Network Essentials for Small Businesses:
A Step-by-Step Planning Guide

Contents

Welcome!

Cisco Systems, Inc., the world's leading supplier of networking solutions for the Internet, has prepared this guide to make networking easier to understand and more approachable for your small or medium-sized business. If you're new to networking, it's an ideal introduction, starting with the most basic of components and helping you pinpoint the best technologies and design for your network. And if you already know your networking ABCs, look to this guide for straightforward explanations of key terms and concepts to keep building your knowledge base.

Cisco solutions are at the foundation of thousands of business networks worldwide, from large multinational corporations to single locations with as few as two users. Today, nearly all Internet traffic runs on Cisco solutions. So when you install Cisco, you're choosing the networking equipment that's proven suitable for the world's largest and fastest growing network.

For details on Cisco solutions for your network, call 800 553-NETS, or visit our Web Site at www.cisco.com/smbiz.

What This Guide Can Do for You

Most people wouldn't use the terms "networking" and "basic" in the same sentence. But 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 employees, customers, and suppliers, increasing productivity, and opening new paths to worldwide information resources. In this respect, networks are like cars. You don't have to know the details about the engine 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 business

The Building Blocks: Basic Components of Networks

While the term "network" has many definitions, most people would agree that networks are collections of two or more connected computers. Once their computers are joined in a network, people can share files and peripherals such as modems, printers, tape backup drives, or CD-ROM drives. When networks at multiple locations are connected using services available from phone companies, people can send e-mail, share links to the global Internet, or conduct video conferences in real time with other remote users.

Every network includes:

• At least two computers

• A network interface on each computer (a 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, although wireless communication between networked computers and peripherals is also possible.

• Network operating system software, such as Microsoft Windows 95 or Windows NT, Novell NetWare, Appleshare, or Artisoft LANtastic.

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

Basic Networking Components

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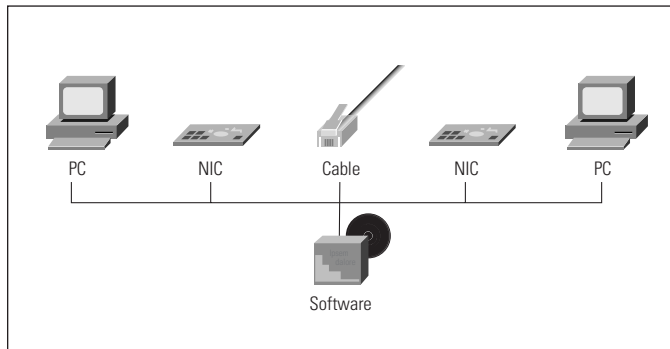

Figure 1: Basic Networking Components

Clients and Servers

Often, as the 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 dedicated 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*.

Note that you don't need to have a dedicated server in your network. With only a few computers connected, networking can be "peer to peer." Users can exchange files and e-mail, copy files onto each other's hard drives, and even use printers or modems connected to just one computer. But as more users are added to the network, a dedicated server can provide a central point for management duties such as file backup and program upgrades.

Wiring and Cable

There are three primary types of network wiring (also referred to as "media"):

Twisted-pair—the industry standard in new installations. This wire comes in several standards. Unshielded Twisted Pair (UTP) Category 3 wire, often used for phone lines, and UTP Category 5 wire are the current networking standards.

Coaxial—resembles round cable television wiring.

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 to adjacent buildings. Fiber optic cable is the most reliable wiring but also the most expensive.

Take care in selecting the cabling for your offices 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 example, Ethernet can use UTP Category 3 wiring. However, Fast Ethernet requires at least the higher-grade UTP Category 5 wiring. As a result, all new wiring installations should be Category 5. You may 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 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. In addition, you need to ensure that your NICs will support the type of cabling you will use—twisted-pair (also called 10BaseT), coaxial (also called 10Base2), or a mixture of both.

Hubs

Hubs, or repeaters, are simple devices that interconnect groups of users. Hubs forward any data *packets*—including e-mail, word processing documents, spreadsheets, graphics, print requests— they receive over one port from one workstation 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.
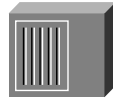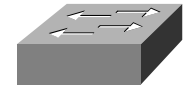
Examples:
Cisco Micro Hub series
Hewlett-Packard 10BaseT Hub-16M
Cisco FastHub series

For Example

To understand how a hub serves your business 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 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.

Switches

Switches are smarter than hubs and offer more dedicated bandwidth to users or groups of users. 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 once the conversation is done.

Examples:
Cisco 1548 Micro Switch 10/100
Cisco Catalyst® series

For Example

A switch would be like a phone system with private lines in place of the hub's "party line." Jane Tipton at the Berkley 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 any one time, so more guests can communicate.

Routers

Compared to hubs and switches, routers are smarter still. Routers use a more complete packet "address" to determine which router or workstation should receive each packet next. Based on a network road map 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 fails, 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 of protocols include Internet Protocol (IP), Internet Packet Exchange (IPX®) and AppleTalk. Routers not only connect networks in a single location or set of buildings but 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:
Cisco 700 series
Cisco 800 series
Cisco 1000 series
Cisco 1600 series
Cisco 1720 access router
Cisco 2500 series
Cisco 2600 series
Cisco 3600 series
Cisco 4000 series

For Example

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

Cable Modems

Cable modems offer extremely fast and relatively inexpensive access to the Internet. A cable modem connects directly to the same line that provides cable TV service to a home or business, and then to an Ethernet network interface card (NIC) in a PC.

While a traditional dial-up modem provides access at speeds up to 56 kilobits per second, a cable modem can deliver transmission rates of up to 10 megabits per second—nearly 200 times as fast. And unlike dial-up modems, cable modems have a connection to the Internet that is "always on." In other words, you won't face busy signals or delays while your computer connects to the Internet.

By the same token, since you are sharing the connection with multiple users on your cable system, your performance will depend on how many users are online at once. Another caution: in today's cable modem systems, users on a single segment of cable are essentially connected to a single local area network (LAN). To prevent neighbors from accessing files on a computer, that computer's file sharing options should be turned off.

Ready to sign up? You might need to be patient. About 65 million locations in the U.S. alone have cable service. But only a small percentage of those links are cable modem-ready—the rest will require upgrades to handle the two-way traffic of Internet surfing.

Upsides

- Extremely fast transmission rates for downloading Web pages and files (uploading to the Internet—mostly mouse clicks and e-mail—occurs at a slower but still quick speed of up to about 2 Mbps).

- Inexpensive service—about $50 per month today, or close to the cost of basic cable TV.

- Minimal requirements—all you need to make the connection is a relatively new PC, a cable modem (often leased from the cable company), an Ethernet card in the PC, and a connection point from your cable service provider.

Downsides

- Limited availability—at this writing, only about 10 percent of the U.S. has access to the upgraded cable systems needed to support cable modems. The experts say it will be about five years before the technology is widespread.

- Extra installation steps—gaining Internet access today can be as simple as installing a modem and browser software and calling your Internet Service Provider's access number. With a cable modem, the cable company most likely will need to send out a technician to check your wiring quality and install the device. You also will need to have an Ethernet card installed in the PC, if it doesn't already have one.

Example:
Cisco uBR 904

Digital Subscriber Line (DSL) Service

Digital Subscriber Line or DSL technology is a high-speed service that, like ISDN, operates over ordinary twisted pair copper wires supplying phone service to businesses and homes in most areas. DSL is often expensive than ISDN in markets where it is offered today.

Using special modems and dedicated equipment in the phone company's switching office, it offers faster data transmission than either analog modems or ISDN service, plus—in most cases—simultaneous voice communications over the same lines. This means you don't need to add lines to supercharge your data access speeds. And since DSL devotes a separate channel to voice service, phone calls are unaffected by data transmissions.

There are several flavors of DSL. ADSL delivers asymmetrical data rates (for example, data moves faster on the way to your PC than it does on the way out to Internet). Other DSL technologies deliver symmetrical data (same speeds going in and out of your PC).

The type of service available to you will depend on the carriers operating in your area. Because DSL works over the existing telephone infrastructure, it should be easy to deploy over a wide area in relatively little time. As a result, the pursuit of market share and new customers is spawning competition between traditional phone companies and a new breed of firms called Competitive Local Exchange Carriers (CLECs). If you choose DSL service for connecting your business to the Internet or for giving remote sites and users high-speed access to your central network, your carrier will help you install the appropriate hardware and software.

Example:
Cisco 675

Networking Technologies Overview

Local-Area Networks: Ethernet and Fast Ethernet

Ethernet has been around since the late 1970s and remains the leading network technology for local-area networks (LANs) or networks contained in buildings or on a single site. Ethernet is based on a standard referred to as carrier sense multiple access with collision detection (CSMA/CD). (See Token Ring in the Glossary section to learn about 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—when the network is "quiet." Otherwise, it waits to transmit, as a person might wait for another to speak during a conversation.

If multiple stations sense an opening and start sending at the same time, a "collision" occurs. Each station then waits a random amount of time and tries to send its packet again. After 16 consecutive failed attempts, the original application that sent it must 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 slow the network. 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, the network can slow dramatically or even grind to a halt.

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

Shared Ethernet is like a single-lane highway with a 10-Mbps speed limit. 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. Switched Ethernet look likes 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.
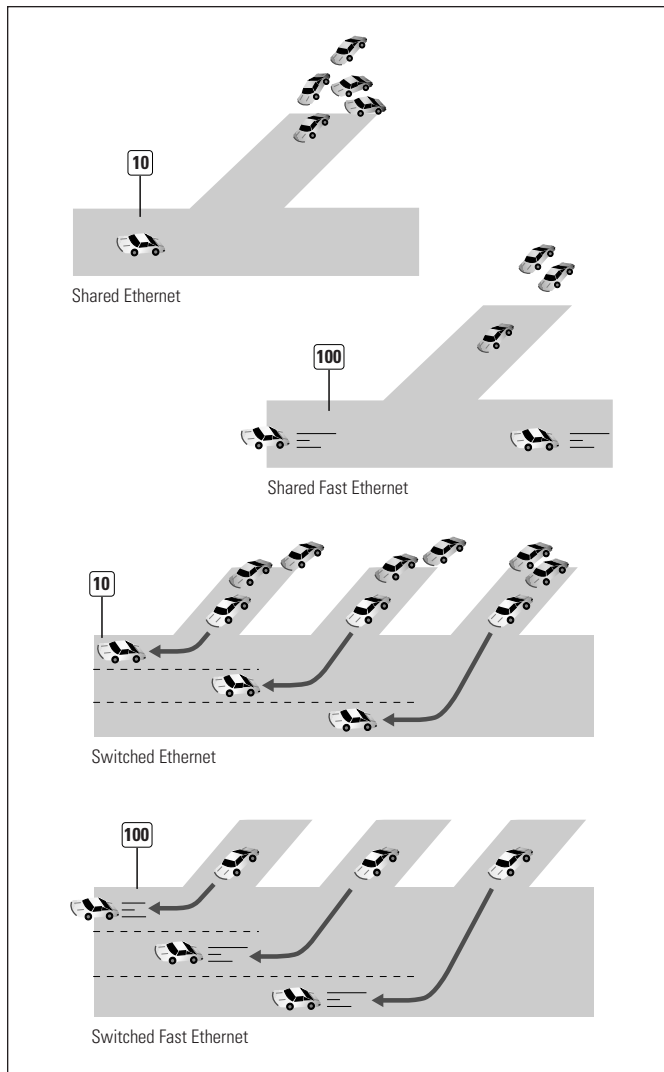

Figure 2: Types of Data Transmission

Remote Access and Wide-Area Networks

LANs accommodate local users—people within a building or on a campus. Wide-area networks (WANs) connect users and LANs spread between various sites, whether in the same city, across the country, or even 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 business gains access to the Internet through some type of remote connection. A single user can dial up an Internet service provider (ISP) via modem. 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 megabits per second (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 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.

Virtual Private Networks: A Cost-effective Alternative to Building Your Own WAN

As businesses grow, they need to connect a rising number of remote offices and individuals to their central network to share information and resources electronically. Traditionally, this has been accomplished by building a private wide area network (WAN), using leased lines to connect offices, and dial-access servers to support mobile users and telecommuters.

For a small or medium-sized business, a traditional private WAN can be costly to build and manage. The leased lines, telecommunications services and equipment needed to interconnect offices can be expensive, and each added location requires a new leased line. Individuals or small branches dialing into a central site via the public telephone network incur long-distance charges, and managing dial access servers at the central site can be resource-intensive and complex.

Now, businesses have an alternative for connecting remote sites and users to the main company network—virtual private networks (VPNs). A VPN offers the security and full data access of a private wide area network, but since it runs over the Internet, it is more affordable and flexible.

- **More affordable**—Remote users can connect with central network resources through a local link to an Internet Service Provider, at the price of a local call. This is a much more cost-effective method than making a long distance call to the central site.

- **More flexible**—New sites can be added easily, without need for extensive new equipment or an additional, dedicated private line. VPNs also simplify the task of creating an {extranet}, which gives customers or suppliers password-protected to a portion of a private network—for example, to order products, check status of shipments, or submit invoices.

- **More reliable**—VPNs leverage the equipment and full-time expertise of the vast public network infrastructure and the companies that oversee it.

How VPNs Keep an Internal Network Safe

Offering access to your internal network through the Internet might seem like a recipe for data disaster, but VPNs use tunneling and encryption to protect your private traffic. Tunneling creates a temporary, point-to-point connection between the remote and central sites, blocking access to anyone outside. Encryption scrambles the data on the sending end and reassembles it on the receiving end, so it cannot be read or changed while in transit.

What You Need to Build a VPN

You can build and maintain your own VPN, but most small and medium-size businesses will find it easier to rely on a Service Provider. In this case, you simply connect to the Service Provider using routers (for sites with multiple users or heavy-duty usage) or modems (for individuals or branch offices with light usage)—just as you might connect your central site and remote users to the Internet. Note that there are two types of VPNs—dial VPNs and dedicated VPNs. This means VPNs can leverage the low cost of ordinary dial-up services, or, where a high-speed, high-capacity remote link is needed, they can operate over frame relay services or leased lines.

Once you implement a VPN, the offices in your network will need a firewall to act as a "sentry" to protect your network from unauthorized users. This firewall can be a stand-alone device, but for small networks, firewalls can be integrated into a server or router, simplifying management and lowering capital cost.

Keep in mind that using a VPN means relinquishing some control over your network. Be sure to find a Service Provider who can provide a strong service level guarantee (99 percent uptime or better) and support the protocols you are using (most likely, IP or Internet Protocol) with minimal latency or traffic delay. If you have sites in multiple countries, you also may want to look for a Service Provider that already has—or is planning to have—local points or presence in the nations where you operate. This keeps your costs down by minimizing long-distance charges: your sites connect using local calls.

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 lines. 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 at 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 Web sites on the Internet, you should choose modems that operate at a minimum of 33.6 Kbps (also called V.34) and that have V.42 (error correction) and V.42bis (data compression) capabilities.

While modems offer a simple solution for dial-out 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. (Find more information in the *Small Business Networking Examples* section about overcoming this limitation by installing a router for wide-area communications and your Internet link.)

"Dial-on-demand" routing is sometimes used as a compromise between the dialup method of connecting and full-fledged routing. With dial-on-demand routing, 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, makes the calls as requested by the router.

ISDN

ISDN 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 a flat rate, if they are linked to a local CENTREX system.

Technically, ISDN comprises two 64 Kbps channels that work separately. Load-balancing or "bonding" of the two channels into a 128-Kbps single channel is possible when you have compatible hardware on each end of a connection (for example, between two of your sites). What's more, as a digital service, ISDN is not subject to the "line noise" that slows most analog connections, and thus it 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.

Leased Lines

Phone companies offer a variety of leased-line services, which are digital, permanent, point-to-point communication paths that 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. Most appropriate leased lines for small and medium-sized businesses range in speed from 56 Kbps to 45 Mpbs (a T3 service). Because they all work the same way, choosing the right line for you depends on the number of users and the amount of remote traffic the network will carry (and how much bandwidth you can afford). A common service for businesses with substantial WAN usage 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 business or branch office to the phone company's switch, and then to your other offices. Often, the phone or data services company may need to install new cabling.

Which Service Is Right for You?

The best service depends first of all on what is available in your area and then on what your usage will be and how much the services cost.

Analog services are least expensive, widely available and easy to use. ISDN and DSL cost somewhat more, but both improve performance over even the fastest analog offerings at present. ISDN is more widely available than DSL and Cable which makes it more viable. Cable modems are faster still and inexpensive for Internet access, but they are available only in a small percentage of locations at present. Leased lines are the costliest of these options but offer dedicated, digital service for more demanding situations. Which option is best? Answer the following questions:

- Will employees use the Internet frequently?

- Will you use the Internet for conducting business (e.g., inventory management, online catalog selling or account information, bidding on new jobs)?

- Do you anticipate a large volume of traffic between branch offices of your business?

- Do you plan to use videoconferencing or video training between your locations?

- Who will use your main office's connection to the Internet—individual employees at the central office, telecommuting workers dialing in from home, mobile workers dialing in from the road?

The more times you answered "yes," the more likely it is that you need to move up the scale of connectivity choices—away from analog lines toward ISDN, DSL, or even leased lines.

It is also possible to mix and match services. For example, small branch offices or individual employees dialing in from home might connect to your central office using ISDN or DSL, while the main connection from the central office to the Internet would be a T-1.

Which service you select also depends on what your Internet Service Provider (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 T-1 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.

Also consider that a VPN can allow you to extend full private-network and Internet access to remote offices and individuals, at a significant savings compared to using leased lines or long-distance calls for remote connectivity. Ask yourself these additional questions:

• Are you adding remote sites or remote users at a rapid pace?

• Are your current remote-access line costs rising rapidly?

• Would you rather focus on your core business than on building a WAN?

• Do you plan to create an extranet, and offer password-protected access to suppliers, customers or other trading partners?

If you answered "yes" to any or all of these questions, you may be a good candidate for a VPN. Contact Service Providers for details on their VPN offerings.

Small Business Networking Examples

A Local-Area Network for a Small Office

This LAN starts simply—shared Ethernet, with a pair of servers and analog modems connecting employees to the Internet. Employees can share documents, presentations, spreadsheets and customer reports between computers; they can dial up the Internet for occasional research; they can communicate via e-mail; and the business can save money by sharing printers, modems and hard-drive storage between users.
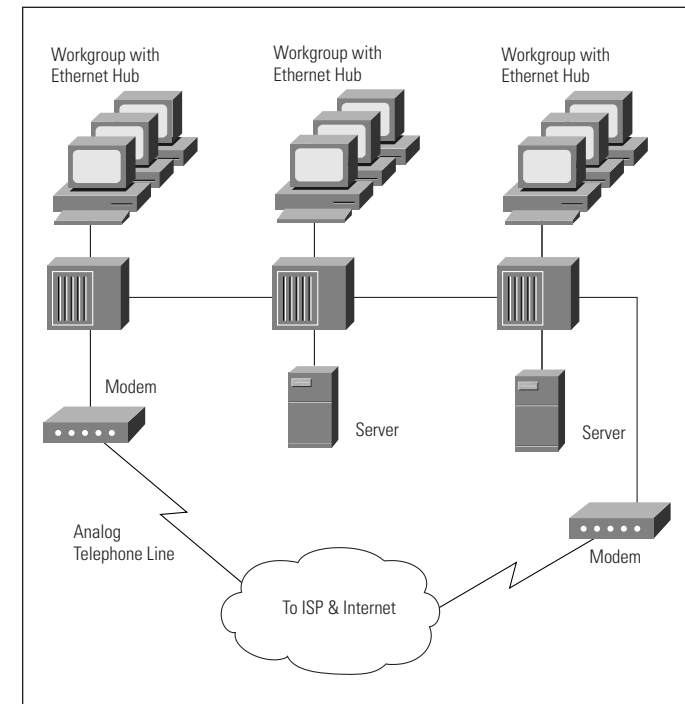

Figure 3: Small LAN

As the Office Network Grows

Unfortunately, this network can't accommodate the growing demands of the business. Too many users are competing for the 10 Mbps Ethernet network pathway. Only one user can connect to the Internet at one time from a modem. And as employees begin incorporating more graphics in their files and sending these files back and forth between their clients and the server, network performance stumbles.

The solution is to segment the network using Ethernet switches and add a router for Internet connections. This provides more bandwidth for all employees and permits multiple simultaneous links to the Internet through one line. The business can give product designers using bandwidth-hungry computer-aided design (CAD) programs the performance they need and dedicated 10-Mbps Ethernet channels to their individual workstations. And the network upgrade saves money by incorporating existing equipment and wiring.
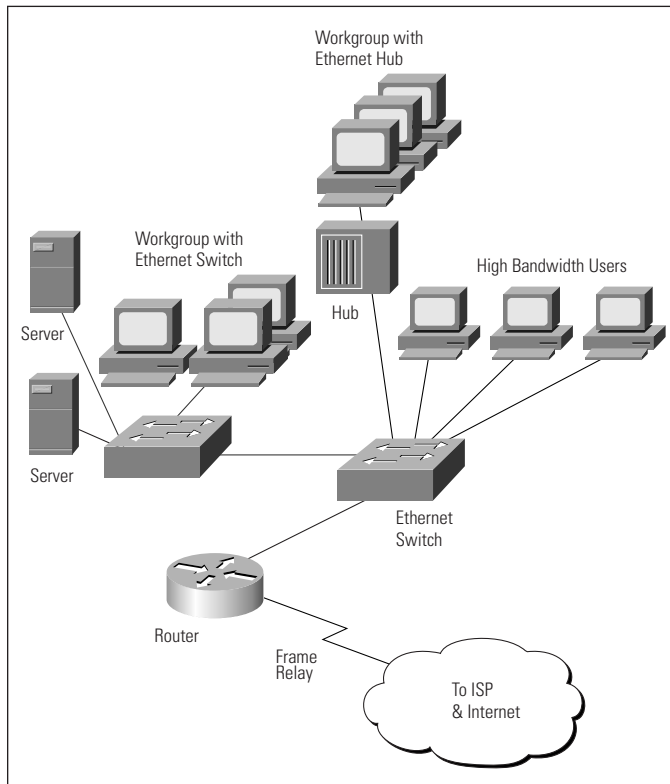

Figure 4: Growing LAN

A Wide-Area Network for Multiple Small Sites

To improve communications between a pair of small remote offices and a central office, a business decides to install a wide-area network. The upgrade also will allow the business to economize on Internet connectivity by offering all offices a link through a central high-speed line.
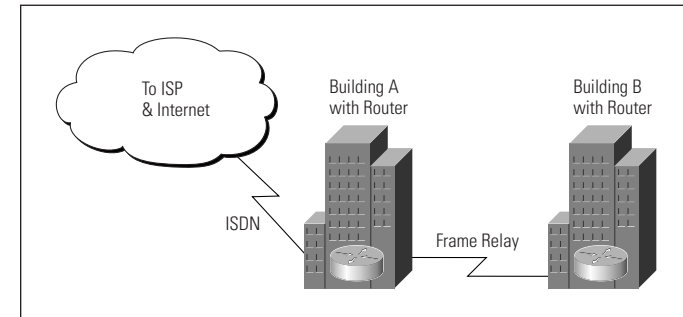

Figure 5: Small WAN

A High-Performance WAN

A growing business sees rising network traffic at its three locations in different cities. It wants to install future-ready local networks to support rapidly rising traffic volumes. It also wants to provide high-speed WAN links to allow employees at the Chicago and Omaha offices to take advantage of video training which originates at the Minneapolis office. In addition, because several sales employees work from home, the business wants to allow them to dial up their local servers from home.
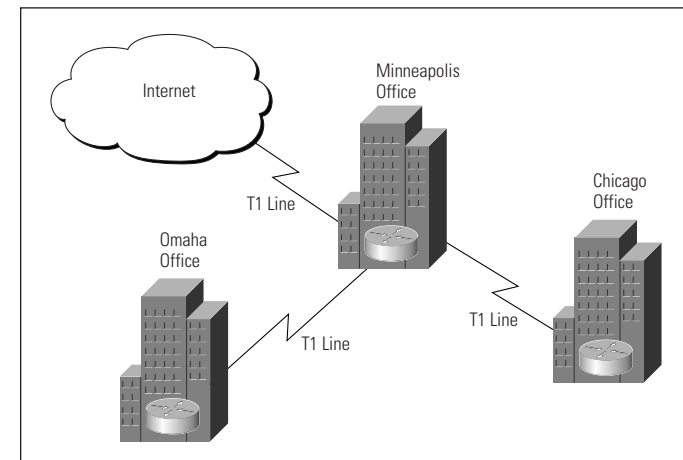

Figure 6: High-Performance WAN

A Small-Scale Virtual Private Network (VPN)

A small business is adding remote sites and users at a hectic pace. Connecting them all via leased lines and dial-up access would require the business to devote more time to administering its wide area network and would mean dramatically higher line charges and long-distance phone bills each month. Instead, the company chooses to implement a VPN, with help from its Service Provider. The Service Provider has access points to its network across the nation, so the remote users can connect with their company's central network using inexpensive local calls. At the central site, a Cisco 1720 VPN Access Router provides an all-in-one solution for connecting to the Service Provider (and the public Internet). It integrates a router, firewall, encryption and tunneling services, password protection, and a high-speed link to the central site's LAN.
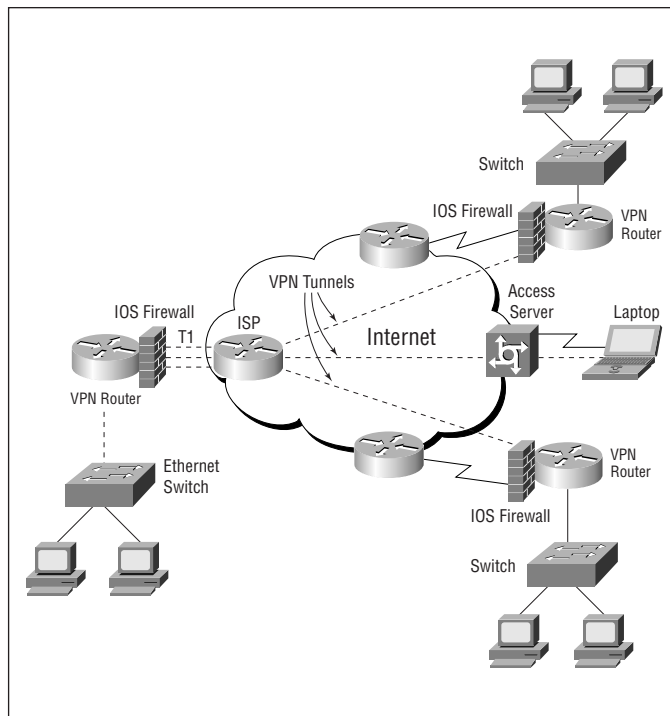

Figure 7: Small-Scale VPN

Making the Right Connection: Network How-Tos

How to Connect to the Internet

The Internet is a global network of thousands of computers, growing by leaps and bounds each year. It allows a global 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 businesses, universities, and governments, simplifying information gathering and providing a medium for an increasing amount of electronic trade in both goods and services.

A great number of businesses still lack Internet connections. If your business is among them, you will be pleased to hear that connecting to the Internet is easier than ever.

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 range of prices, based on a range of line speeds up to T3 (45 Mpbs) 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 your local-area network, allowing multiple users to access the Internet.
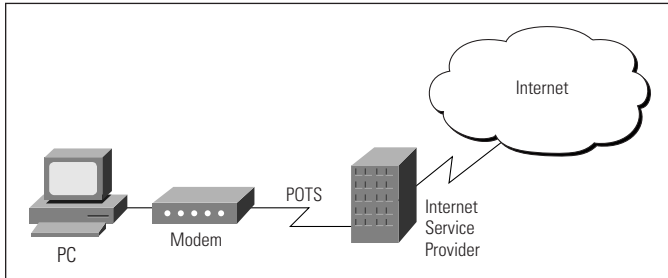
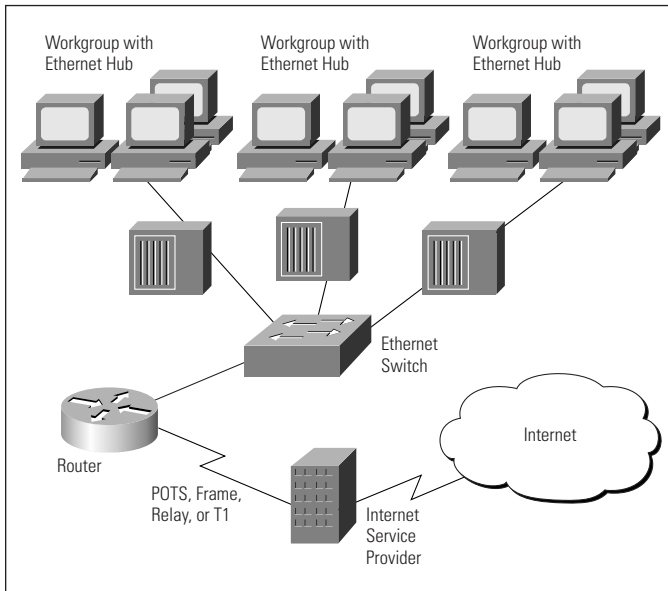*Figure 8: Dialup Access*

Figure 9: Shared Access

Modem connections are inexpensive and easy to acquire, so they can be a good idea if you're just starting out, or if your business has only a few users or computers. But 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 connections to the Internet. 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 have a growing array of ISPs to choose from, and they offer a wide range of services and pricing structures. An ISP can be a commercial business or a local university, state agency, or nonprofit organization. You can find out about ISPs in your area through the Internet, from advertisements and the yellow pages, and from Internet books and guides. You also will find a list of ISPs on the World Wide 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.

Support

If your business does not have its own networking expert or staff, you'll need extra ISP support. 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. 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.

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. Also note that as of this writing, standards for 56-K modems were still not solidified. Make sure your 56-K technology is compatible with your ISP's.)

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 office 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 the 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.

If you are a dialup user, 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.

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

• Domain Name System (DNS)—provides translation from Internet computer names (for example, cisco.com) to numerical addresses (for example, 198.92.30.31).

• Electronic mail service—establishes e-mail accounts and allows users to receive and send e-mail. USENET news—Maintains a local usenet news conferencing system.

• World Wide Web or Gopher publishing—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 (find more information in the following section, *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 **HyperText Markup Language (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 system. 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.

Once you have created your Web site, the next step is publishing it. For a monthly fee, 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 (www.cisco.com is Cisco Systems' domain name).

You can also establish a dedicated server in your own business. 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.

Basic Network Design:
Issues and Answers

A Problem Solvers' 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's 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.

- A rapidly growing number of users accessing the Internet.

- The increased power of new PCs and servers.

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 relatively short. 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 time-out and disconnect, and applications or operating systems may actually crash, requiring a system restart. But 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, special network monitoring equipment, such as protocol analyzers or remote monitoring (RMON) devices, may be required.

There are many variables to consider when trying to determine what constitutes acceptable utilization, including the number of stations on the LAN, software or application behavior and network traffic patterns. In other words, is most traffic between users and a local server, or are users reaching out of their own segments across the network and creating congestion? For most small business environments, any of the following utilization levels can be used as "rules of thumb" for determining 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 worst hour of the day

- 50 percent averaged over the worst 15 minutes of the day

Dissatisfied Users

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

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 hub. A logical connection can be defined in your network software, so that users in one area of a building can be in the same logical network segments as a server located at the opposite end of that building.) 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.

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 a network and as they send larger files across a network, the traffic loads rise.

In the *Small Business Networking Examples* section of this guide, we demonstrated how breaking a network into multiple "subnetworks" or separate collision domains could alleviate congestion.

Ethernet switches, Fast Ethernet hubs, and Fast Ethernet switches immediately and dramatically improve network performance compared to 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 adding a lane and increasing the speed limit (in the case of a Fast Ethernet switch).

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), the performance difference between the two technologies is relatively minor. In this case, 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 (NICs).

Fewer Larger Files

"Bursty" or sporadic traffic with large file transfers and power users running high-bandwidth applications require a different approach. An example of sporadic traffic with large file transfers is a group of engineers working in a CAD program. Because these types of large files take too long to arrive at 10 Mbps, high-speed shared 100BaseT hubs provide the wider, faster "data highway" the engineers need.

Many Larger Files

For sustained, large-file traffic such as with network backups, Fast Ethernet hubs—or Fast Ethernet switches—provide the best solution. They can increase throughput and speed of the transactions, reducing the impact on the backbone and minimizing network 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 (break it into smaller "collision domains") and then give each segment a dedicated network link or highway lane at up 100 Mbps. You also can give popular servers their own 100-Mbps links. Most often in today's networks, a Fast Ethernet switch will act as the "backbone" of the LAN, with Ethernet hubs, Ethernet switches or Fast Ethernet

hubs 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 links to the network.

Streaming Multimedia

Finally, for single-server environments running streamed multimedia applications (such as video training over the network), the large overall bandwidth of Fast Ethernet switches is the best solution. These swtiches can provide dedicated 100-Mbps connections to each server. Switches also can provide additional relief by containing multicasts —transmissions sent over the network to a single address, to which multiple client computers can listen.

Making the Most of Your Existing Equipment as Your Network Evolves

How you boost performance depends partly on what networking equipment you already have installed—including network interface cards (NICs), PCs and servers, and cabling.

For example, Fast Ethernet hubs 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 hubs 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 NICs are already installed, Ethernet switches are a good idea. They provide an immediate boost in performance without sacrificing your current investment in NICs. See the table below for other minimum requirements for Ethernet and Fast Ethernet network connections.

As noted previously, whether you choose to install Ethernet switches or Fast Ethernet hubs, we highly recommend that you install 10/100-Mbps NICs in any new PC or server, because the incremental cost for these adapters is marginal. 10/100 NICs also take advantage of the 30- to more than 90-Mbps throughput and power of EISA and PCI computers.

Cabling is an additional equipment consideration when deciding on switched or Fast Ethernet. Switched Ethernet runs on the common two-pair Category 3 cabling that many companies have installed as well as Category 4 and Category 5 UTP (unshielded twisted pair) cabling. But 100BaseTX, the most commonly used Fast Ethernet implementation, requires Category 5 cabling. All new UTP cable installations should be Category 5.

Networking Basics Checklists...

The following checklists provide a general idea of the components you will 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

- Hub

- Cabling

- Network Operating System software (e.g., Windows NT, Windows 95, Novell Netware, LANtastic, and AppleShare.)

- Modem for dialup Internet access (optional)
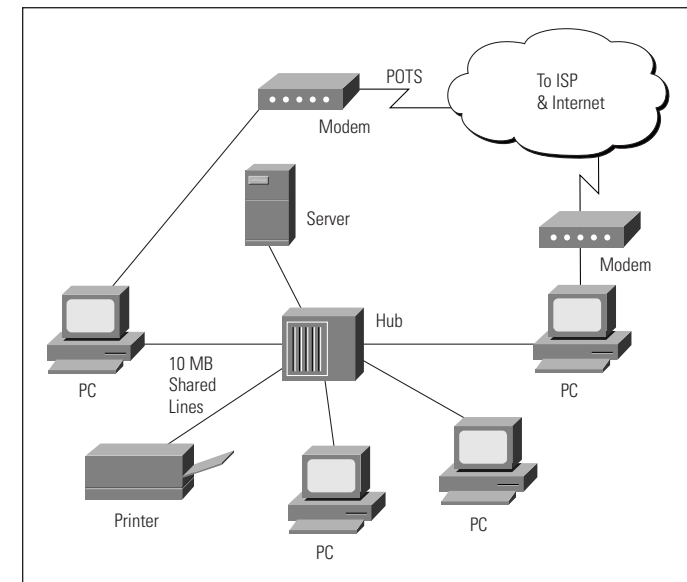
Figure 10: Building a Small LAN

For Connecting Offices and Departments

- Clients with NICs installed
- Servers
- Hubs
- Switch
- Cabling
- Network Operating System software (e.g., Windows NT, Windows 95, Novell Netware, LANtastic, and AppleShare.)
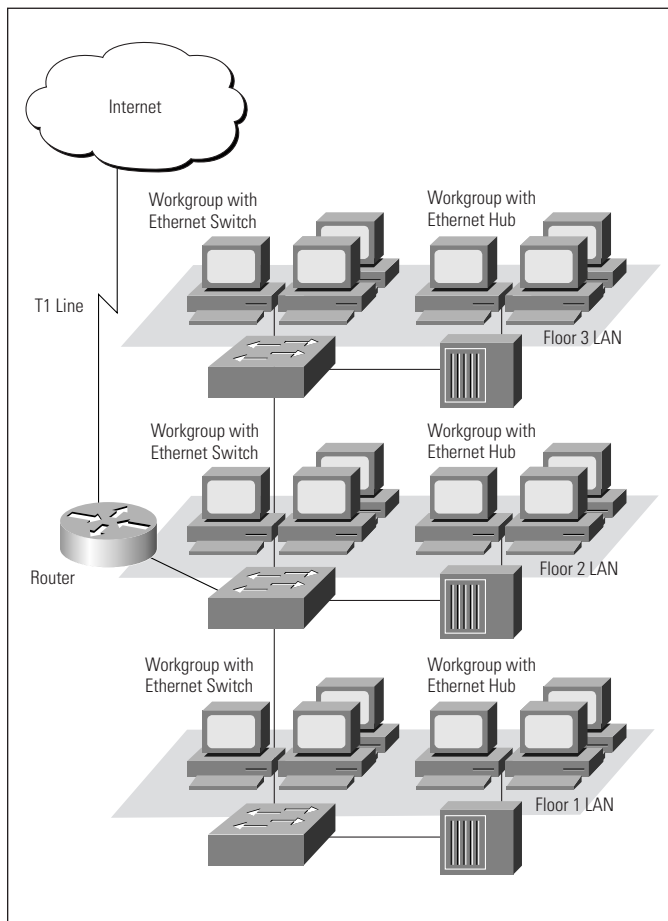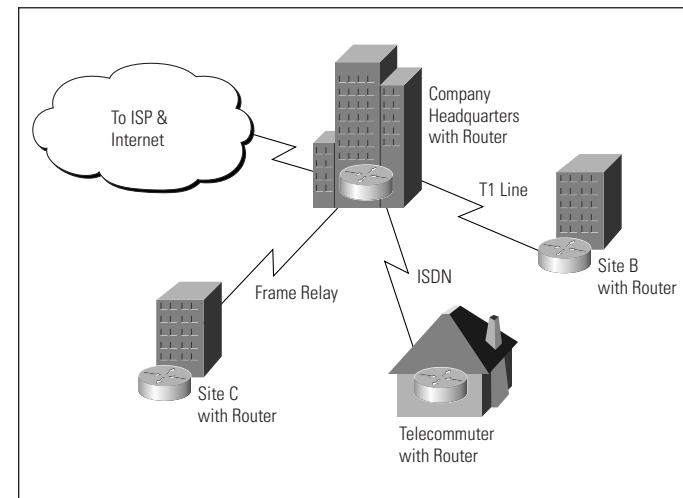- Router for shared Internet access (optional)

Figure 11: Connecting Offices and Departments

For Connecting Dispersed Office Sites

- Clients with NICs installed
- Servers
- Hubs
- Switches
- 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 (e.g., Windows NT, Windows 95, Novell Netware, LANtastic, and AppleShare.)

Figure 12: Connecting Dispersed Office Sites

Glossary

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 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 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.

DSL	digital subscriber line. 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 10BaseT.
Extranet	A network that provides access to company documents such as price lists, inventory reports, shipping schedules and more to external users—such as your suppliers, independent sales agents and dealers.
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.
HTML	hypertext markup language. Simple document formatting language used for preparing documents to be viewed by a tool such as a worldwide 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 and accessible from any computer with a modem or router connection and the appropriate software.
Intranet	An internal network that leverages some of the same tools popularized on the Internet (browsers for viewing material, HTML for preparing company directories or announcement, etc.).
ISDN	Integrated Services Digital Network. Communication protocol offered by telephone companies that permits high-speed connections between computers and network 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	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.
Remote Access Server	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	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 services to clients—such as file storage (file server), programs (application server), printer sharing (print server), fax (fax server) or modem sharing (modem server). See also 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 further reduces competition for bandwidth between the clients, servers or workgroups connected to each switch port.
Token Ring	LAN technology in which packets are conveyed between network end stations by a token moving continuously around a closed ring between all the stations. Runs at 4 or 16 Mbps.
VPN	Virtual Private Network. Enables IP traffic to travel securely over a public TCP/IP network by encrypting all traffic from one network to another. A VPN uses "tunneling" to encrypt all information at the IP level.

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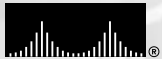
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