Basic Network Concept

This chapter begins with a discussion of the basic components of computer networks, and their interaction. It introduces the centralized and distributive processing networks, and outlines the differences among these networks. It concludes with a discussion of Local Area Networks (LANs), Metropolitan Area Networks (MANs), and Wide Area Networks (WANs).

2.1 Network

A *network* can be classified either as a telephone network or computer network although this distinction is rapidly disappearing. But, in this chapter we didn't introduce the telephone network, we will only briefly discuss information theory, then we will describe the computer network.

2.1.1 Information Theory

Information theory is concerned with the mathematical laws governing the transmission, reception, and processing of information. More specifically, information theory deals with the numerical measurement of information, the representation of information (such as encoding), and the capacity of communication systems to transmit, receive, and process information. Encoding can refer to the transformation of speech or images into electric or electromagnetic signals, or to the encoding of messages to ensure privacy.

Information theory was first developed in 1948 by the American electrical engineer Claude E. Shannon. The need for a theoretical basis for communication technology arose from the increasing complexity and crowding of communication channels such as telephone and teletype networks and radio communication systems. Information theory also encompasses all other forms of information transmission and storage,

including television and the electrical pulses transmitted in computers and in magnetic and optical data recording.

2.1.2 The Computer Network

A typical *computer station* is shown in Figure 1.8. The devices shown are, in most cases, manufactured by different vendors. Also, if we need to communicate with another computer station, we must connect one end of the modem to the telephone line, and the other end to the computer.

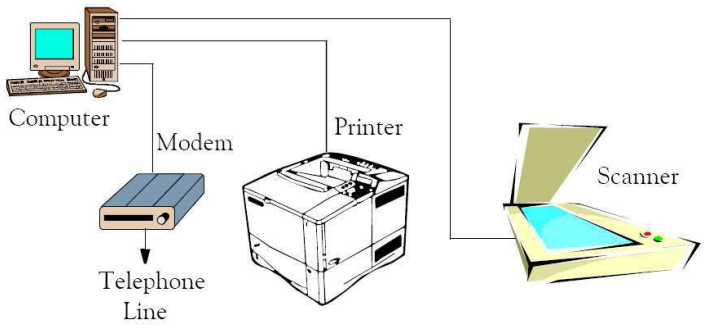

Figure 1.8. Typical computer station

Obviously, if we need to have an effective system that will provide us with world−wide telecommunications (telephone) services and data (computer) communications, we must interface the computer network with the telephone network as shown in Figure 1.9.

The services of the telecommunications network part shown in Figure 1.9 are provided by a telecommunications service provider such as AT&T, MCI, Sprint, British Telecom, etc. The Data Communications part provides communications among computers. As shown, modems transfer the information from digital to analog at the telephone terminals, and these are converted back to digital at the destination points.

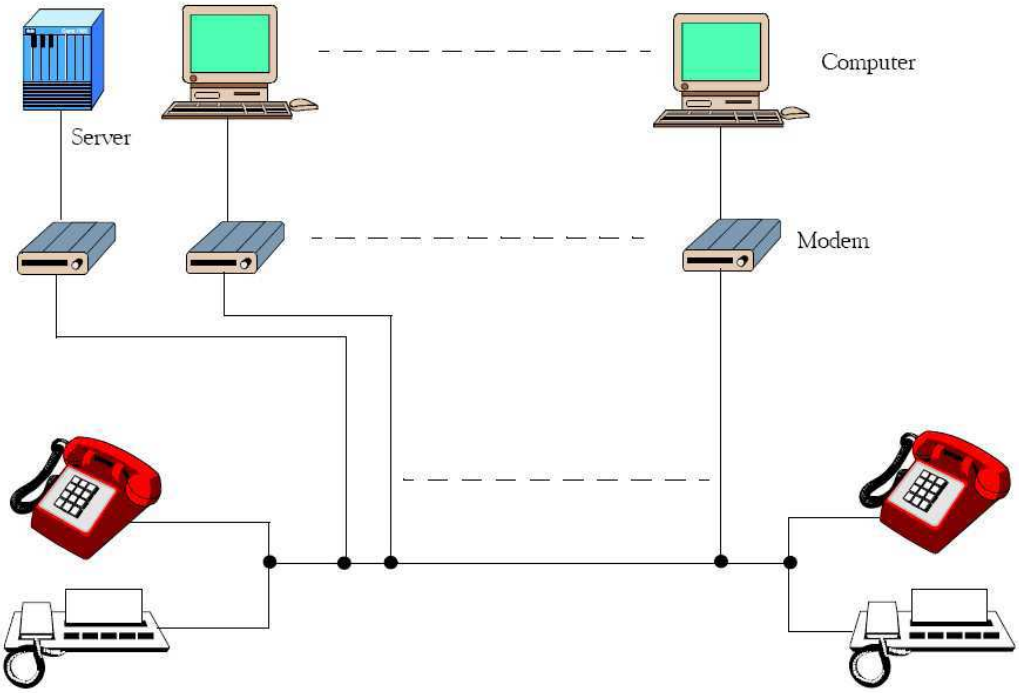

Figure 1.9. The telephone–computer network interface

Henceforth, a *network* will be understood to be a system of computers and peripherals interconnected by telephone wires or other means in order to share information. Its purpose is to process and store large amounts of information quickly and efficiently. A network is often used by both small companies and large corporations. The employees of a company assigned to a specific task in the network are referred to as *users*. While a user is normally assigned a specific task, a group of users must share resources other than files, such as printers, fax machines, and modems.

Figure 1.10 shows how several computers are interconnected to share a printer and a fax machine.

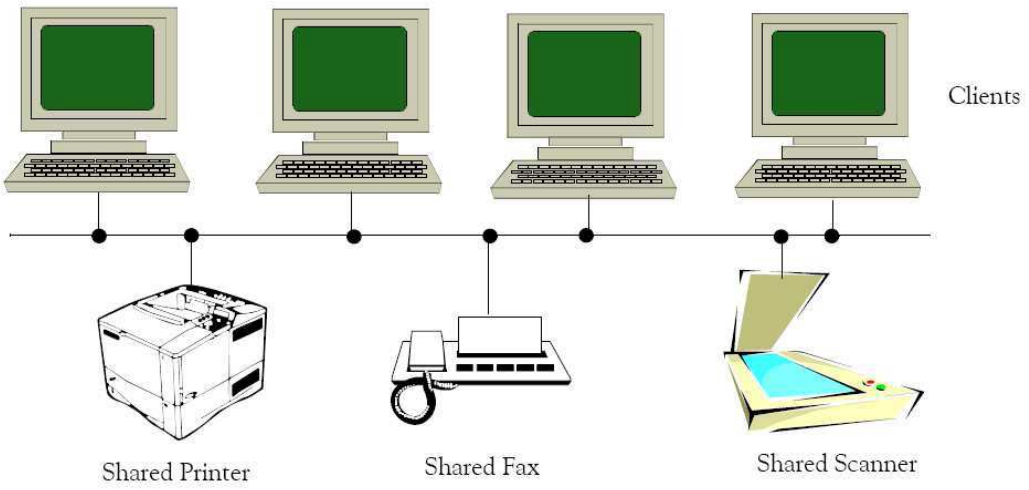

Figure 1.10. A network where several users share a printer, a fax machine, and a scanner

The person in charge of operations on a computer network is referred to as the *network administrator* or *system administrator*. The duties of a network administrator can be broad and might include such tasks as installing new *workstations*[*] and other devices, adding and removing authorized users, archiving files, overseeing password protection and other security measures, monitoring usage of shared resources, and handling malfunctioning equipment.

The network administrator must also consider fault tolerance. *Fault tolerance* is the ability of a computer or an operating system to respond to a catastrophic event or fault, such as a power outage or a hardware failure, in a way that ensures that no data is lost and any work in progress is not corrupted. This can be accomplished with a battery−backed power supply, backup hardware, provisions in the operating system, or any combination of these. In a fault−tolerant network, the system has the ability either to continue the system's operation without loss of data or to shut the system down and restart it, recovering all processing that was in progress when the fault occurred.

[*] *A powerful stand−alone computer of the sort used in computer−aided design and other applications requiring a high−end, usually expensive, machine with considerable calculating or graphics capability.*

Tandem processors are multiple processors wired so that the failure of one processor transfers CPU operation to another processor. We use tandem processors for implementing fault−tolerant computer systems.

A typical large network consists of:

1. A *server*: A powerful computer that provides services to other computers on the network.
2. *Clients:* These are computers that use the services provided by the server.
3. *Peer:* A computer that can act as both a client and a server.
4. *Media*: The physical connection among the devices on a network.
5. *Protocols:* Written rules used for communications.
6. *Resources*: The devices that are available to a client. These are printers, fax machines, modems, etc.
7. *User:* A person using a client to access resources on the network.

2.2 Methods of Processing

In this section we will consider the *centralized* and *distributive* types of data processing.

2.2.1 Centralized Processing

With this type of networks, the location of computer processing facilities and operations in a single (centralized) place.

A typical example of a centralized network is the ATM banking system where all data are kept in one location, the server*, and all users have access to the same information regardless of their location.

* *Another type of server is the proxy server. Proxy servers are used by many networks to do things such as monitoring the internet use by individual employees, or to block access to certain sites.*

2.2.2 Distributive Processing

With this type of networks, information is performed by separate computers linked through a communications network. Distributive processing is usually categorized as either true distributive processing or plain distributive processing.

True distributive processing has separate computers perform different tasks in such a way that each performs part of a task for the entire project. This latter type of processing requires a highly−structured environment that allows hardware and software to communicate, share resources, and exchange information freely. With this type of networks, all storage and processing is performed on a local workstation. It allows all users to share resources and services.

Plain distributive processing[*] shares the workload among computers that can communicate with one another. In other words, certain tasks are done by one computer and other tasks by others.

Table 1.1 lists the advantages and disadvantages of each of these types.

2.3 Network Architecture Types

This section discusses the *peer−to−peer network*, and the *server−based network*.

2.3.1 Peer-to-Peer Network Architecture

A *peer−to−peer network* is a network of two or more computers that use the same program or type of program to communicate and share data. Each computer, or peer, is considered equal in terms of responsibilities and each acts as a server to the others in the network. Users must share data and resources connected to the network. A typical peer−to−peer network architecture is shown in Figure 1.11.

[*] *Some books refer to this type of processing as collaborative or cooperative processing.*

TABLE 1.1 Advantages / Disadvantages of processing methods

Processing Method	Advantages	Disadvantages
Centralized	• Assurance that everyone obtains same information • Back up data in server only • Security required in server only • Low cost maintenance • Not very susceptible to viruses	• Slow in accessing server and processing data • Limited options
True Distributive	• Fast data access • Less expensive servers • Increased functionality • Low cost maintenance • Multiple uses • Users can be working on different versions of the same file	• More susceptible to viruses • Requires frequent backup of data to avoid the possibility that users will be working with different versions of the same file
Plain Distributive	• Fastest data access • Multiple uses	• More susceptible to viruses • Backup of data is more difficult since data can be stored in different systems of the network • Difficult file synchronization since several copies of the same file could be stored throughout the network.

A peer-to-peer network architecture would be appropriate for a group of people working in an office where each has a good networking knowledge, the users have full control over their data, and yet they can share their data with the other users in that office. Also, in a peer-to-peer network using Windows for Networking, accounts must be created on each client computer if different permissions are to be assigned for access to resources.

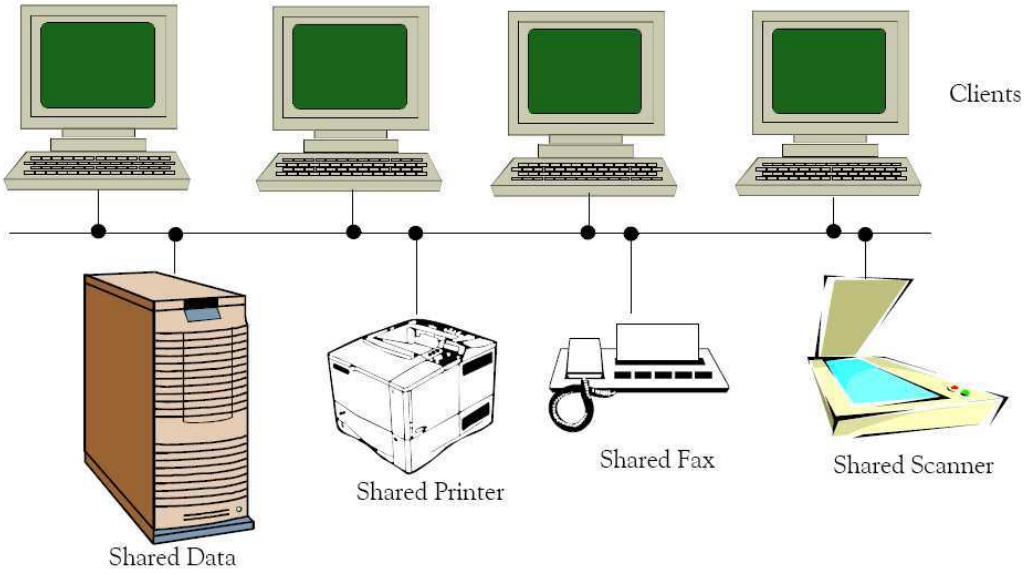

Figure 1.11. Typical peer–to–peer network architecture

2.3.2 Server Base Network Architecture

Server–Based Network Architecture is an arrangement used on local area networks–to be defined on the next section–that makes use of distributed intelligence to treat both the server and the individual workstations as intelligent, programmable devices, thus exploiting the full computing power of each. This is done by splitting the processing of an application between two distinct components: a “front–end” client and a “back–end” server. The client component is a complete, stand–alone personal computer (not a "dumb" terminal), and it offers the user its full range of power and features for running applications.

The server component can be a personal computer, a minicomputer, or a mainframe that provides the traditional strengths offered by minicomputers and mainframes in a time–sharing environment: data management, information sharing between clients, and sophisticated network administration and security features. The client and server machines work together to accomplish the processing of the application being used. Not only does this increase the processing power available over older architectures, but it also uses that power more efficiently.

The client portion of the application is typically optimized for user interaction, whereas the server portion provides the centralized, multiuser functionality. The server controls the data and resources the clients need to access. Servers are optimized to pass on data as fast as possible. A typical server−based network architecture is shown in Figure 1.12.

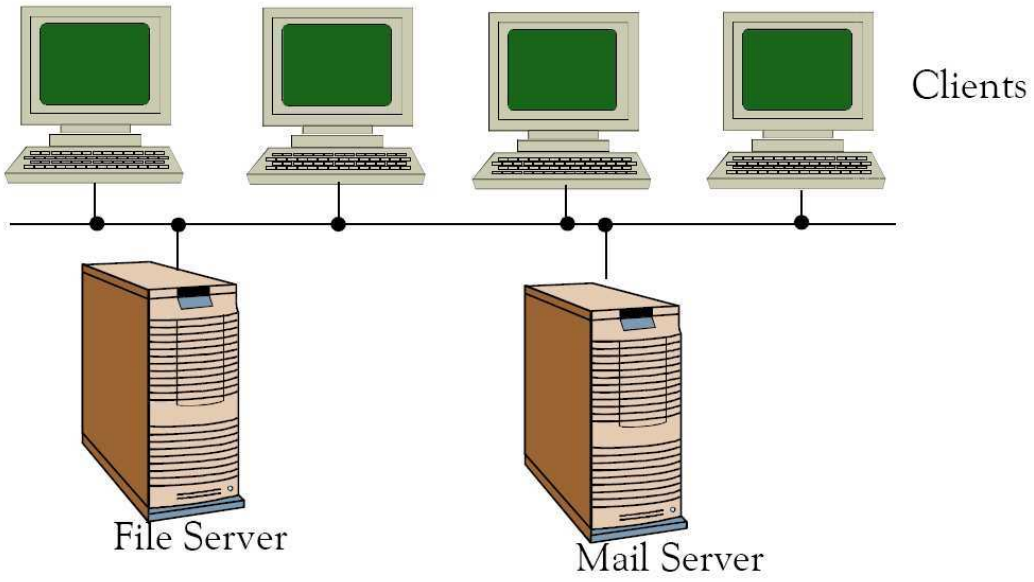

Figure 1.12. Typical server−based network architecture

Microsoft Windows includes the *Event Viewer* that enables the network administrator to view the number of logins and find out which users have logon on to the network. It also includes the *Server Manager* which can display the resources that are being used, and the for how long each user has been using them. Thus, if the network administrator wishes to know how many users are using the network at any one time, he should choose a server−based network. Windows has also built−in peer−to−peer capabilities.

Table 1.2 lists the advantages and disadvantages of each of these architectural types.

TABLE 1.2 Advantages / Disadvantages of networking architectures

Networking Architectures	Advantages	Disadvantages
Peer–to–Peer	• Less expensive • Easy to setup • Easy and low cost maintenance • Does not require a server operating system	• Requires that each user manages his/her own security • Users can easily become confused since there is no central data depository • Requires more user training • Limited to 10 or less clients
Server–based	• Since the server stores all data, large hard disk drives and extra RAM are not required on client computers. • Central security • Synchronized files • Easy backup • Easy expansion	• Requires a server • Must have an administrator • Requires a server operating system (Windows or Novell's NetWare).

2.4 Network Services

Networks provide several services. The most common are *file services*, *print services*, *message services*, *directory services*, and *application services*.

2.4.1 File Services

File services include the following tasks:

- ***File Transfer***

  The process of moving or transmitting a file from one location to another, as between two programs or over a network. This is accomplished with the use of a *file server* which is a file–storage device on a local area network that is accessible to all users on the network. Unlike a disk server, which appears to the user as a remote disk drive, a file server is a sophisticated device that not only stores files but manages them and maintains order as network users request files and make changes to them. To deal with the tasks of handling multiple— sometimes simultaneous— requests for files, a file server contains a processor and controlling

software as well as a disk drive for storage. On local area networks, a file server is often a computer with a large hard disk that is dedicated only to the task of managing shared files.

The most important component for a file server is the disk access speed. If the disk drive is slow, it doesn't matter how much memory we have, how fast the processor is, or how fast the network card is; the bottleneck will still be the disk drive. The only way to improve the speed would be to change the drive(s) to faster ones or possibly add more disk controllers if we are using multiple drives. By using multiple controllers, we could potentially access two disks at the same time.

- ***File Storage***

  The process of storing a file in different media such as floppy disks, hard disks, CD−R/Ws, and magnetic tape. *Online storage* implies that data is stored information that is readily available on a server. *Offline storage* implies that data is stored information in a resource, such as a disk, that is not currently available to the network. *Data migration* implies that data is transferred from one storage to another. *Archives* are places or collections containing records, documents, or other materials of interest. The process of backing up data in case of a hard disk failure is referred to as *archiving*.

2.4.2 Print Services

A *print server* is a workstation that is dedicated to managing the printers on a network. The print server can be any station on the network. A print spooler is software that intercepts a print job on its way to the printer and sends it to disk or memory instead, where the print job is held until the printer is ready for it. *Spooler* is an acronym created from *simultaneous print operations on line*.

Networks provide the ability to share *print services*. Thus, only a few printers can be connected to a network and can be shared among the users. Print services include also queue−based printing and fax services.

Queue−based printing allows a client's application to spool the print job off to a network server so the application thinks the job has been printed and lets the user continue to work.

2.4.3 Message Services

Message services allow for e−mails with attachment files. Many people have come to rely on e−mail attachments as a way of transferring information, so message services have become a necessity on most networks. E−mail is no longer just sending text messages back and forth over a network. We can send video, sound, documents, and almost any other type of data.

Groupware* applications that use e−mail as their connection backbone are also becoming popular.
These enable users to share calendars and scheduling information as well.

2.4.4 Directory Services

A *directory service* on a network is a service that returns mail addresses of other users or enables a user to locate hosts and services. Directory services let us maintain information about all of the *objects* in our network. An object is anything we can store information about, such as users, printers, shared resources, servers, and so on. Before directory services were popular, we had to keep separate configuration information about users on each file server. If a user wanted to connect to resources on multiple servers, they needed an account on each one. With directory services, we only create one user account object for that user. Each of the servers see that object, and we can then assign resource rights to that user account. The actual directory information is stored in files on the server, which are usually hidden. The network operating systems that

* *Software intended to enable a group of users on a network to collaborate on a particular project. Groupware may provide services for communication (such as e−mail), collaborative document development, scheduling, and tracking. Documents may include text, images, or other forms of information.*

support directory services have predefined methods to share and update this information.

2.4.5 Application Services

Application services are basically a client/server process. The server is providing the application service. Normally with application services, a small application is loaded on the client computers, and the main application and data is loaded on the server. The small application on the client is usually just a front−end to give the user an interface. It does no processing of its own. The client application sends queries to the server and lets it do the processing. The server then returns the requested information. A typical travel agent uses application services. He/she loads a small front−end application on his/her terminal to query the main database server that includes information on airlines and flight information. The database server looks up the flight number, itinerary, and price, and returns the information about it. No processing is done on the travel agent's terminal.

2.4.6 Database Services

One major consideration of a networked database is the coordination of multiple changes. All or part of the databases may also be replicated to other servers on a network to distribute the load. It can be more efficient to have portions of the database in the same regional location as the users who access it. When using distributed data, the database appears to be a single database to the users. Replicating the database to other servers can also serve as a form of backup. The database is not dependent on one particular server. Database services are responsible for updating replicated databases and keeping them current. A *database server* is a network station, dedicated to storing and providing access to a shared database.

2.5 LANs, MANs, and WANs

The sizes of networks are categorized into three groups: Local Area Network (LAN), Metropolitan Area Network (MAN), and Wide Area Network (WAN).

2.5.1 Local Area Network

The smallest network size is a *local area networ*k, or LAN. LANs are normally contained in a building or small group of buildings. Some characteristics of a LAN are high speed, small error counts, and inexpensive price. Figure 1.13 shows computers set up on a LAN.

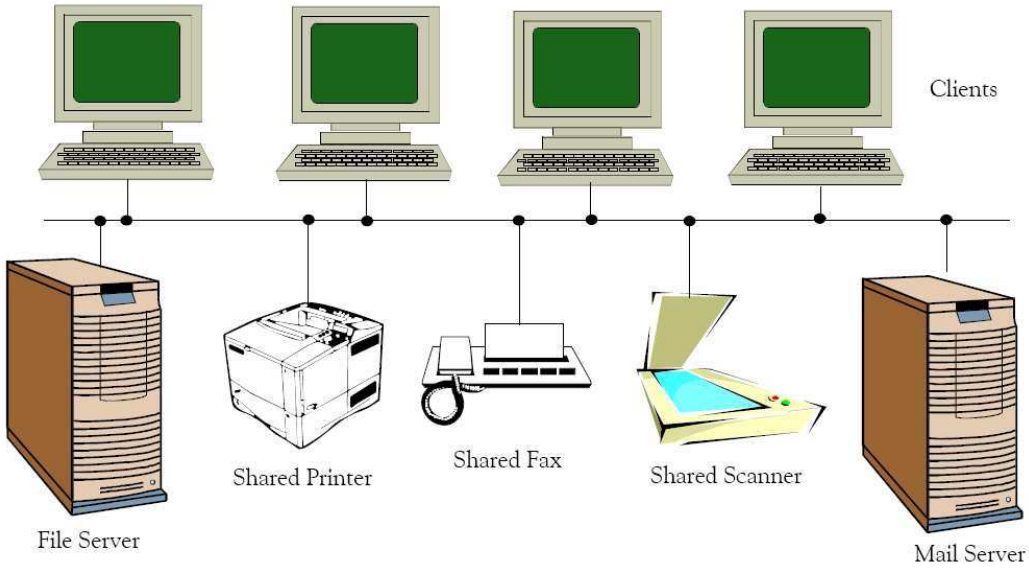

Figure 1.13. Typical LAN

Since LANs are contained in small areas, high−speed cable can be used. Also, since the installed media is usually high quality, few to no errors are generated on the network. Prices of LAN equipment are fairly cheap. Network adapters−to be discussed in a later chapter−used in LANs can be found for less than $15 each.

2.5.2 Metropolitan Area Network

A *Metropolitan Area Network* (MAN) is a high−speed network that can carry voice, data, and images at up to 200 Mbps over distances of up to 75 km. A MAN, which can include one or more LANs as well as telecommunications equipment such as microwave and satellite relay stations, is smaller than a Wide Area Network (WAN) but generally operates at a higher speed. Figure 1.14 illustrates how several LANs can be set up as a MAN. Typical MANs are computer networks in city halls, university campuses, etc.

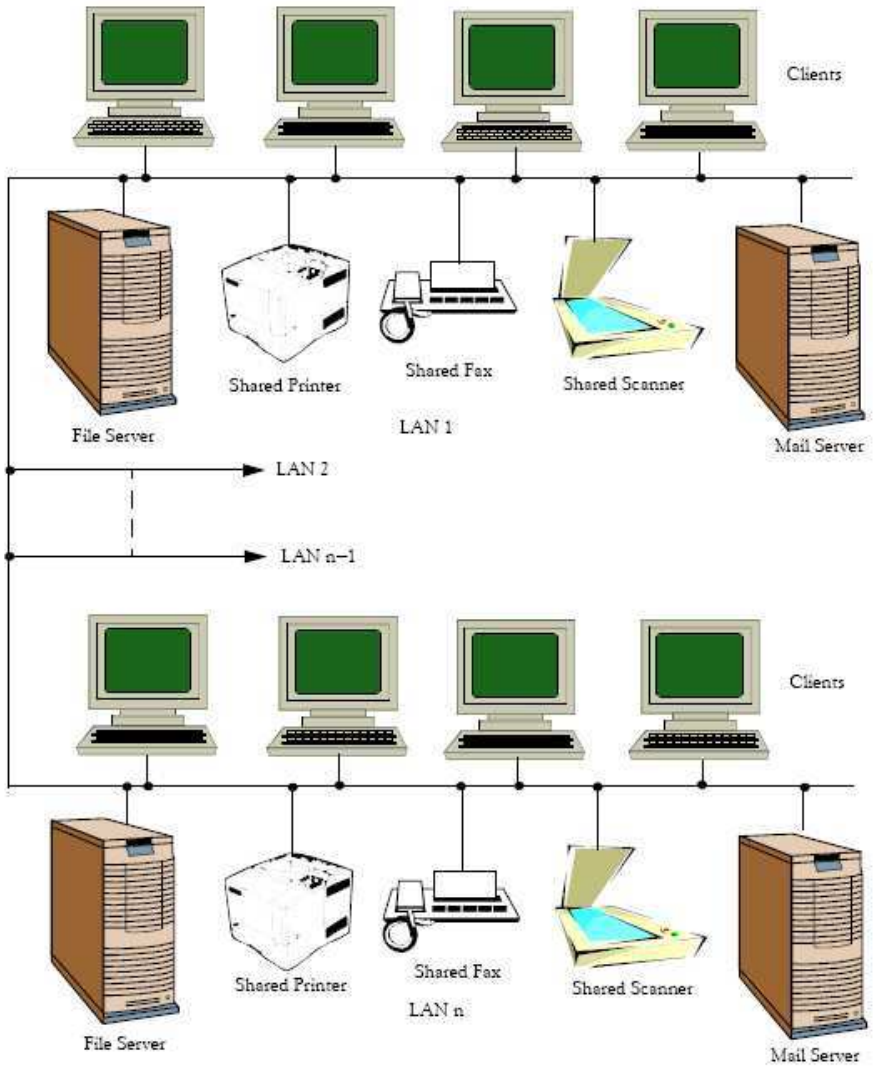

Figure 1.14. Typical MAN

2.5.3 Wide Area Network

A *Wide Area Network* (WAN) is a communications network that connects geographically separated areas. WANs are interconnections of any number of LANs and MANs. They can connect networks across cities, states, and countries. The internet can be thought of as the largest WAN. Table 1.3 lists the advantages and disadvantages of LANs, MANs and WANs.

TABLE 1.3 Advantages / Disadvantages of LANs, MANs, and WANs

Network Size	Advantages	Disadvantages
Local Area Network (LAN)	• Fast data access • Small space requirements • Less expensive equipment • Low error rates • Less investment for hardware and software	• Limited options
Metropolitan Area Network (MAN)	• Accommodates a large number of clients • Moderate error rates	• Large space requirements • Slower data access • More expensive equipment
Wide Area Network (WAN)	• Can grow without bounds • Multiple uses	• Large space requirements at different locations • Slower data access • Very expensive equipment • Highest error rates

2.6 Summary

In this chapter we discussed the basic components of a network and the types of resources networks can share. We learned the three methods of data processing: centralized, true distributed, and plain distributed. We explained the difference between peer−to−peer and server−based network architectures. We defined file services, print services, message services, directory services, application services, and database services. We concluded the chapter with the definitions and characteristics of LANs, MANs, and WANs. A review of concepts and definitions follows.

- A telecommunications network or telephone network, is a group of telephones and associated devices such as answering machines and faxes that are connected by communications facilities. A

telephone network can involve permanent connections, such as telephone wires and trunks, cables, or temporary connection made through telephone or other communication links.

- Computer Networks are groups of computers connected together by some type of media (the physical connection among the devices on a network) to allow them to communicate and share information.

- Servers are large, powerful computers that provide services to clients.
- Clients are smaller desktop computers that users use to access network services.
- Peer computers act as both clients and servers.
- The physical connection between the computers on a network is referred to as the media.
- Resources are devices and equipment that clients can have access to. Printers, scanners, and hard disks are examples of resources.
- Users are humans that use clients and resources.
- Protocols are the written rules for communication between devices on a network.
- Centralized processing is done with a large central system with terminals as clients. All processing is done by a central computer, and the terminals are for input and output.
- Distributive Processing is a form of information processing in which work is performed by separate computers linked through a communications network. Distributed processing is usually categorized as either plain distributed processing or true distributed processing. Plain distributed processing shares the workload among computers that can communicate with one another. True distributed processing has separate computers perform different tasks in such a way that their combined work can contribute to a larger goal. This latter type of processing requires a highly−structured environment that allows hardware and software to communicate, share resources, and exchange information freely.
- Peer−to−peer architectural network is a network of two or more computers that use the same program or type of program to

communicate and share data. Each computer, or peer, is considered equal in terms of responsibilities and each acts as a server to the others in the network. Unlike a client−server architecture, a dedicated file server is not required. However, network performance is generally not as good as under client−server, especially under heavy loads.

- Client/Server architectural network is an arrangement used on local area networks that makes use of distributed intelligence to treat both the server and the individual workstations as intelligent, programmable devices, thus exploiting the full computing power of each. This is done by splitting the processing of an application between two distinct components: a "front−end" client and a "back−end" server. The client component is a complete, stand−alone personal computer (not a "dumb" terminal), and it offers the user its full range of power and features for running applications. The server component can be a personal computer, a minicomputer, or a mainframe that provides the traditional strengths offered by minicomputers and mainframes in a time−sharing environment: data management, information sharing between clients, and sophisticated network administration and security features. The client and server machines work together to accomplish the processing of the application being used.
- Fault tolerance is the ability of a computer or an operating system to respond to a catastrophic event or fault, such as a power outage or a hardware failure, in a way that ensures that no data is lost and any work in progress is not corrupted.
- Tandem processors are multiple processors wired so that the failure of one processor transfers CPU operation to another processor. We can use tandem processors to implement fault−tolerant computer systems.
- File servers are file−storage devices on local area networks that is accessible to all users on the network. Unlike a disk server, which appears to the user as a remote disk drive, a file server is a sophisticated device that not only stores files but manages them and maintains order as network users request files and make changes to them. To deal with the tasks of handling multiple—sometimes simultaneous— requests for files, a file server contains a processor and controlling software as well as a disk drive for storage.

- Print servers are workstations that are dedicated to managing the printers on a network. The print server can be any station on the network. A print spooler is a computer software application that intercepts a print job on its way to the printer and sends it to disk or memory instead, where the print job is held until the printer is ready for it.
- Message services provide mail services such as e-mail.
- A directory is a listing of the files contained in a storage device, such as a magnetic disk. It contains a description of the various characteristics of a file, such as the layout of the fields in it.
- Directory services allow us to maintain information about every object in our network.
- Applications are programs designed to assist in the performance of a specific task, such as word processing, accounting, or inventory management. Clients can let the central network servers process data for them by using application services.
- A database is a file composed of records, each of which contains fields, together with a set of operations for searching, sorting, recombining, and other functions. Database services coordinate multiple changes to large network databases and replicate them if necessary.
- Local Area Networks (LANs) are small networks usually contained in one office or building. They have high speed, low error rates, and they are inexpensive.
- Metropolitan Area Networks (MANs) are larger networks that consist of individual LANs to interconnect large campus-type environments such as organizations spread over a city. Their characteristics fall in between LANs and WANs, in that they are relatively fast, have moderate error rates, and their equipment prices fall between LANs and WANs.
- Wide area networks can cover an entire organization's enterprise network. WANs can cover a few states or, in the case of the Internet, the entire globe. Since this is the largest network, it is the most expensive. It is also usually low speed when compared with the other network size models.