get where you need to go.

As a result, this guide does not attempt to make you a networking expert. Instead, it has been carefully designed to help you:

- Understand the primary building blocks of networks and the role each one plays
- Understand the most popular networking technologies or methods of moving your data from place to place
- Determine which approach to networking and which technologies are best for your campus or district campus

Throughout "Cisco Networking Essentials for Educational Institutions", you will find Margin Notes—helpful sidelights on subjects related to the main concepts in each section.

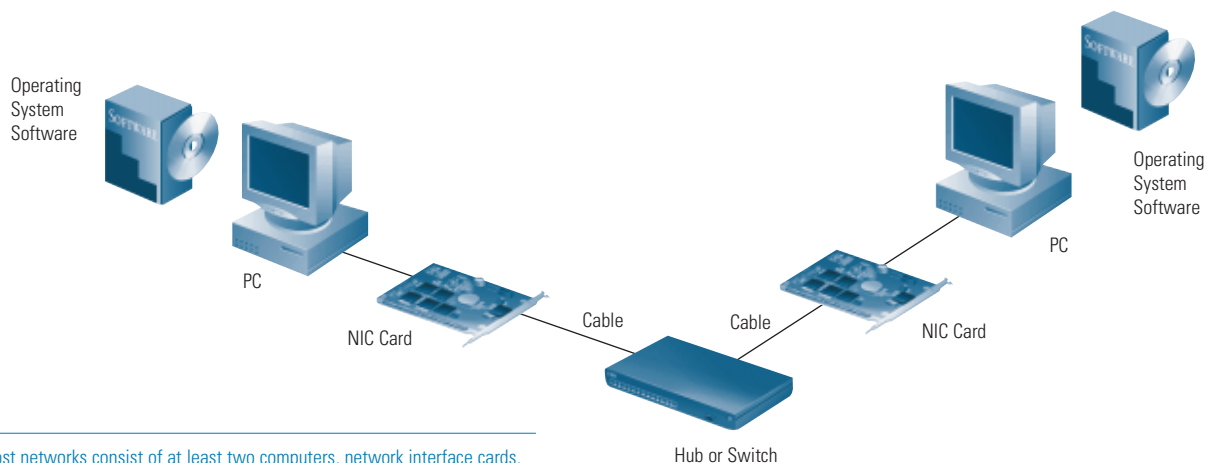
Terms highlighted in color may be found in the glossary in back.



The Building Blocks: Basic Components of Networks

There are as many definitions for the term “network” as there are networks. However, most people would agree that networks are collections of two or more connected computers. When their computers are joined in a network, people can share files and peripherals such as modems, printers, tape backup drives, and CD-ROM drives. When networks at multiple locations are connected using services available from Internet service providers such as phone, cable, and other access companies, people can send e-mail, share links to the global *Internet*, or conduct video-conferences in real time with other remote users on the network. Modern networks can also provide connections for telephones, fax machines and a wide variety of Internet-enabled devices.

Basic Networking Components



Most networks consist of at least two computers, network interface cards, cabling, network operating system software, and a hub or a switch.

CLIENTS AND SERVERS

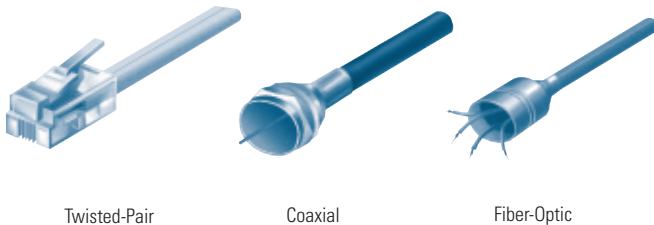
Often, as a network grows and more computers are added, one computer will act as a *server*—a central storage point for files or application programs shared on the network. Servers also provide connections to shared peripherals such as printers. Setting up one computer as a server prevents you from having to outfit every networked computer with extensive storage capability and duplicate costly peripherals. The computers that connect to the server are called *clients*.

Every network includes:

- At least two computers
- A network interface on each computer (the device that lets the computer talk to the network—usually called a network interface card [NIC] or adapter)
- A connection medium—usually a wire or cable, but wireless communication between networked computers and peripherals is also available
- Network operating system software—such as Microsoft Windows 95, 98, 2000 or Windows NT, and Novell NetWare

Most networks—even those with just two computers—also have a *hub* or a *switch* to act as a connection point between the computers.

WIRING AND CABLE



Networks use three primary types of wiring (also referred to as “media”):

Twisted-pair—This wire comes in several “standards.” Unshielded twisted pair (UTP) Category 3 wire is often used for your phone lines, and UTP Category 5 wire is the current networking standard.

Coaxial—Coaxial cable is less expensive than fiber-optic cable, is well known, and has been used for many years for all types of data communication and is still being used for TV cable. Coaxial cable consists of an insulated single inner wire made of two conducting elements (one being copper) surrounded by a hollow outer cylindrical conductor (comprising half the electrical circuit and shielding the inner wire). Covering this shield is the cable jacket. Coaxial cable is no longer commonly used in Ethernet networks because of challenges with installation, maintenance, and wiring plan changes.

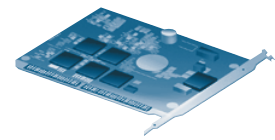
Fiber-optic—usually reserved for connections between “backbone” devices in larger networks, though in some very demanding environments, highly fault resistant fiber-optic cable is used to connect desktop workstations to the network and to link adjacent buildings. Fiber-optic cable is the most reliable wiring but also the most expensive.

Care should be taken in selecting the cabling for your classrooms and buildings. You want to be sure the wires running through ceilings and between walls can handle not only your present needs, but any upgrades you foresee in the next several years. For instance, while *Ethernet* can use UTP Category 3 wiring, *Fast Ethernet* and *Gigabit Ethernet*

require at least the higher-grade UTP Category 5 wiring. As a result, all new wiring installations should be Category 5 or better. You may also want to explore plenum cable, which can be routed through many types of heating and cooling ducts in ceilings. Check with your architect or wiring contractor to ensure this process is fire code compliant.

NETWORK INTERFACE CARDS

Network interface cards (NICs), or adapters, are usually installed inside a computer’s case. With portable and notebook



Network Interface Card

computers, the NIC is usually in the credit card-sized PC card (PCMCIA) format, which is installed in a slot. Again, when selecting NICs, plan ahead. Ethernet NICs support only Ethernet connections, while 10/100 NICs cost about the same and can work with either Ethernet or higher-performance *Fast Ethernet* connections. NICs supporting 10/100/1000 speeds cost more, but may be necessary for high-traffic applications and devices such as video-on-demand servers. In addition, you need to ensure that your NICs will support the type of cabling you will use—twisted-pair, coaxial, or a mixture of both.

Some NICs will support wireless networking, which uses radio technology to transmit a signal through the air instead of over a wire. These NICs handle most of the same functions as a NIC in a wired network, preparing data for transmission over the connecting media. PCI (Peripheral Component Interconnect) and ISA (Industry Standard Architecture) NICs are available for desktop computers to provide wireless connectivity to the wired network, and PCMCIA cards are available for laptops and notebooks.

HUBS

Hubs, or repeaters, are simple devices that interconnect groups of users. Hubs forward any data *packets* they receive over one port from one workstation—including e-mail, word processing documents, spreadsheets, graphics, or print requests—to all of their remaining ports. All users connected to a single *hub* or stack of connected hubs are in the same “segment,” sharing the hub’s *bandwidth* or data-carrying capacity. As more users are added to a segment, they compete for a finite amount of bandwidth devoted to that segment. Hubs are now used only for low bandwidth applications or segments with small numbers of users.



Hub

Examples of Cisco hub products:

Cisco Hewlett Packard 10BaseT hub-1bm

Cisco FastHub® series

For example, to understand how a hub serves your campus network, imagine a hotel with just one phone line available to all guests. Let’s say one guest wants to call another. She picks up her phone and the phone rings in all rooms. All the other guests have to answer the phone and determine whether or not the call is intended for them. Then, as long as the conversation lasts, no one else can use the line. With only a few guests, this system is marginally acceptable. However, at peak times of the day—say, when everyone returns to their rooms at 6 p.m.—it becomes difficult to communicate. The phone line is always busy.

ACCESS POINTS

Wireless networks can utilize an access point that performs many of the same functions as a simple hub. Access points act as a bridge between the wireless and the wired Ethernet or Fast Ethernet network. Access points also offer additional management and roaming functionality.

Network Management

Network management software allows you to monitor traffic flows, configure new equipment, and troubleshoot network problems. “Managed” hubs and switches have the ability to tell a network management software “console” how much data they are handling, sound alarms when problems occur, and record traffic volumes over time to help you understand when users are placing the heaviest demands on the network throughout the day. While not essential for very small networks, network management becomes increasingly important as the network grows. Without it, keeping traffic flowing smoothly throughout the network, adding or moving users, and troubleshooting problems can be difficult guessing games.

Modems

Modems are used for “dialup” communications; in other words, they dial up a network connection when needed, and when the transmission is completed, the connection is disabled. They work with ordinary telephone lines. When you want to send data across telephone lines, the modem takes the information from digital format and converts it (or modulates it) into an analog signal. The receiving modem converts the analog signal back into digital form (or demodulates it) to be read by your computer. This modulating and demodulating gives the modem its name.

Cable Modems

A new form of broadband “dialup” is the cable modem installed by the local cable television provider. Cable modems can provide speeds up to 1Mbps, but share that bandwidth among users on the provider’s selected service area.

INTERNET

SWITCHES

Switches are smarter than hubs and offer more *bandwidth*. A switch forwards data packets only to the appropriate port for the intended recipient, based on information in each packet's header. To insulate the transmission from the other ports, the switch establishes a temporary connection between the source and destination, then terminates the connection when the conversation is done.

As such, a switch can support multiple “conversations” and move much more traffic through the network than a hub. For comparison, a single eight-port Ethernet hub provides a total of 10 megabits per second (Mbps) of data-carrying capacity shared among all users on the hub. A “full-duplex,” eight-port Ethernet switch can support eight 10-Mbps conversations at once, for a total data-carrying capacity of 160 Mbps. “Full-duplex” refers to simultaneous two-way communications, such as telephone communication. With half-duplex communications, data can move across the cable or transmission medium in just one direction at a time.

Examples of Cisco switch products:

Cisco Catalyst® 2900 Series XL
Cisco Catalyst 3500 Series XL

For example, switches are like a phone system with private lines in place of the hub's “party line.” Jane Tipton at the Berkeley Hotel calls Bill Johnson in another room, and the operator or phone switch connects the two of them on a dedicated line. This allows more conversations at a time, so more guests can communicate.



Switch

ROUTERS

Compared to switches and *bridges*, *routers* are smarter still. *Routers* use a more complete packet “address” to determine which router or workstation should receive each packet. Based on a network roadmap called a “routing table,” routers can help ensure that packets are traveling the most efficient paths to their destinations. If a link between two routers goes down, the sending router can determine an alternate route to keep traffic moving.

Routers also provide links between networks that speak different languages—or, in computer speak—networks that use different “protocols.” Examples include IP (Internet Protocol), IPX (Internet Packet Exchange) Protocol, and AppleTalk. Routers not only connect networks in a single location or set of buildings, they provide interfaces—or “sockets”—for connecting to wide-area network (WAN) services. These WAN services, which are offered by telecommunications companies to connect geographically dispersed networks, are explained in more detail in the next chapter.

Examples of Cisco router products:

Cisco 700 series, Cisco 1000 series, Cisco 1600 series,
Cisco 2500 series, Cisco 2600 series, Cisco 3600 series,
Cisco 4500 series

For example, to understand routing, imagine the Berkeley Hotel and all the other fellow hotels in its chain have trained their operators to be more efficient. When guest Jane Tipton at the Berkeley Hotel calls guest Rita Brown at the Ashton Hotel, the operator at the Berkeley knows the best way to patch that call through. He sends it to the Pembroke operator, who passes it to the Ashton. If there's ever a problem with the switchboard at the Pembroke, the operator at the Berkeley can use an alternate route to get the call through—for example, by routing it to another hotel's switchboard, which in turns sends the call to the Ashton.



Router

IP Telephony Basics

IP telephony allows you to get more out of your data network by running converged data, voice and video applications over a single infrastructure. Migration to IP telephony begins by connecting your voice equipment—phones, fax machines, and private branch exchange (PBX) or key system—to your data network. IP telephony leverages the nearly universal Internet Protocol (IP) to send digitized voice transmissions over your company's data network.

In a later phase, users can be equipped with individual IP handsets, which work like traditional phones but plug directly into network switches and deliver enhanced integration with the data network. And in most cases, deploying IP telephony requires only minor modifications to the existing equipment.

IP Telephony Benefits at a Glance

- Integrates all types of employee- and customer-contact streams (voice, data, fax, and even video) onto a single network, for enhanced productivity and improved service
- Provides a platform for productivity-enhancing applications such as Unified Messaging, collaborative data sharing in real time, and networked video
- Reduces line charges, network costs, and IT expenses by letting voice traffic travel at no added cost over data lines and equipment—without requiring significant restructuring of your existing network
- Simplifies operations management by consolidating traffic onto one network

Uninterruptible Power Supplies

Uninterruptible power supplies (UPS) are not essential to networks but are highly recommended. They use constantly recharging batteries to prevent momentary power outages from shutting down your network *servers, clients* and *networking equipment*. Most of them also provide protection against potentially damaging voltage spikes and surges.

Bridges

As the network becomes crowded with users or traffic, *bridges* can be used to break them into multiple segments. Switches are basically multiple *bridges* in a single device. Bridges help reduce congestion by keeping traffic from traveling onto the network "*backbone*" (the spine that connects various segments or "subnetworks"). If a user sends a message to someone in his own segment, it stays within the local segment. Only those packets intended for users on other segments are passed onto the backbone. In today's networks, switches are used where the simplicity and relative low cost of *bridges* are desired.

Networking Technologies Overview

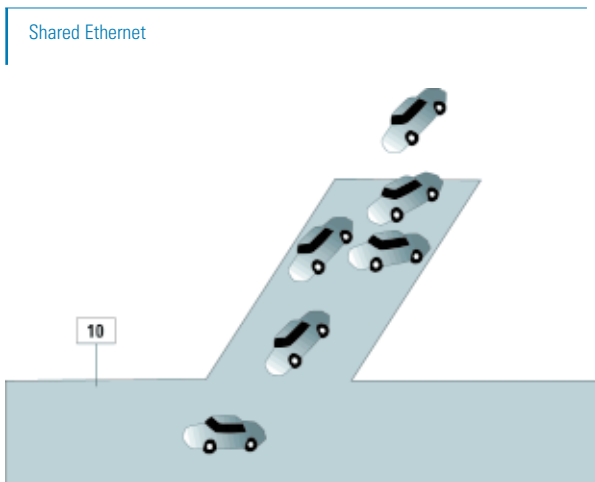
LOCAL-AREA NETWORKS: ETHERNET, FAST ETHERNET, GIGABIT ETHERNET AND WIRELESS

Ethernet has been around since the late 1970s and remains the leading network technology for local-area networks (*LANs*). (A LAN is a network contained in a building or on a single campus.) Ethernet is based on carrier sense multiple access with collision detection (CSMA/CD). (See the margin note on Token Ring for another basic style of network communication.)

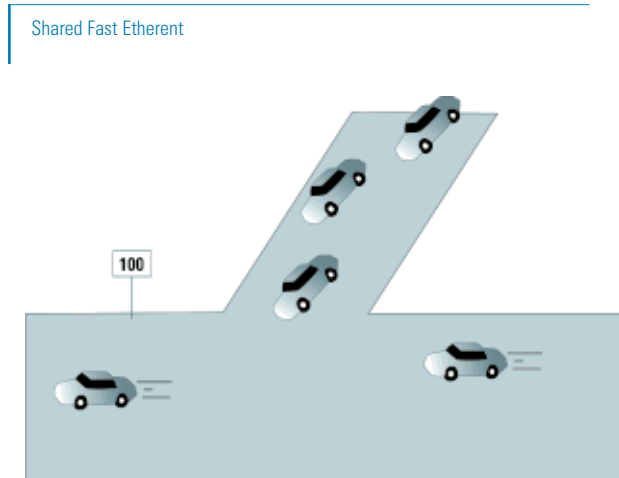
Simply put, an Ethernet workstation can send data packets only when no other packets are traveling on the network, that is, when the network is “quiet.” Otherwise, it waits to transmit, just as a person might wait for another to finish speaking during conversation.

If multiple stations sense an opening and start sending at the same time, a “collision” occurs. Then, each station waits a random amount of time and tries to send its packet again. After 16 consecutive failed attempts, the original application that sent the packet has to start again. As more people try to use the network, the number of collisions, errors, and subsequent retransmits grows quickly, causing a snowball effect.

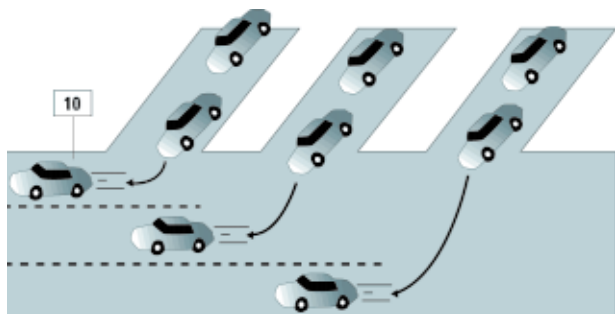
Collisions are normal occurrences, but too many can start to cause the network to slow down. When more than 50 percent of the network’s total bandwidth is used, collision rates begin to cause congestion. Files take longer to print, applications take longer to open, and users are forced to wait. At 60 percent or higher bandwidth usage, the network can slow dramatically or even grind to a halt.



ETHER



Switched Ethernet

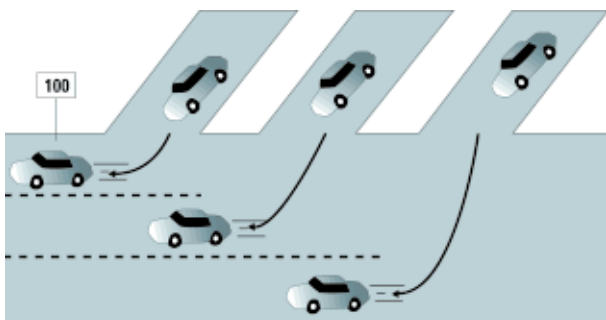


As noted in the previous section, Ethernet's *bandwidth* or data-carrying capacity (also called throughput) is 10 Mbps. *Fast Ethernet* (or 100BaseT) works the same way—through collision detection—but it provides 10 times the bandwidth, or 100 Mbps. Gigabit Ethernet (or 1000BaseT) also works the same way, but at 100 times greater bandwidth than Ethernet, or 1000 Mbps.

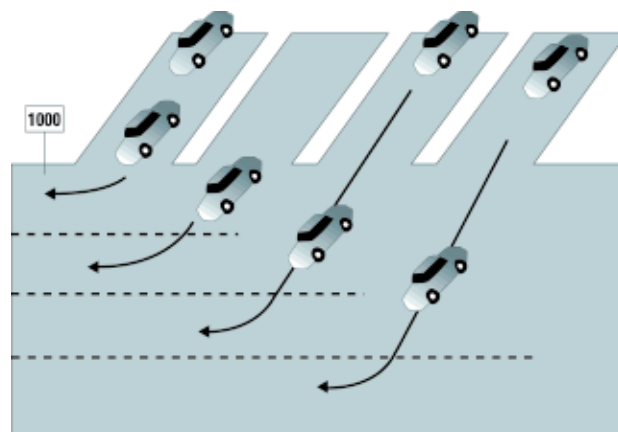
Shared Ethernet is like a single-lane highway with a 10-Mbps speed limit (see diagrams at left). Shared Fast Ethernet is like a much wider highway with a 100-Mbps speed limit; there is more room for cars, and they can travel at higher speeds. What would Switched Ethernet look like? A multilane highway with a speed limit of 10 Mbps in each lane. Switched Fast Ethernet also would be a multilane highway, but with a speed limit of 100 Mbps in each lane. Switched Gigabit Ethernet would have even more lanes with a speed limit of 1000 Mbps in each lane.

Wireless networking previously had not been widely adopted due to the low data rates supported and the lack of an international standard. The Institute of Electrical and Electronics Engineers (IEEE) is the International group that creates such standards—both Ethernet and Fast Ethernet are IEEE ratified standards. The IEEE has recently created a high-speed standard for wireless networking, IEEE 802.11b, which specifies the use of Direct Sequence Spread Spectrum (DSSS) technology. This technology has a shared throughput of up to 11 Mbps. With the advent of the 11-Mbps IEEE 802.11b standard, wireless networking is now a viable solution for today's campus LAN.

Switched Fast Ethernet



Switched Gigabit Ethernet



NET

Token Ring

Token Ring is a “token-passing” technology and an alternative to Ethernet’s collision-detection method. A token travels through the network, which must be set up in a closed ring, and stops at each workstation to ask whether it has anything to send. If not, the token continues to the next point on the network. If there is data to send, the sending station converts the token frame into a data frame and places it into the ring. The frame continues around the ring, with sets repeated by all stations, but the destination station also copies the frame into memory. When the frame comes around to the sending station, it strips the data frame from the ring and releases a new token. Token Ring networks operate at either 4 or 16 Mbps, but with the low cost, ease of use, and easy migration to higher performance in Ethernet networks, Token Ring is rarely used for new network installations.

High-Speed LAN Technologies

Today’s growing, fast-changing networks are like growing communities; the traffic they create tends to cause congestion and delays. To alleviate these problems, you can install higher-speed LAN technologies in your network that move traffic more quickly and offer greater data-carrying capacity than Ethernet, Fast Ethernet, or Token Ring. **Fiber Distributed Data Interface (FDDI)** is another “token-passing” technology, operating at 100 Mbps. But because it requires different wiring (fiber) and different hubs and switches from Ethernet, FDDI is losing ground to Fast Ethernet and other high-speed technologies. **Asynchronous Transfer Mode (ATM)** operates at a range of speeds up to 622 Mbps. It is a popular choice for the backbones of extremely demanding or large networks, it has special features such as the ability to carry voice and video traffic along with data, and it can be used for wide-area networks connecting geographically separated sites. **Gigabit Ethernet** operates at 1000 Mbps and is fully compatible with Ethernet and Fast Ethernet wiring and applications.

REMOTE ACCESS AND WIDE-AREA NETWORKS

LANs accommodate local users—people within a building or on a campus. WANs connect users and LANs spread between various sites, whether in the same city, across the country, or around the world. “Remote access” refers to a simple connection, usually dialed up over telephone lines as needed, between an individual user or very small branch office and a central network.

Your campus gains access to the *Internet* through some type of remote connection. A single user can use a *modem* to dial up an Internet service provider (ISP). Multiple users within a campus might choose to rely on a *router* to connect to the ISP, who then connects the campus to the Internet.

In general, LAN speeds are much greater than WAN and remote access speeds. For example, a single shared-Ethernet connection runs at 10 Mbps (mega means “million”). Today’s fastest analog *modem* runs at 56 kilobits per second (kbps) (kilo means “thousand”)—less than one percent of the speed of an Ethernet link. Even the more expensive, *dedicated* WAN services such as T1 lines don’t compare (with bandwidth of 1.5 Mbps, a T1 line has only 15 percent of the capacity of a single Ethernet link). For this reason, proper network design aims to keep most traffic local—that is, contained within one site—rather than allowing that traffic to move across the WAN.

ANALOG LINES

Using analog lines to dial out to other networks or to the Internet—or to allow remote users to dial *into* your network—is a straightforward solution. Most ordinary phone lines are analog phone lines, also known as POTS (plain old telephone service). Connect a modem to your computer and to a wall jack and you’re in business. You pay for a connection as you would pay for a phone call—by the minute, or a set rate per local call (long distance charges are the same as for a long distance telephone call).

At present, the fastest analog modems operate at 56 kbps for transferring data. With today’s larger file sizes and graphically sophisticated World Wide Web sites on the Internet, you should look for modems that operate at a

minimum of 33.6 kbps (also called V.34) and have V.42 (error correction) and V.42bis (data compression) capabilities for better performance.

While modems offer a simple solution for dialout connections to other LANs and the Internet, they do not scale well as your network grows. Each modem can support only one remote “conversation” at a time, and each device that wants to connect with the outside world needs a modem. See the examples in the next section for ways to overcome this limitation by installing a router for wide-area communications and your Internet link.

The school must install a modem bank or preferably a remote access device or server, if it wants to support analog modem connections from users’ homes.

ISDN

ISDN is a service that operates at 128 kbps and is available from your phone company. Charges for ISDN connections usually resemble those for analog lines—you pay per call and/or per minute, usually depending on distance. ISDN charges also can be flat rate if linked to a local Centrex system.

Technically, ISDN consists of two 64-kbps channels that work separately. Load-balancing or “bonding” of the two channels into a 128-K single channel is possible when you have compatible hardware on each end of a connection (for instance, between two of your campuses). What’s more, as a digital service, ISDN is not subject to the “line noise” that slows most analog connections, and thus offers actual throughput much closer to its promised maximum rate.

You can make ISDN connections either with an ISDN-ready router or with an ISDN terminal adapter (also called an ISDN modem) connected to the serial port of your router. Again, modems are best for single users, because each device needs its own modem, and only one “conversation” with the outside world can happen at any one time. Your ISDN router, modem, or terminal adapter may come with analog ports, allowing you to connect a regular telephone, fax, modem, or other analog phone device. For example, a ISDN router with an analog phone jack would allow you to make phone calls and send faxes while staying connected via the other ISDN digital channel.

Analog vs. Digital

The difference between analog and digital signals is very important for data communications. The most familiar “analog” communication is a phone call. Varying electrical voltage reflects the variations in the volume and tone of the human voice. By contrast, digital communications use a series of 1s and 0s to carry information from point to point. *Modems* actually convert the digital data of one computer into an analog signal for transmission over the phone lines. On the receiving end, another modem converts the analog signal back into a series of 1s and 0s, so the receiving computer can interpret the transmission. Today, phone companies can offer fully digital service between LANs (leased lines such as 56K, 384K known as fractional T1s and T1s are digital services), or Integrated Services Digital Network (*ISDN*) which allows dialup connections on an as-needed basis. When it comes to moving data, digital communications are less susceptible to errors and faster than analog signals because they are not susceptible to problems such as electrical “noise” on transmission lines.

Modems vs. Routers

When choosing between modems and routers for remote access to a central network or the Internet, consider the following pros and cons:

Modems

- Inexpensive
- Good for one user or limited remote access for a small group
- Portable, so they can be used remotely from any location with a phone line
- Compatible with existing telephone lines
- Connections can be made at a relatively low cost (essentially the same as a local or long-distance phone call)

Routers

- Support faster WAN connections than modems
- Support multiple users
- Many routers have a “live” connection (so you don’t get busy signals), and you save time not having to dial up the connection
- The connections are more reliable than with telephone lines but may be more costly than ordinary phone lines and may not support voice calls
- Offer data encryption (for enhanced security) in addition to data compression (for enhanced performance)

“Dial-on-demand routing” (DDR) is sometimes used as a compromise between the dialup method of connecting and full-fledged routing. “Dial-on-demand” means the router establishes (and is charged for) a connection only when the connection is in use. This solution uses a basic router paired with either a modem or an ISDN line, which makes the calls as needed, when the router requests a connection.

Broadband

DSL and cable modems can provide access to the Internet and to campus resources as well. These connections, operating at much higher speeds, require more powerful servers and a robust network on campus to keep up.

DSL

Digital subscriber line (DSL) is a service that offers a faster Internet connection than a standard dialup connection. DSL uses the existing phone line and in most cases does not require an additional phone line. The DSL service attaches to your existing phone line. This gives 24/7 access and does not tie up the phone line and cause it to have a busy signal. Over any given link, the maximum DSL speed is determined by the distance between the customer site and the phone company’s central office. Most ISPs offer DSL data services at different speeds ranging from 128 kbps, 384 kbps, and 784 kbps to 1.04 Mbps, and now even faster up to 6.0 Mbps—so educators can choose the rate that meets their specific needs. At the campus site, a DSL router or modem connects the DSL line to a local-area network (LAN) or an individual computer. Once installed, the DSL router provides the customer site with continuous connection to the Internet.

CABLE MODEM

A cable modem is a device that enables you to hook up your network to a local cable TV line and receive data at about 1.5 Mbps. This data rate far exceeds that of the prevalent 28.8 and 56 kbps telephone modems and the up to 128 kbps of ISDN and is approximately the data rate available to subscribers of DSL telephone service. In addition to the faster data rate, an advantage of cable over telephone Internet access is that it is a continuous connection.

Although a cable modem modulates between analog and digital signals, it is a much more complex device than a telephone modem. Typically, the cable modem attaches to a standard 10BaseT Ethernet card in the computer. A cable modem can be added to or integrated with the system that provides your campus TV sets with channels for Internet access. In most cases, cable modems are furnished as part of the cable access service and are not purchased directly and installed by the subscriber. All of the cable modems attached to a cable TV company coaxial cable line communicate with a Cable Modem Termination System (CMTS) at the local cable TV company office. All cable modems can receive from and send signals only to the CMTS, but not to other cable modems on the line.

LEASED LINES

Phone companies offer a variety of leased-line services, which are digital, permanent, point-to-point communication paths that usually are “open” 24 hours a day, seven days a week. Rather than paying a fee for each connection, you pay a set amount per month for unlimited use. The lease lines that would be appropriate for most campuses range in speed from 384kbps to 45Mbps (a “T3” service). Because they all work the same way, the right one for you depends on the number of users and amount of remote traffic the network will carry (and how much bandwidth you can afford). A common service for campus networks is a “T1” line with 1.5 Mbps of bandwidth.

By “point-to-point,” we mean that leased lines use a direct, physical connection from your campus to the phone company’s switch, and then to other campuses or your central district, regional, statewide office, or ISP. The phone or data services company may need to install new cabling in order to provide your leased line.

“Frame relay” is another form of leased line that provides switched (“on and off”) connections between distant locations. Different providers may have either service or both available.

The Universal Service Fund, or E-Rate

As part of a broad reform initiative to ensure universal access to communications services such as telephones and information networks, the U.S. government created through the Telecommunications Act of 1996 special education subsidies, called the Education Rate (E-Rate). For complete details on the discounts, who qualifies, and how to apply, visit <http://www.sl.universalservice.org>.

Fund-Raising for Network Projects

For innovative fund-raising ideas, start with the Computer Learning Foundation’s “Help Your Campus Build Partnerships and Raise Funds for Technology,” at <http://www.computerlearning.org>.

Remote Access Servers

Remote access servers are like funnels for incoming calls from remote users. A remote access server allows multiple people to connect to the network at once from homes, remote work sites, or anywhere they can find an analog or digital phone line. They make good sense when you want to provide many individuals or small sites temporary access to your central network via modems, rather than the permanent link of a leased line. They also prevent the busy signals that remote users might encounter if they were all dialing up a single modem. A remote access server can have multiple phone lines all “pooled” to a single listed phone number, allowing the user to rotate through the phone lines transparently until finding an open line. As usage increases or decreases, support staff can order more lines to match the demand without affecting the phone number users are familiar with calling.



DISTRICT

WHICH SERVICE IS RIGHT FOR YOU?

Analog services are least expensive. ISDN, DSL, and cable modem services cost somewhat more but are a practical minimum for today's bandwidth needs. Leased lines are the costliest of these three options but offer dedicated, digital service for more demanding situations. Which is right? To decide, answer the following questions:

- Will students and faculty use the Internet frequently?
- Will your libraries provide Internet access for research?
- Do you anticipate a large volume of traffic between campuses and your central office?
- Will the network carry administrative traffic—such as student records and accounting data—between campuses and a central office?
- Do you plan to use videoconferencing between campuses to expand course offerings for students (distance learning)?
- Who will use the campus connection to the Internet—faculty, staff, students, parents?
- Will students and/or parents need to connect directly from home?
- Do you plan to act as an ISP for your students or community?

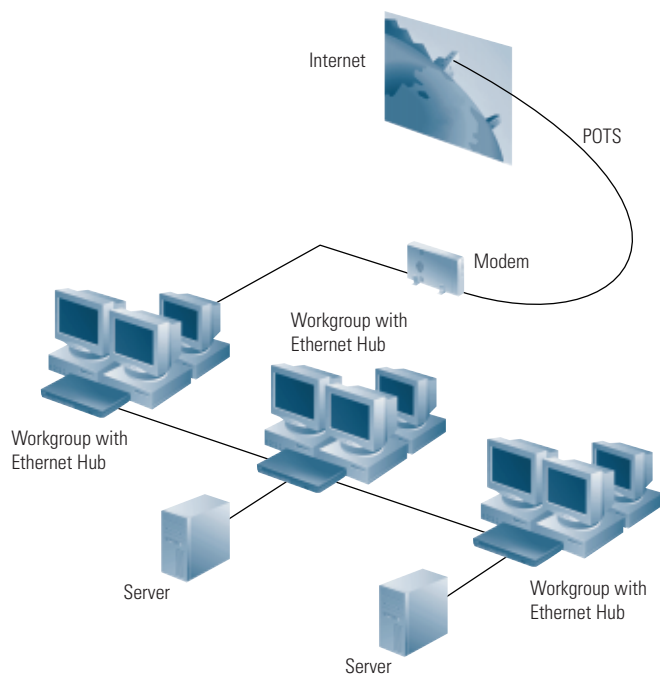
The more times you answered “yes,” the more likely it is that you need leased-line services. This is the direction that most campuses and districts are taking today. It is also possible to mix and match services. For example, individual campuses might connect to each other and to your central office using ISDN, while the main connection from the central office to the Internet would be a T1. Which service you select also depends on what your ISP is using. If your ISP's maximum line speed is 128K, as with ISDN, it wouldn't make sense to connect to that ISP with a T1 service. It is important to understand that as the bandwidth increases, so do the charges, both from the ISP and the phone company. Keep in mind that rates for different kinds of connections vary from location to location. See the next chapter for illustrations of how various “wide-area” connections might work.

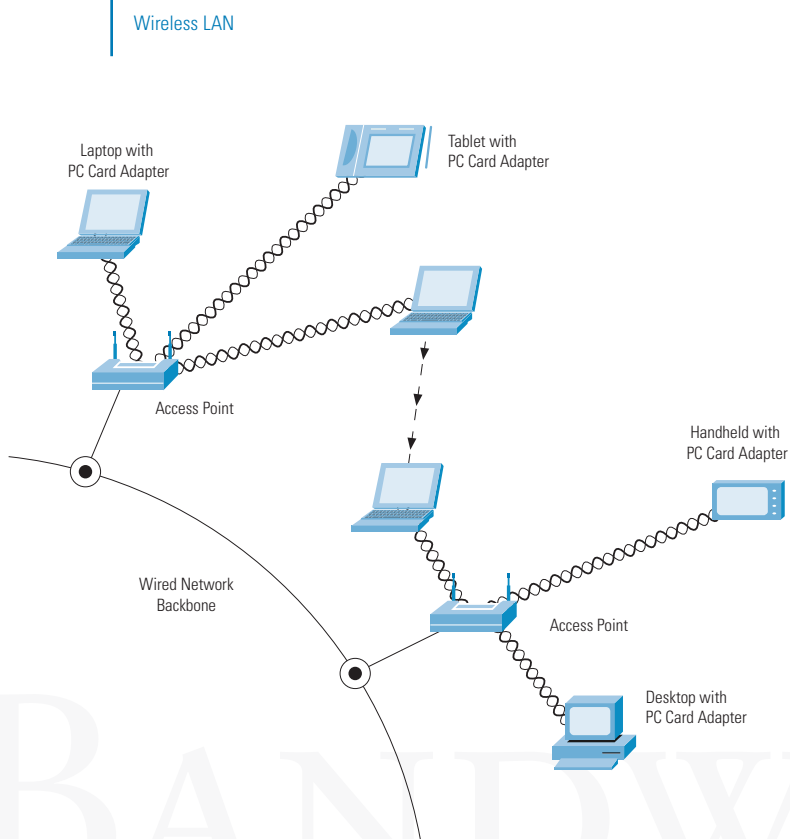
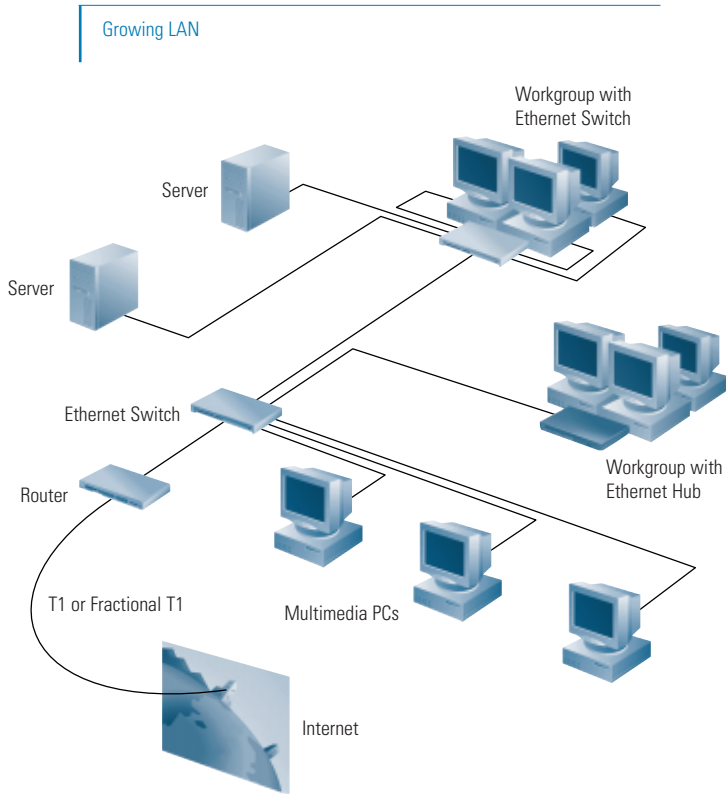
Education Networking Examples

SMALL SCHOOL LOCAL-AREA NETWORK

This LAN starts simply—shared Ethernet, with a pair of servers and a shared analog modem connecting students and faculty to the Internet one at a time. Students can write reports and do math drills on the computers, jumping onto the Internet for research occasionally; faculty can write lesson plans and e-mail colleagues in the campus; and administrators can track attendance and record grades on the local servers.

Local-Area Network





AS THE CAMPUS NETWORK GROWS

Unfortunately, a small school LAN can't accommodate growing campus demands. Too many users compete for the 10-Mbps Ethernet network pathway. Only one user can connect to the Internet at a time. As instructors try to incorporate CD-ROM-based, graphical programs into their lesson plans, network performance stumbles.

The solution shown here segments the network using Ethernet switches and adds a router for Internet connections. This provides more *bandwidth* for students, faculty, and administrators and permits multiple simultaneous connections to the Internet. The campus can create a new multimedia lab, with dedicated 10-Mbps Ethernet channels to individual workstations for smooth performance of video images delivered from the CD-ROM server. The network upgrade also saves money by incorporating all of the campus' existing equipment and wiring. Because of the bandwidth demands that high-performance applications place on the network, a traditional shared 10-Mbps Ethernet network will not provide an adequate foundation for very long. In recent years, the price of 10/100-Mbps LAN switches has dropped significantly. Migrating from 10-Mbps shared Ethernet hubs to 100-Mbps Fast Ethernet switches, then has become quite affordable, and education institutions can realize exponential network performance boosts at a very attractive price. They can gain these benefits with minimal disruption to their networks because Fast Ethernet is based on the same protocol as traditional Ethernet, and expertise required is virtually the same.

If the campus or district wants to add mobility or flexibility to a network, it may choose to add a wireless network segment as a complement or substitute for portions of its wired LAN. Properly deployed, wireless LAN components allow users to remain connected regardless of campus location. This offers scalability for hosting differing numbers of mobile users, such as physical education teachers. Wireless networking can also be used in situations where pulling cables for a wired network isn't possible or doesn't make good fiscal sense, such as in older historic buildings, portable classrooms, or leased office space.

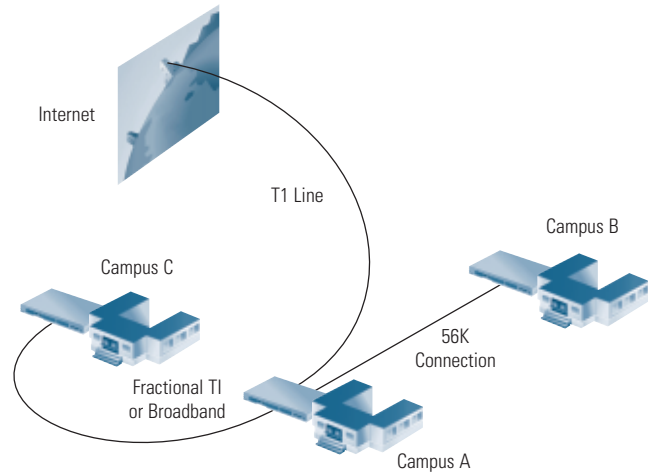
BANDWIDTH

A WIDE-AREA NETWORK FOR A SMALL DISTRICT

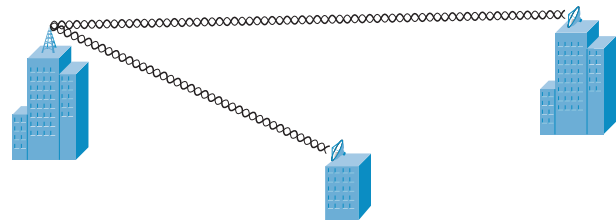
To improve communications between campuses and their central office, the campuses decide to install a wide-area network. The upgrade economizes on Internet connectivity by offering all campuses a connection through a central high-speed line. Student, parent, or community access to campus resources can best be provided via the Internet using the Web and Web-enabled information systems tied to campus databases.

Many districts choose to link multiple sites by building a wide-area network (WAN), using some type of direct connection such as a T1 line. Wireless networking offers another option in the form of building-to-building bridges. Wireless bridges support line-of-sight connections up to 25 miles apart. These bridges allow the district to expand its WAN without the expense or delay of physically connecting the buildings with cable. The wireless connections between buildings are faster than T1 lines, without the recurring monthly fees.

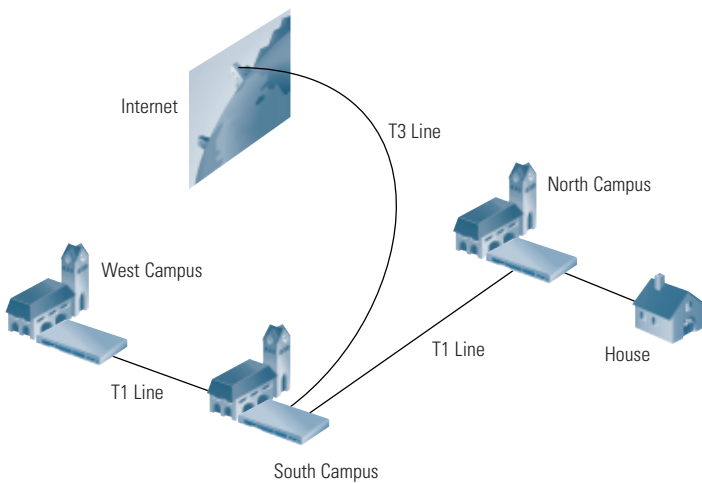
Wide-Area Network



Wireless Bridge (WAN)



Community College WAN

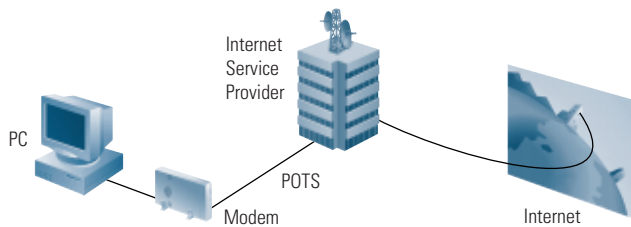


A COMMUNITY COLLEGE WAN

A growing community college system sees rising network traffic at its three campuses. It wants to install future-ready local networks to support multimedia applications and to provide high-speed WAN links that will allow south and west campus students to take advantage of north campus courses via the network (distance learning). In addition, because many students commute from great distances, the college wants to allow students at all three campuses to dial up their local servers from home and retrieve assignments and communicate with professors directly or through the Web.

Making the Right Connection: Network How-Tos

Dialup Access

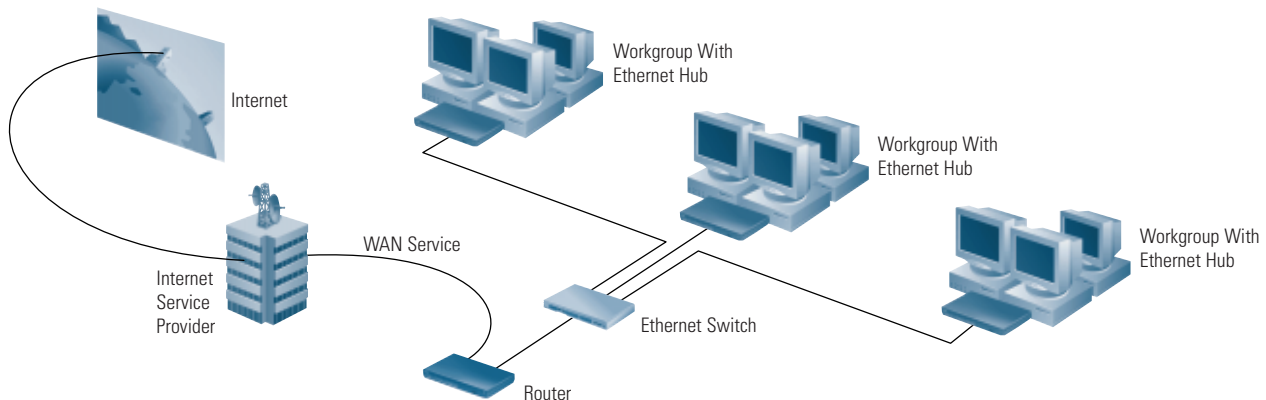


HOW TO CONNECT TO THE INTERNET

The Internet is a global network of millions of computers, growing by leaps and bounds each year. It allows a world-wide community comprising tens of millions of people to communicate over any distance, access information from anywhere in the world, and publish text and images instantly. The Internet is a link to the information resources of campuses, libraries, and businesses, assisting in research projects and cross-cultural studies and permitting a free flow of ideas and studies between students, faculty, and their peers.

Remarkably, however, a large number of classrooms still lack Internet connections. If your campus is among them, you will be pleased to hear that connecting to the Internet is easier than ever.

Shared Access



Where connections once required costly special services, you now have a range of options. Commercial online services such as America Online and the Microsoft network offer dialup Internet access for \$20 or less per month. ISPs offer dialup and shared access connections for a variety of prices, based on a range of line speeds up to T3 (45 Mbps) for environments with heavy demand or a large number of users.

On the hardware side, you can make a dialup connection with a modem attached to one computer or a router attached to your local-area network, allowing multiple users to access the Internet.

Modem connections are inexpensive and easy to acquire, so they are a good idea if you're just starting out or if your campus has only a few computers. However, only one person can use a modem at any given time, leading to heavy competition for Internet access. A single router can provide a shared-access solution, accommodating multiple users and multiple simultaneous Internet connections. It connects you directly to a router at your ISP's location.

However you choose to connect, your window on the Internet is a browser such as Netscape Navigator or Microsoft Internet Explorer: easy-to-use programs that link you to any active site on the Internet.



HOW TO CHOOSE AN INTERNET SERVICE PROVIDER

You can choose from a growing array of ISPs offering a wide range of services and pricing structures. An ISP can be a commercial business or local university, state agency, or nonprofit organization. You can find out about ISPs in your area through the Internet, from advertisements or the yellow pages, and from Internet books and guides. You also will find a list of Internet service providers on the Web at <http://thelist.internet.com>.

Factors to consider when evaluating ISPs include:

Price

Some ISPs offer access at a fixed rate per month or year. Others offer service at an hourly rate or by charging per megabyte of data transferred or archived. If you're not certain what your usage level will be, it makes sense to begin with a fixed-rate plan and then monitor usage. Generally, campus budgets can handle a fixed commitment of a known amount more easily than a variable commitment.

Support

If your campus does not have its own networking staff or is not supported by a central office staff, extra support from the ISP is a necessity. Ask the provider about onsite configuration services, training, startup software supplied with the service, and whether the provider operates a help desk with phone or e-mail consultation. See the Training and Support sidebar near the end of this guide for additional recommendations.

Access

If the ISP offers dialup access, be sure to ask about the size of the modem pool and the number of customers the ISP is serving. Ask the following questions:

- Does the ISP enforce maximum session times and provide password-protected access?
- Does the ISP use a single access number or a pool of numbers?
- What connection speeds are available? (For example, make sure the ISP can connect high-speed analog modems—33.6K and 56K—or ISDN digital modems—128K—if you have this service. Some ISPs can now support broadband services such as DSL and cable modems.)

Performance

It is important to know how the service provider is connected to the Internet. For example, it is not effective to have a T1 leased-line connection from your campus to an ISP if the ISP is connected to the Internet via a T1 connection or less, especially if the ISP supports several customers. Generally, higher connection speeds allow a service provider to accommodate many users and operate more efficiently.

Additional Services

Internet connectivity requires ongoing network administration configuration and maintenance. Your ISP may offer these services, so be sure to ask.

For dialup users: ask your ISP if maintenance of a user account and mailbox is offered on your behalf, with ample mail spool space for the number of users who can receive e-mail at your address. The spool space is very important because it determines how much content your mailbox will hold before rejecting new messages.

For direct access users: ask if your ISP offers registration of network identifiers, such as Internet domain names and IP addresses. You will also need an Internet server computer that performs the following functions:

- Domain Name System (DNS)—Provides translation from URL addresses (for example, www.cisco.com) to numerical addresses (for example, 198.133.219.25)
- Electronic mail service—Establishes e-mail accounts and allows campus users to receive and send e-mail
- USENET news—Maintains a local usenet news conferencing system
- World Wide Web—Allows you to publish information and make it accessible to the Internet community

Commercial Internet server packages that run on a variety of platforms are available, or your ISP can assist with many of these services (see right—“How to Create Your Own Web Site”).

HOW TO CREATE YOUR OWN WEB SITE

The basic tool for creating a Web site is Web authoring software, which can be as simple as a word processor with the ability to convert the final result to HTML for publishing on the Web. HTML is a cross-platform language—in other words, understandable by any computer, from a Microsoft Windows-based PC to a UNIX workstation to an Apple Macintosh. Within HTML documents, you can plant text, images, sounds, and, with advanced authoring software, video clips.

The Internet's File Transfer Protocol (FTP) also provides a means of publishing non-HTML content, which visitors to your sites can download to use on their own computers.

After you have created your Web site, the next step is publishing it. For a monthly fee, some ISPs offer space on their servers and links to your site through their Internet connections. They also can help you secure a domain name or the address at which computer users find your Web site (cisco.com is Cisco Systems' domain name).

An alternative is to establish a dedicated Web server in your own campus or district. This requires you to maintain a direct link to the Internet rather than turning this task over to an ISP, and it demands more upkeep.

Security

Your network is bound to carry at least some information you want to protect from certain users—students' grades and attendance records, for example. For this reason, you'll want to consider some form of network security. Security solutions come in three basic forms: user authentication and authorization, audits, and firewalls. Authentication designates who can access the network, and authorization governs what they can see when they're connected. Audits enable you to track user activity to help spot unauthorized activity before it becomes a full-fledged security breach.

Firewalls protect your internal network from invasion through the Internet or other external sources. Firewalls can restrict access to certain users and control which users can use which applications when dialing in from outside. Cisco provides security in Cisco IOS® software and with security products such as the Cisco PIX™ Firewall and the Windows NT platform Cisco Centri Firewall.

Basic Network Design: Considerations

A PROBLEM SOLVER'S GUIDE TO RELIEVING CONGESTION

Congestion is the networking term for too much traffic clogging network pathways. Common causes of congestion in today's networks include:

- Too many users on a single network segment or *collision domain*
- High demand from networked applications, such as groupware (for scheduling and appointments) and e-mail with large attached files
- High demand from bandwidth-intensive applications, such as desktop publishing and multimedia
- The growing number of users accessing the Internet
- The increased power of new PCs and servers

These last two issues are more recent. Students using the Internet may be downloading multimegabyte image files or MP3 music to move across the network. This can clog pathways created to carry small e-mail and word processing files. Meanwhile, today's Personal Computer Interface (PCI) systems are fast enough to move files like these at 30 to 90 Mbps, easily overloading the actual 8- to 9-Mbps throughput capacity of a shared Ethernet network channel. The speed and bandwidth of these desktop machines, the size of popular Internet files, and the size of attachments sent via e-mail continue to increase at an accelerating pace. Your network bandwidth must grow in step to keep up with these advances.

HOW TO SPOT NETWORK CONGESTION

Some common indicators of network congestion include:

Increased Network Delay

All networks have a limited data-carrying capacity. When the load is light, the average time from when a host submits a *packet* for transmission until it is actually sent on the LAN is short, literally fractions of a second. When many users are vying for connections and communicating, the average delay increases. This delay has the effect of making the network appear "slower," because it takes longer to send the same amount of data under congested conditions than it does when the load is light.

In extreme circumstances, an application can fail completely under a heavy network load. Sessions may take time-outs and disconnect, and applications or operating systems may actually crash, requiring a system restart. Remember that many factors contribute to application performance (for example: CPU speed, memory, and disk performance). The LAN is only one of several possible bottlenecks.

Higher Network Utilization

One important measure of congestion is “channel utilization,” which is the percentage of time that a channel is busy carrying data. It is directly related to the traffic load. While many network management software programs offer visual displays of this information, your system may require special network monitoring equipment, such as protocol analyzers or remote monitoring (RMON) devices.

There are many variables to consider when trying to determine what constitutes acceptable utilization, including the number of stations on the LAN, software or behavior, and network traffic patterns. (In other words, is most traffic moving between users and a local server, or are users reaching out of their own segments across the network and creating congestion?) For most campus environments, any of the following utilization levels can be used as “rules of thumb” to determine when an Ethernet LAN is approaching excessive load:

- 20 percent of full capacity, averaged over an eight-hour work day
- 30 percent averaged over the busiest hour of the day
- 50 percent averaged over the busiest 15 minutes of the day

For very short-term periods (seconds, or even tens of seconds), network utilization may be nearly 100 percent without causing any problems. This situation might occur during a large file transfer between a pair of high-performance stations on an otherwise quiet network. These are not hard and fast rules, and some application environments may operate well under heavier loads or fail at lighter levels.



Dissatisfied Users

Network speeds are partly subjective; the ultimate measure of LAN congestion is whether users can get their work done efficiently. If users are dissatisfied with network performance, there’s a problem—regardless of statistics indicating that the network is doing just fine. Note that user dissatisfaction with performance may not indicate a network congestion problem. The slowdown may be because of applications, computer CPU speeds, hard disk performance, servers, and WAN access devices (slow modems or WAN connections).

NETWORK

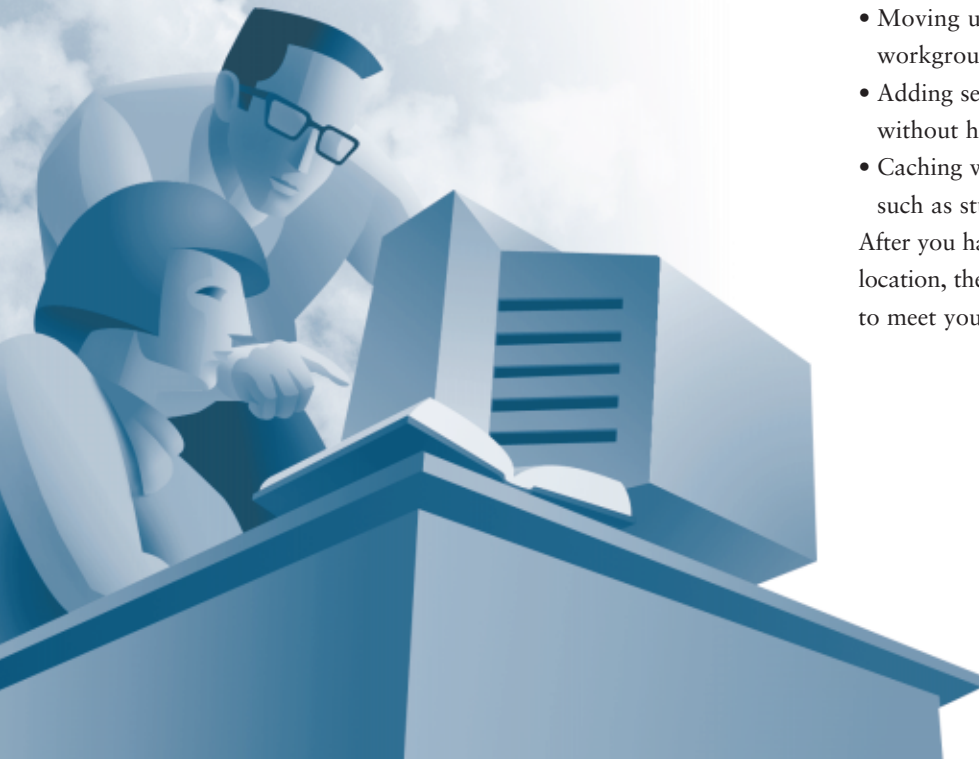
GOOD NETWORK DESIGN: THE 80-20 RULE

The key to good network design is how you place clients in relation to servers. Ideally, client computers should be placed on the same “logical” network as the servers they access most often. (By contrast, a “physical” network connection would mean that a client and server were attached to the same switch. A logical connection can be defined in your network software, so that users in one classroom can be in the same logical network segments as a server located at the opposite end of a building or campus.) This simple task minimizes the load on the network backbone, which carries traffic between segments.

Here’s a good rule of thumb. In a properly designed small to medium-sized network environment, 80 percent of the traffic on a given network segment is local (destined for a target in the same workgroup), and not more than 20 percent of the network traffic should need to move across a backbone (the spine that connects various segments or “subnetworks”). Backbone congestion can indicate that traffic patterns are not meeting the 80-20 rule. In this case, rather than adding switches or upgrading hubs, it may be easier to improve network performance by doing one of the following:

- Moving resources (applications, software programs, and files from one server to another, for example) to contain traffic locally within a workgroup
- Moving users (logically, if not physically) so that the workgroups more closely reflect the actual traffic patterns
- Adding servers so that users can access them locally without having to cross the backbone
- Caching web pages or other Internet-accessible resources such as student information systems

After you have ensured proper network design and resource location, the next step is to determine the optimal technology to meet your growing needs.



GIVING YOUR NETWORK A PERFORMANCE BOOST

Most LANs start as shared Ethernet networks, with all users sharing a single segment. Obviously, as more users plug into the network and send larger files across it, traffic loads rise.

In the section “Education Networking Examples,” we demonstrate how dividing a network into multiple “subnetworks” or separate collision domains can alleviate congestion.

Ethernet switches, Fast Ethernet hubs and Fast Ethernet switches immediately and dramatically improve network performance compared with traditional shared 10-Mbps hubs in a heavily loaded network. Adding these devices to your network is like adding lanes to a highway (in the case of a switch), increasing the speed limit (in the case of a Fast Ethernet hub), or both (in the case of a Fast Ethernet switch).

Gigabit Ethernet can increase throughput by another factor of ten on certain portions of the network. However, like adding a new freeway segment, this super capacity can end up moving congestion to other parts of the network. Thorough planning with a systems engineer can make the best of the new high speed capabilities.

In sheer performance, shared Fast Ethernet is always faster than switched 10-Mbps Ethernet for environments with one server or moderately loaded multiple-server environments. How much of a performance boost you see depends on the type of network traffic.

Many Smaller Files

For sustained traffic with smaller files (frequent e-mail messages or database reports on student attendance), the performance difference between the two technologies is relatively minor. In this instance, the congestion is caused by a constant stream of small files between the client and server. For existing installations, segmenting the network with an Ethernet switch provides the most cost-effective solution. Segmentation delivers 10 Mbps per port and a 100-Mbps uplink for high-speed access to servers or the network backbone, while leveraging the existing 10-Mbps network interface cards.

Fewer Larger Files

“Bursty” or sporadic traffic with large file transfers and for power users running high-bandwidth applications requires a different approach. An example is a group of students using an interactive learning program with full-motion video clips. Because these types of large files take too long to arrive at 10 Mbps, high-speed 100BaseT switches along with 10/100 NICs provide the wider, faster “data highway” you need.

Many Larger Files

For sustained, large-file traffic such as in a library’s multimedia lab or with network backups, Fast Ethernet hubs or Fast Ethernet switches would be the best choice. They can increase the throughput and speed of the transactions, reducing the impact on the backbone and minimizing network congestion.

Types of Ethernet Traffic

Ethernet traffic consists of three different types of packets: unicast, multicast, and broadcast. How much of each type of traffic you have on your network can be important in determining whether you need a switch or a hub and types of switch features.

Unicast packets are addressed to a single destination. This type typically comprises the bulk of traffic on an Ethernet LAN.

Multicast refers to a single transmission sent to a group of users. This capability lightens the load on the server and the network because only one data stream is sent rather than one per user.

At the other extreme, *broadcast* packets are sent to all nodes within a single network segment and can be a major source of congestion.

DEDICATED BANDWIDTH TO WORKGROUPS AND SERVERS

If you need to provide up to 100 Mbps of bandwidth to workgroups, servers, or workstations sending large files at high volume, a Fast Ethernet switch is the right choice.

A Fast Ethernet switch allows you to segment your LAN (that is, divide it into smaller “collision domains”) and then give each segment a dedicated network link or highway lane at up to 100 Mbps. You also can give popular servers their own 100-Mbps links. In some of today’s networks, a Fast Ethernet switch will act as the “backbone” of the LAN, with Ethernet hubs, Ethernet switches, or Fast Ethernet switches providing the desktop connections in workgroups. As demanding new applications such as desktop multimedia or videoconferencing become more popular, you may choose to give certain individual desktop computers their own dedicated 100-Mbps network links.

Streaming Multimedia

Finally, for single-server environments running streamed multimedia applications (such as a distance learning course offered by a remote campus that you tune into over the network), the large overall bandwidth of Fast Ethernet switches is the minimum solution within the campus with Gigabit Ethernet access as the ideal. They can provide dedicated 100-Mbps or even 1000 Mbps to each server. Switches can provide additional relief by distributing multicasts. A multicast is a single transmission, replicated by the switch or router and sent to a specific group of users. When connecting across the district WAN a T1 or T3 line provides the needed bandwidth.

MAKING THE MOST OF YOUR EXISTING EQUIPMENT AS YOUR NETWORK EVOLVES

How you boost performance depends partly on what networking equipment you have installed—NICs, PCs and servers, and cabling.

For example, Fast Ethernet hubs and switches support all existing Ethernet programs and management systems, but you'll need 100BaseT or 10/100 NICs in all computers attached to Fast Ethernet ports. These switches make sense in all new networks, extensions to existing networks, and areas where increased, high-volume throughput is essential.

In existing networks in which regular Ethernet NIC adapters are already installed, Ethernet or Fast Ethernet 10/100 switches are a good idea. They provide an immediate boost in performance without sacrificing your current investment in adapters. See the table below for other minimum requirements for Ethernet and Fast Ethernet network connections.

As noted previously, whether you choose to install Ethernet or Fast Ethernet switches, Cisco highly recommends you install 10/100-Mbps NICs in any new PC or server, because the incremental cost for these adapters is marginal. The 10/100 NICs also take advantage of the 30- to more than 90-Mbps throughput and power of Extended Industry-Standard Architecture (EISA) and PCI computers.

Cabling presents additional equipment consideration in deciding on Switched or Fast Ethernet. Switched Ethernet runs on the common two-pair Category 3 cabling that some campuses have installed as well as Category 4 and Category 5 UTP cabling. However, 100BaseTX, the most commonly used Fast Ethernet implementation, requires Category 5 cabling. Again, all new UTP cable installations should be Category 5.

Do you meet the minimums?

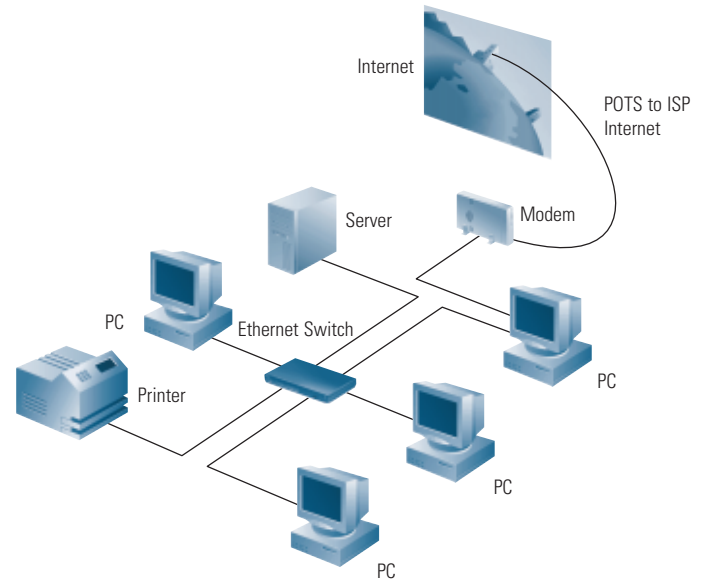
	10 Mbps	100 Mbps
Cabling	UTP Category 3	UTP Category 5
PCs	ISA	PCI, EISA
Adapters	Existing 10 Mbps	New 10/100 Mbps

Networking Basics Checklists

The following checklists provide a general idea of the components you need to install your network. These are meant to be rough guidelines only; your own installation will vary based on your needs.

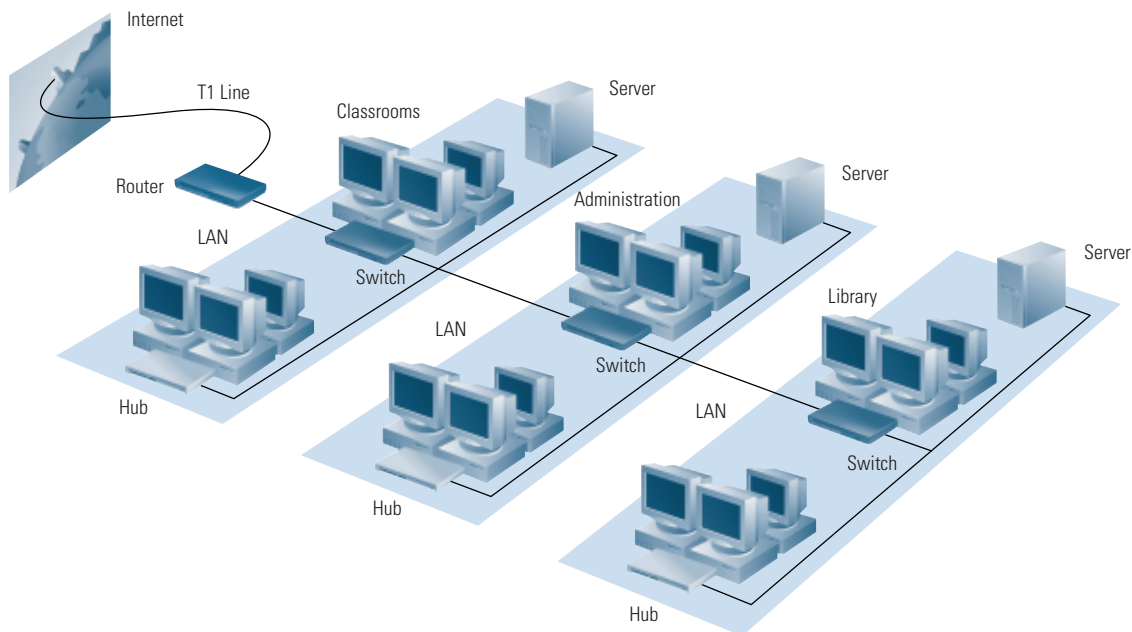
For Building a Small LAN

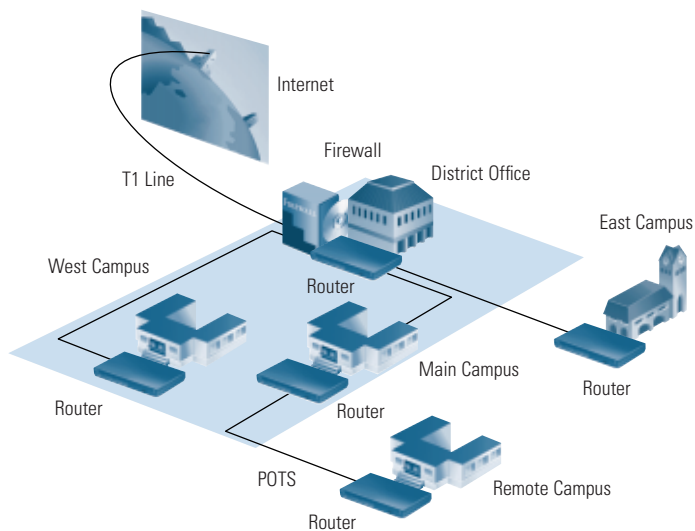
- Clients with NICs installed
- Server
- Switch or hub
- Cabling
- Network operating system software (for example, Windows NT, Windows 95, and Novell NetWare)
- Modem for dialup Internet access (optional)
- For Wireless Networking:
 - Clients with wireless NICs installed
 - Correctly deployed access points



For Connecting Buildings on a Campus

- Clients with NICs installed
- Servers
- Ethernet Switch
- Fast Ethernet Switch
- Cabling
- For Wireless Networking:
 - Clients with wireless NICs installed
 - Correctly deployed access points
- Network operating system software (for example, Windows NT, Windows 95, and Novell NetWare)
- Router for shared Internet access (optional)





For Connecting to Another Campus or District

- Clients with NICs installed
- Servers
- Hubs
- Switches
- Fiber Backbone—Fast Ethernet, EtherChannel® technology or Gigabit Ethernet
- Routers at each location for WAN connections, shared Internet access
- Access server for dialup access for remote users
- Cabling
- WAN service (ISDN, Frame Relay, or leased-line service from phone company)
- Network operating system software (for example, Windows NT, Windows 95, and Novell NetWare)

For Wireless Networking

- Building-to-building bridges

Training and Support

Studies of technology in campuses and colleges universally point to teacher training as a critical success factor. Investing in networking hardware and software is only the first step. Equipping faculty to integrate those tools in their lesson plans maximizes the value of technology investments.

Another frequently neglected aspect of productive network operation is support and management. Especially in smaller campuses and districts, it can be difficult to dedicate resources and personnel to the network full time. However, network reliability depends on planning for growth and monitoring for trends that could cause trouble in the future.

Networking equipment resellers offer training and support. In addition, peer assistance can prove invaluable, and some service providers organize user meetings and similar gatherings to help their customers use the Internet more effectively. Districts should consider the “train the trainer” model of spreading network expertise, which has proven effective across the country where a small group of technology “evangelists” share home-grown enthusiasm and expertise.

You also have unique options available for including networking studies as part of your curriculum to expand student opportunities and help support your campus needs for qualified support staff. For more information, visit <http://www.cisco.com/edu> on the Web and check out the Cisco Networking Academies Program.

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 FDDI). This feature 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.

Broadband

Broadband refers to telecommunication that provides multiple channels of data over a single communications medium, typically using some form of frequency or wave division multiplexing.

Cable Modem

A cable modem is a device that enables you to hook up your network to a local cable TV line and receive data at about 1.5 Mbps. In addition to the faster data rate, an advantage of cable over telephone Internet access is that it is a continuous connection.

DSL

Digital Subscriber Line (DSL) is a service that offers a much faster Internet connection than a standard dial up connection usually at a fixed price. DSL uses the existing phone line and in most cases does not require an additional phone line. This gives 24/7 access and does not tie up the phone line and cause it to have a busy signal.

Gigabit Ethernet

Gigabit Ethernet is the latest version of Ethernet. It offers 1000 Mbps (1 Gbps) raw bandwidth, that is 100 times faster than the original Ethernet, yet is compatible with existing Ethernets, as it uses the same CSMA/CD and MAC protocols. Gigabit Ethernet competes most directly with ATM and is forcing out FDDI and Token Ring.

Bridge

A device that passes packets between multiple network segments using the same communications media. 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.

Client

A networked PC or terminal that shares “services” with other PCs. These services are stored on or administered by a server.

Collision Domain

In Ethernet, the result of two nodes transmitting simultaneously. The frames from each device collide and are damaged when they meet on the physical media.

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.

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 can use the same cabling (if Category 5 cabling is used), applications, and network management tools. Variations include 100BaseFX, 100BaseT4, and 100BaseTX.

FDDI

A 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

A 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.

HTML

HyperText Markup Language. Document-formatting language used for preparing documents to be viewed by a tool such as a World Wide Web browser.

HTTP

HyperText Transmission Protocol. Protocol that governs transmission of formatted documents over the Internet.

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).

Internet

A massive global network, interconnecting tens of thousands of computers and networks worldwide. It is accessible from any computer with a modem or router connection and the appropriate software.

ISDN

Integrated Services Digital Network. Communication protocol offered by telephone companies that permits high-speed connections between computers and networks in dispersed locations.

LAN

Local-area network. Typically, a network or group of network segments confined to one building or a campus. Compare to WAN.

Modem

A device that enables a computer to connect to other computers and networks using ordinary phone lines. Modems “modulate” the computer’s digital signals into analog signals for transmission, then “demodulate” those analog signals back into digital language that the computer on the other end can understand.

Packet

A block of data with a “header” attached that can indicate what the packet contains and where it is headed. Think of a packet as a “data envelope,” with the header acting as an address.

POTS, PSTN

Plain Old Telephone Service (POTS) and Public Switched Telephone Network (PSTN). General terms referring to the variety of telephone networks and services in place currently worldwide.

Remote Access Server

A device that handles multiple incoming calls from remote users who need access to central network resources. A remote access server can allow users to dial into a network using a single phone number. The server then finds an open channel and makes a connection without returning a busy signal.

Router

A device that moves data between different network segments and can look into a packet header to determine the best path for the packet to travel. Routers can connect network segments that use different protocols. They also allow all users in a network to share a single connection to the Internet or a WAN.

Server

A computer or even a software program that provides clients with services—such as file storage (file server), programs (application server), printer sharing (print server), fax (fax server) or modem sharing (modem server). Also see “client.”

Switch

A device that improves network performance by segmenting the network and reducing competition for bandwidth. When a switch port receives data packets, it forwards those packets only to the appropriate port for the intended recipient. This capability further reduces competition for bandwidth between the clients, servers, or workgroups connected to each switch port.

WAN

Wide-area network. A data communications network that serves users across a broad geographic area and often uses transmission devices provided by common carriers. Compare to LAN.

Who is Cisco Systems?

Cisco Systems, (Nasdaq: CSCO) is the worldwide leader in networking for the Internet. Cisco Systems originated at Stanford University in the early 1980s and has since grown into the worldwide leader in network technology, with \$20 billion in annual revenue and more than 30,000 employees. Cisco products—including routers, LAN and WAN switches, dialup access servers, and network management software—leverage the integrated network services of Cisco IOS software to link geographically dispersed LANs, WANs, and IBM networks.

Cisco maintains its commitment to education through support for a wide array of educational programs, including: AASA; Consortium for School Networking (CoSN); Council of Great City Schools; EDUCAUSE; International Society for Technology in Education (ISTE); Internet Engineering Task Force (IETF); Internet Society; League for Innovation in Community Colleges; National Educational Computing Conference (NECC); National Learning Infrastructure Initiative (NLII); National School Board Association (NSBA); and Internet2.

Cisco solutions are the networking foundation for thousands of campuses and universities worldwide. Cisco is committed to helping education institutions establish interactive and engaging electronic relationships among students, teachers, administrators, suppliers, and a host of global learning resources. Under the Cisco “Global Networked Campus” model, educational institutions can boost productivity and enhance the learning experience they offer through networked applications such as business services, registration, student records, classroom resources, collaborative research, and more.

Cisco Networking Academy Program—A partnership with education institutions to educate high school and college students to design, build, and maintain computer networks. Graduates are prepared for testing to attain industry-standard networking certification.

The Virtual Schoolhouse Grant Program—Provides Cisco products, services, and training to enable Internet access in selected K-12 campuses.

NetDay (<http://www.netday.org>)—Cisco is a founding corporate member of this national program to wire America’s K-12 campuses.

TECH CORPS (<http://www.techcorps.org>)—Recruits, places, and supports volunteers from the technology community to advise and assist schools in the introduction and integration of new technologies into the educational system.

Internet2 (I2) (<http://www.internet2.edu>)—Announced in October 1996, this project is a collaborative effort joining more than 100 of America's leading universities, federal research institutions, and private companies to develop the next generation of computer network applications and Internet development. Cisco was the project's first corporate partner.

New Media Centers (NMCs) (www.newmediacenters.org)—A not-for-profit consortium of 85 higher education institutions and key technology companies partnering to enhance teaching and learning through the use of new media.

E-Rate (http://www.cisco.com/warp/public/779/edu/why_cisco/eratewhat.html)—Cisco Systems is committed to helping educational institutions take maximum advantage of their opportunities to leverage the Universal Services Fund. Cisco can be a valuable resource for preparing the networking portion of technology plans, which are a prerequisite when applying for E-Rate discounts.

Education World (<http://www.education-world.com>)—Cisco sponsors the News/Eye on schools section of Education World, including The Cool School of the week and year awards.

NETAID (<http://www.netaid.org>)—

A new, long-term effort to use the unique networking capabilities of the Internet to promote development and alleviate extreme poverty across the world. The NetAid Foundation serves as a global exchange point to link people to successful agents and agencies of change. NetAid's mission is to use the powers of the Internet to help the millions of men, women, and children who live on the edge of survival.

Cisco E-learning (<http://www.cisco.com/warp/public/10/wwtraining/elearning/>)—

E-learning will be the great equalizer in the next century. By eliminating barriers of time, distance, and socio-economic status, individuals can now take charge of their own life-long learning. To learn more point your browser to the URL listed above.





Corporate Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 526-4100

European Headquarters
Cisco Systems Europe
11, Rue Camille Desmoulins
92782 Issy Les Moulineaux
Cedex 9
France
www.cisco.com
Tel: 33 1 58 04 60 00
Fax: 33 1 58 04 61 00

Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
www.cisco.com
Tel: 408 526-7660
Fax: 408 527-0883

Asia Pacific Headquarters
Cisco Systems Australia, Pty., Ltd
Level 17, 99 Walker Street
North Sydney
NSW 2059 Australia
www.cisco.com
Tel: +61 2 8448 7100
Fax: +61 2 9957 4350

Cisco Systems has more than 190 offices in the following countries. Addresses, phone numbers, and fax numbers are listed on the
Cisco.com Web site at www.cisco.com/go/offices.

Argentina • Australia • Austria • Belgium • Brazil • Canada • Chile • China • Colombia • Costa Rica • Croatia • Czech Republic • Denmark • Dubai, UAE
Finland • France • Germany • Greece • Hong Kong • Hungary • India • Indonesia • Ireland • Israel • Italy • Japan • Korea • Luxembourg • Malaysia
Mexico • The Netherlands • New Zealand • Norway • Peru • Philippines • Poland • Portugal • Puerto Rico • Romania • Russia • Saudi Arabia • Singapore
Slovakia • Slovenia • South Africa • Spain • Sweden • Switzerland • Taiwan • Thailand • Turkey • Ukraine • United Kingdom • United States • Venezuela