Topic A: Networking Fundamentals

Explanation

To start with, you need to be familiar with the common terminology associated with networking environments, as well as the different types of networks available. The types of networks available include legacy, peer-to-peer and client/server environments.

Types of Networks

In working with networks, you will probably encounter one or more types of networks, such as legacy networks, peer-to-peer networks and client/server networks.

Legacy Networks

You might at times encounter or want to incorporate a new computer network with a legacy network. Typically, the term *legacy* is used to define an existing mainframe or minicomputer environment.

Traditional mainframe and minicomputer operations are set up in a centralised processing environment. The features characterising this type of environment include:

- All processing takes place at the central computer.
- Dumb terminals, or terminals having no processing power, provide user access to the mainframe/minicomputer.
- Most applications are custom-built. Therefore, there are only a limited number of off-the-shelf software products available for purchase.
- Support staff is needed for management and control.
- Incremental growth is prohibitively expensive.

Peer-To-Peer Networks

In a peer-to-peer environment, also referred to as a workgroup solution, systems both provide and receive services. Each workgroup member acts both as a server and as a workstation. Resource and security management is handled at the individual system level. The software providing these services might run as a separate application or might be integrated into the operating system.

Features characterising this type of environment include:

- Workstations normally store their own application and data files.
- Processing occurs at the workstation. Therefore, speed is primarily a factor of the workstation used.
- Each node on the system talks to all other nodes.
- Peer-to-peer communications make some level of file and printer sharing possible.
- No one system is in charge of the network.
- Security might be limited.

- This type of system doesn't work well with more than approximately 10 workstations or nodes because Microsoft limits most peer connectivity to 10 simultaneous connections to a drive, shared folder, printer and so on.

Windows 95, Windows 98, Windows NT Workstation, Windows 2000 Professional and Windows XP Professional have integrated support for peer-to-peer configurations.

Client/Server Networks

In a client/server environment, there are separate systems for providing resources (servers) and for accessing resources (clients). Resource and security management is fully centralised. If the servers and workstations reside within the same building or a small geographical area, this type of environment is typically referred to as a Local Area Network (LAN).

The client/server model provides distributed processing due to the following:

- Application and data files can be stored on the server.
- Files are downloaded to intelligent workstations (clients) for processing.
- Results are uploaded to the server for storage.
- The server might provide additional services, such as printing or communications support, to the client.

Most high-level network operating systems use the client/server model. Novell's NetWare and Microsoft's Windows 2000 Server and Windows Server 2003 operate in a client/server environment.

There are some similarities between mainframe, minicomputers and LAN operations. PC LANs owe several of their features to ideas first developed in the mainframe world:

- **Multiple users.** Users are able to share data and critical resources quickly and easily.
- **Shared data.** Data files are accessed by different users on the system, making it easier for people to work together.
- **Common applications.** Applications training and support become more efficient and easier to handle.
- **Shared resources.** Selected hardware resources are made available to all (or specified groups of) network users.
- **Centralised security system.** Limits access to sensitive data. Also improves data security through password protection and central backup of all data files.

Other benefits of PC LANs include:

- **Standard PC hardware.** Typically, standard PCs are used as network servers and workstations. In some cases, Apple Macintosh and UNIX-based systems might be found in the network as well. This provides a great deal of design flexibility, relatively uncomplicated maintenance and helps keep costs to a minimum.

- **Fault tolerance.** Usually, a number of fault tolerance features are supported and implemented, such as UPS (Uninterruptible Power Supply), RAID and more recently, Cluster technology. This improves reliability and minimises network downtime.
- **Communications.** In the majority of LANs, an electronic messaging or groupware system is in place, making communications between users easier and more effective.

There are significant differences between LAN and mainframe computing:

- LANs are less expensive to implement.
- LANs support a wide range of off-the-shelf products.
- LANs incorporate a modular design that makes incremental expansion possible with ease.

Note: Installation of a LAN doesn't always mean replacement of a mainframe or minicomputer system, but it might involve integration of the LAN and the legacy system.

Another aspect of a LAN is that is uses private wiring that is internal to the company in which the LAN operates.

CANS, MANS and WANS

As networks in geographically contiguous buildings begin to be connected, a c*ampus area network* (CAN) is formed. As is true for multiple networks contained within a single building (still a LAN), a backbone might connect multiple buildings that are geographically contiguous. The distance, physical environment and transmission speed requirements combine to determine the network design components.

Metropolitan area networks (MANs) connect networks that are non-contiguous, but located within a local calling area. Local telephone companies or Alternate Service Providers (ASPs) supply telecommunications facilities to link the locations together. Exhibit 1-1 shows examples of CAN and MAN.

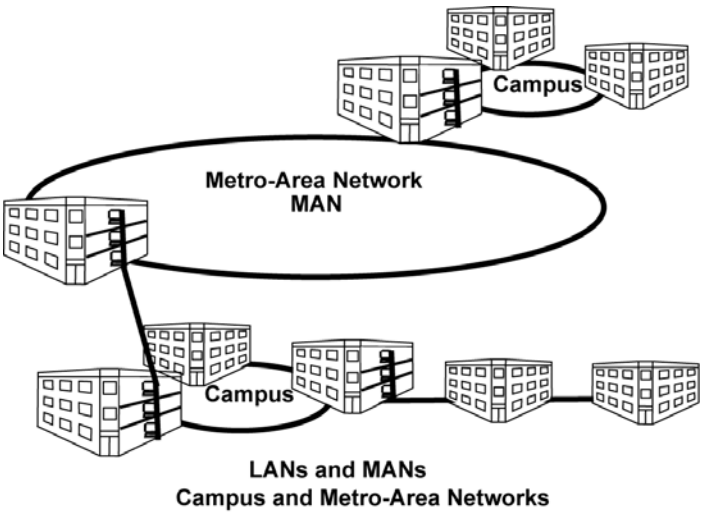

Exhibit 1-1: Examples of CAN and MAN

A wide area network (WAN) links networks that are located in different local calling areas, known as Local Access Transport Areas (LATAs).

Wide area networks (WANs) expand the basic LAN model by linking LANs to communicate with each other. By traditional definition, a LAN becomes a WAN when you expand the network configuration beyond your own premises and must lease data communication lines from a public carrier. WANs support data transmissions across public carriers by using facilities such as dial-up lines, dedicated lines, or packet switching, as shown in Exhibit 1-2. A WAN is characterised by:

- Wide geographic area, any size up to national or international
- Low- to high-speed links
- Remote links that might be operational LANs or groups of workstations only

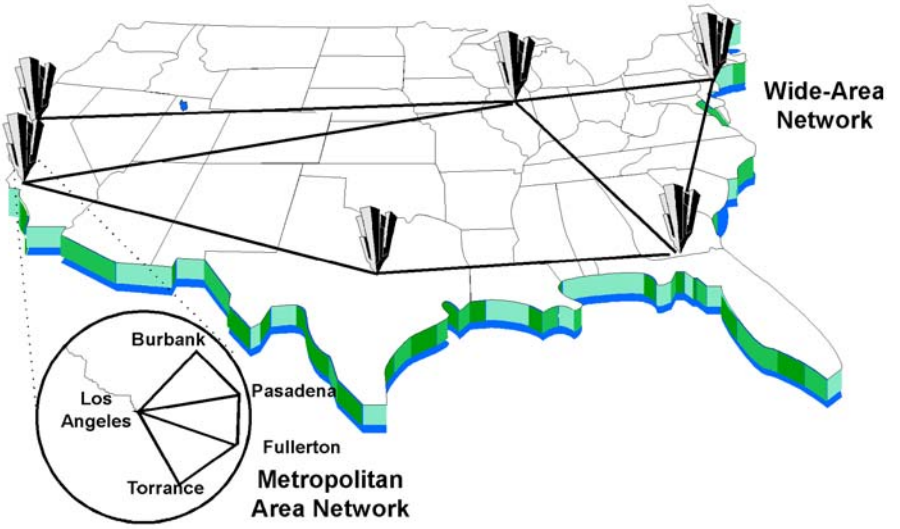

Exhibit 1-2: A Wide Area Network (WAN)

The Role of Network Operating Systems

Explanation

A network operating system (NOS) runs on the server in a client/server network configuration and turns a PC into a network server. Examples of NOSs include Microsoft Windows NT/2000 Server/Server 2003, Novell NetWare, IBM OS/2, Banyan VINES, Mac OSX, AppleShare IP, UNIX and Linux. A LAN can support multiple types of network operating systems concurrently.

Each workstation runs software that gives it access to the network and makes it possible to use the network's shared resources. The client software is a core portion of the workstation's operating system. For example, earlier versions of Windows included compatible client software for a variety of network operating systems and in newer versions of Windows, client software is tightly integrated after installation.

The final software components are end-user applications and data files. Some applications make it possible for users to share data files and access

shared data. This functionality is built into an operating system. More advanced applications take advantage of the network by making it possible for users to access shared databases, communicate with each other through electronic mail, or even collaborate in real time with video conferencing software and other advanced solutions.

Network Advantages

A network has a number of advantages over stand-alone PCs. By giving users access to network services and applications, you can:

- **Reduce costs.** Cost savings come from reduced hardware requirements for each workstation. In addition, licensing for LAN applications is usually less expensive than for multiple copies of stand-alone products.
- **Streamline operations.** Files can be shared through the network instead of manually carrying copies of the file to others by using disks or other media. You can also support simultaneous multi-user access to databases.
- **Improve end-user support.** Networks make it possible for you to enforce common applications with consistent levels and versions. File support is centralised and most file maintenance can be performed from any network location.
- **Improve security.** Data is physically protected by storing it in a central location where it is easily backed up. Access to data can be limited according to user needs.

Network Pitfalls

A network doesn't, however, replace good policies and procedures, appropriate applications, or users trained to a minimum level of competency. In fact, it has some pitfalls:

- Not all applications are fully network-compatible: Some stand-alone application packages won't work on a network. Others might work but need special management.
- You must take care while setting access privileges and directory structures: Without careful planning, a network can quickly become a management nightmare if not a complete disaster.
- Multiple, competing standards are available: This can make your initial decisions about setting up a LAN confusing.
- The network needs regular, ongoing maintenance, like any other computer system: An improperly installed and managed network can be worse than a set of unconnected personal computers.

Servers, Workstations and Hosts

Servers, workstations and hosts are components of any networking environment. Servers are computers that run network operating systems, workstations are personal computers that are connected to a network and hosts are network devices that have a TCP/IP address.

Servers

The NOS turns a personal computer into a network server. Servers on most networks are computers that have been optimised to run a network operating system. They might include multiple processors, redundant power supplies and heavy-duty cooling systems and they will have significantly more RAM and hard drive space than other machines in the office.

Some network operating systems need a dedicated server, that is, the computer running the NOS cannot be used for any other purpose. It is strictly a server. This is the case with Novell NetWare.

Other network operating systems make it possible for the server to perform other functions. For example, you can compose a letter by using a word processing application on a Microsoft Windows 2000 or Server 2003 server. However, server resources are typically best used for processing user requests; therefore, using the server for these types of tasks is not recommended.

Workstations

A workstation can be described as a personal computer that is connected to a network, which can perform tasks through applications or utilities. The term client or station might also be used. While a workstation can share resources such as files with other network users, this is not the workstation's primary function. A workstation must be connected to a network using some type of media, such as a cable or through a wireless connection and it must have a networking protocol, such as TCP/IP, installed.

Hosts

A host is any network device that has a TCP/IP address. In the context of network operating systems, a host can be a server, a workstation, or other peripheral device, such as a printer, print server or fax server.

Topic B: Types of Servers

Explanation

A network operating system provides basic network services, such as resource sharing and centralised management. For additional functionality, network software and peripherals can be added. While these options may or may not be included with the network operating system, many are available from the NOS (network operating system) manufacturer, as well as from third-party companies. These options supplement the network by adding additional services.

Many of these optional components do not necessarily need a dedicated server. They can be loaded as a process or service on a server you already own. If your current servers are already running at high utilisations, or the addition of the optional service will overload a marginal server, you might want to consider dedicated equipment to balance the load.

Fax Servers

A *network fax* server permits users to send and, in some cases, receive facsimiles at their network workstations. Fax servers manage the re-direction of faxes to the appropriate location. There are many companies currently offering fax server products. Some fax servers are software-based products that are loaded on a server, while others are separate hardware devices.

Before selecting a product, make sure it meets your requirements. Some of the items to be considered are:

- Is it compatible with your network operating system?
- What are the hardware requirements?
- How many inbound and outbound phone lines will it support?
- Does it need any special telephone lines?
- Will it integrate with your electronic mail system?

Sending Faxes

Most products permit faxes to be sent by simply selecting a special print device under Windows 95/98/NT/2000/XP. In actuality, the print device is not a printer at all, but rather a fax service that is advertised on the network in the same way as shared printers.

When the correct drivers are installed on the workstation, a user selects the fax server and merely uses the print option from any application to generate the fax. The drivers automatically prompt the user for a phone number and information for a cover page. When the information is complete, the workstation sends the fax job to the fax server, which sends the document.

Receiving Faxes

Receiving faxes through a fax server is a bit more complicated. Generally, two methods are used. Each potential fax recipient is assigned an ID number. The fax sender enters this number by using the dial pad on a standard fax machine after the destination fax has answered the call. When

the fax transmission is complete, the fax server uses the ID number to deliver the document to the appropriate user via e-mail or some other alert mechanism.

If the sender does not know the recipient's ID, the fax server will still receive the fax, but will not notify the recipient. Usually, the fax server will permit an administrator to view the first page of the fax, usually the cover page, to identify the recipient. The administrator will then have to manually send the document via e-mail.

The ability to route faxes to the desktop depends to some extent on the type of phone lines and modems being used. The ability to directly route faxes to a desktop based on an extension or ID number typically needs special digital phone lines and modems.

CD Servers

A decline in the cost of CD-ROM readers, along with the growing popularity of CD-ROM media, has prompted an increase in CD server implementations. A CD server is usually a stand-alone device consisting of four or more, perhaps as many as 100 CD-ROM readers. These devices are frequently implemented with a runtime version of a network operating system. A runtime version is a minimal implementation of a network operating system that will provide basic file sharing and network access, along with the benefits of the NOS file-caching scheme.

Installing a CD server can provide the entire enterprise with access to installation media, such as workstation applications, reference media and periodicals, or any other data needed by multiple users. The benefit of a CD server over a standard server implementation is cost. To purchase a full version of a network operating system with sufficient licenses for all users can be costly. A CD server is preconfigured with the CD-ROM drives and, with its minimal NOS, can be cost effective.

E-Mail Servers

Explanation

Electronic mail (e-mail) is one of the popular forms of business and personal communication. Many organisations have found that e-mail can facilitate organisational communications, reduce paper costs and create a communications trail for future use.

In a small enterprise, the e-mail service is usually combined on the same server with file and print sharing. Due to the large volume of messages even a medium-sized network will generate, e-mail servers are frequently implemented on dedicated servers.

Many of today's e-mail packages include features such as calendars and scheduling functions, forms routing and even document management. When an e-mail package provides more functionality than just e-mail, it is called groupware. Some examples of popular groupware packages are Microsoft Exchange, Novell GroupWise and Lotus Notes.

All of these examples are designed to scale to hundreds, even thousands of users. They are best implemented on a dedicated server, as the processing

needs for groupware tend to be high. When evaluating e-mail and groupware packages, the needs of your users, as well as the importance of industry standards are equally important. Your package will probably have to interface with other packages and the Internet, as e-mail is now a global business resource.

Internet Gateways

For many companies, connecting to the Internet is no longer optional. The Internet is commonly used for research, advertising, customer contact and competitor information. This, coupled with the importance of Internet e-mail, typically needs a network-oriented access solution rather than an individual user solution.

Due to market demand, hardware manufacturers have addressed this need with some specialised hardware. This hardware provides a LAN connection port and a connection to the Internet that typically is shared by all computers on the network, using only a single IP address. This scenario cuts down on costs by permitting multiple machines to access the Internet through a single account.

Firewall protection hides the nodes within the company from the Internet by restricting or limiting incoming traffic to certain trusted systems or specific applications.

Some of the more popular products are produced by 3Com, Ascend, Nortel Networks and Cisco Systems. Each model might vary and you might need to test the equipment before making a commitment.

Print Servers

Printers can be directly attached to workstations or servers.

Third-Party Alternatives

Network-direct printers feature internal network interfaces that provide a direct connection to the network cable system. In many cases, this interface also operates as a print server that is capable of polling and servicing print jobs in queues or spools.

Because data is transmitted to the printer at network speeds, network-direct printers provide the highest performance printing solution available.

Most network operating systems support the use of third-party print services such as the JetDirect series from Hewlett-Packard and the NetPort line from Intel. These connect directly to various network types and provide one or more ports for shared printer connections.

In addition, most models provide support for other client or server operating systems, including AppleTalk for Macintosh and IP for UNIX.

Implementing a Third-Party Print Solution

Most third-party print servers offer efficient and reliable operation. They typically need less administration than workstation-attached printers that

need special configuration through utilities like Novell's NPRINTER or Microsoft's File and Printer Sharing.

Third-party print server devices include proprietary installation and management utilities that eliminate the need for the NOS utilities. The setup requirements of a third-party print server are typically performed by using a graphical utility. For example, Hewlett-Packard provides the JetAdmin and JetPrint utilities with all JetDirect products. When considering the use of third-party print servers in an environment, verify that the products you purchase are compatible with the NOS with which you want to use them.

Note: Some manufacturers provide an EEPROM firmware upgrade for their print servers. Check with your manufacturer if you have older print server products that will not connect with newer NOS technology.

Other Types of Servers

In today's network environments, you'll also encounter other types of servers such as Web servers, database servers, application servers and so on. Each provides specific functionality and depending on the size and needs of your organisation may be dedicated servers or share functionality with other servers.

Topic C: Topologies

Explanation

Topology defines how the physical media links the network nodes. Several methods are available, each with advantages and drawbacks.

Topology Overview

There are four types of topologies commonly used in LANs:

- Bus
- Ring
- Star
- Mesh

Additional topologies have been developed for WAN connectivity and include point-to-point, multipoint and clouds. Hybrid topologies are usually found in a WAN. This is simply an implementation of multiple topologies.

Bus Topology

A bus topology, as shown in Exhibit 1-3, consists of a linear transmission medium that is terminated at both ends. Nodes attach directly to the bus, making it difficult to troubleshoot. Difficulty in troubleshooting is considered the biggest drawback for this topology.

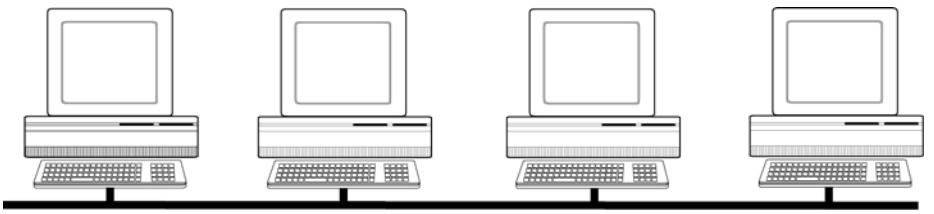

Exhibit 1-3: A bus topology

Although a bus is normally represented as a straight line in the picture, most bus networks represent cables that snake, weave and wrap their way through building conduits and corridors. This results in the rapid growth of the overall bus length. In addition, any break in the bus causes the entire network to become inoperable.

Bus topologies commonly use coaxial cable as their transmission medium. Traditionally, Ethernet has used a bus topology. Bus topologies are usually used for small, temporary installations.

With a bus topology, the 5-4-3 rule applies. There can be no more than five network segments and four repeaters and only three of the five segments can be populated with hosts.

Ring Topology

A ring topology, as shown in Exhibit 1-4, provides a closed-loop transmission medium. Repeaters at each node connection repeat the signals. This is done to minimise any signal degradation.

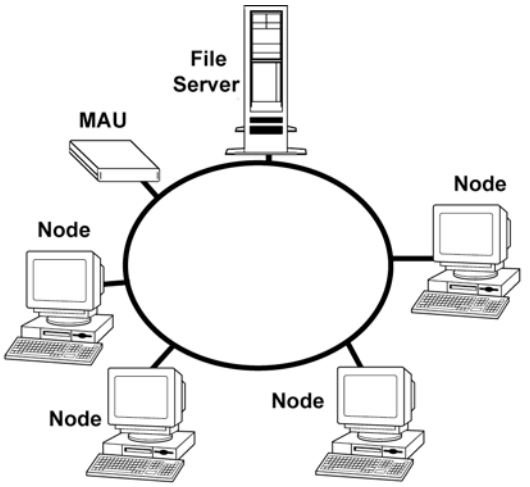

Exhibit 1-4: A ring topology

Traditional rings have the same failure risk as buses. Any break brings the entire network down. To prevent these failures, most ring implementations (such as Token Ring) are actually wired in a star topology with an out loop and a return loop from each workstation to the wiring hub.

Star Topology

Star/hub networks connect the peripheral devices via point-to-point links to a central location (hub). Star topologies, as shown in Exhibit 1-5, provide architectural flexibility but need more cable than traditional bus and ring topologies.

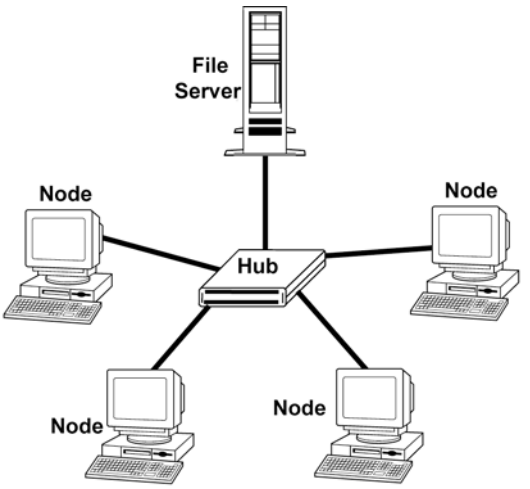

Exhibit 1-5: A star topology

Virtually all the modern data networks are configured in a star. This permits simplified adds, moves and changes. System failure from any individual segment break is minimised.

Mesh Topology

A mesh configuration, as shown in Exhibit 1-6, consists of a network where each device has a point-to-point connection to every other device on the network. This provides the dedicated capacity of a point-to-point link to each device and significant fault tolerance. However, the complexity and cost make this configuration impractical for networks with a large number of devices. Also, much of the bandwidth available in mesh configurations is wasted. For those reasons, mesh topologies are generally used for interconnecting only the most important sites with multiple links. This is called a hybrid mesh or partial mesh.

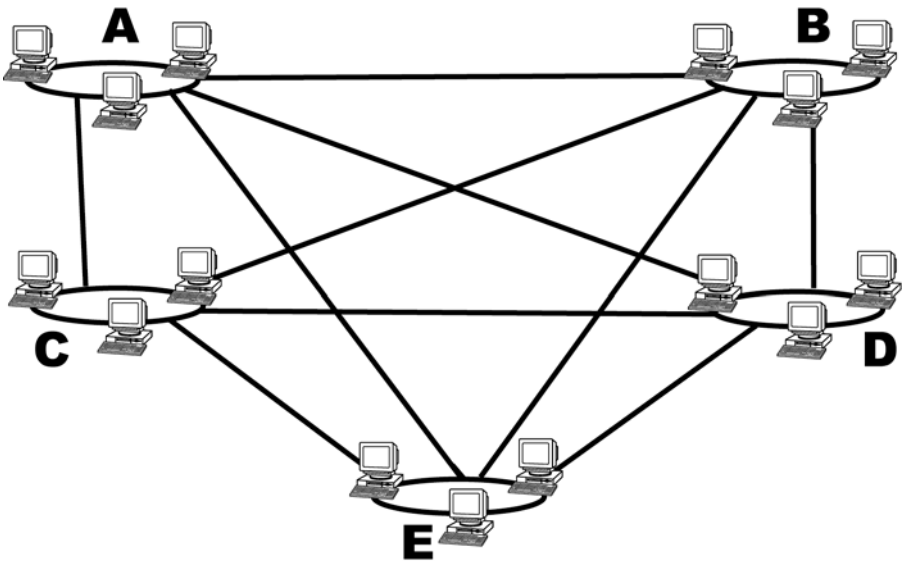

Exhibit 1-6: A mesh configuration

You can list the advantages and disadvantages of the hybrid mesh as follows:

Advantages:

- Troubleshooting is easy.
- Isolation of network failures is easy.
- Fault tolerance is maximised by rerouting traffic around failed links.

Disadvantages:

- Difficult to install.
- Difficult to reconfigure.
- Expensive because of redundant connections and wasted bandwidth.