COMPUTER NETWORK

The merging of computers and communications has had a profound influence on the way computer systems are organized. The concept of the "computer center" as a room with a large computer to which users bring their work for processing is now totally obsolete. The old model of a single computer serving all of the organization's computational needs has been replaced by one in which a large number of separate but interconnected computers do the job. These systems are called computer networks. The design and organization of these networks are the subjects of this book.

The term "computer network" means an *interconnected* collection of *autonomous* computers. Two computers are said to be interconnected if they are able to exchange information. The connection need not be via a copper wire; fiber optics, microwaves, and communication satellites can also be used. By requiring the computers to be autonomous, we wish to exclude from our definition systems in which there is a clear master/slave relation. If one computer can forcibly start, stop, or control another one, the computers are not autonomous. A system with one control unit and many slaves is not a network; nor is a large computer with remote printers and terminals.

Need of computer network

- Access to remote & recent information
- Less time is required
- Person to person communication
- Interactive environment
- Communication is easier, faster, cheaper, reliable

Advantage of computer network

- **Program & File Sharing:** The major advantage of a computer network is that is allows file sharing and remote file access. A person sitting at one workstation of a network can easily see the files present on the other workstation, provided he is authorized to do so. It saves the time which is wasted in copying a file from one system to another, by using a storage device. In addition to that, many people can access or update the information stored in a database, making it up-to-date and accurate.

- **Network Resource Sharing**: Resource sharing is also an important benefit of a computer network. For example, if there are four people in a family, each having their own computer, they will require four modems (for the Internet connection) and four printers, if they want to use the resources at the same time. A computer network, on the other hand, provides a cheaper alternative by the provision of resource sharing. In this way, all the four computers can be interconnected; using a network, and just one modem and printer can efficiently provide the services to all four members. The facility of shared folders can also be availed by family members.

- **Database sharing:** Another wonderful advantage of computer networks is the data sharing. All the data such as documents, file, accounts information, reports, multimedia etc. can be shared with the help computer networks. Hardware sharing and application sharing is also allowed in many organizations such as banks and small firms.

- **Increased Storage Capacity:** As there is more than one computer on a network which can easily share files, the issue of storage capacity gets resolved to a great extent. A standalone computer might fall short of storage memory, but when many computers are on a network, memory of different computers can be used in such case. One can also design a storage server on the network in order to have a huge storage capacity.
- **Increased Cost Efficiency:** There is much software available in the market which is costly and takes time for installation. Computer networks resolve this issue as the software can be stored or installed on a system or a server and can be used by the different workstations.
- **Centralized Administration:** Centralized administration reduces the number of people needed to manage the devices and data on the network, reducing time and cost to the company. Individual network users do not need to manage their own data and devices. One administrator can control the data, devices, and permissions of users on the network. Backing up data is easier because the data is stored in a central location.
- **Data Security and Management:** In a business environment, a network allows the administrators to much better manage the company's critical data. Instead of having this data spread over dozens or even hundreds of small computers in a haphazard fashion as their users create it, data can be centralized on shared servers. This makes it easy for everyone to find the data, makes it possible for the administrators to ensure that the data is regularly backed up, and also allows for the implementation of security measures to control who can read or change various pieces of critical information.
- **Remote access and login:** Employees of different or same organization connected by the networks can access the networks by simply entering the network remote IP or web remote IP. In this the communication gap which was present before the computer networks no more exist.

Disadvantage of computer network

- **Expensive to Install:** Although a network will generally save money over time, the initial costs of installation can be prohibitive. Cables, network cards, and software are expensive, and the installation may require the services of a technician.
- Networking software requires **memory space** in each of the computer used on the network. This reduces the memory space available for other programs.
- **Hardware and Software Management and Administration Costs:** Networking adds another level of complexity to the computer operations. The installation and management of a network requires for more technical and administrative skills.
- Some controls on the part of the user are lost. One may face the situation like entire network suddenly **locking up** because one user has made a mistake.
- **Data Security:** If a network is implemented properly, it is possible to greatly improve the security of important data. In contrast, a poorly secured network puts critical data at risk, exposing it to the potential problems associated with hackers, unauthorized access.

NETWORK CLASSIFICATION

It is now time to turn our attention from the applications and social aspects of networking to the technical issues involved in network design. There is no generally accepted taxonomy into which all computer networks fit, but two dimensions stand out as important: transmission technology and scale.

Broadly speaking, there are two types of transmission technology:

1. Broadcast networks.
2. Point-to-point networks.

Broadcast networks have a single communication channel that is shared by all the machines on the network. Short messages, called packets in certain contexts, sent by any machine are received by all the others. An address field within the packet specifies for whom it is intended. Upon receiving a packet, a machine checks the address field. If the packet is intended for itself, it processes the packet; if the packet is intended for some other machine, it is just ignored.

Broadcast systems generally also allow the possibility of addressing a packet to all destinations by using a special code in the address field. When a packet with this code is transmitted, it is received and processed by every machine on the network. This mode of operation is called broadcasting. Some broadcast systems also support transmission to a subset of the machines, something known as multicasting. One possible scheme is to reserve one bit to indicate multicasting. The remaining n - 1 address bits can hold a group number. Each machine can "subscribe" to any or all of the groups. When a packet is sent to a certain group, it is delivered to all machines subscribing to that group.

In contrast, point-to-point networks consist of many connections between individual pairs of machines. To go from the source to the destination, a packet on this type of network may have to first visit one or more intermediate machines. Often multiple routes, of different lengths are possible, so routing algorithms play an important role in point-to-point networks. As a general rule (although there are many exceptions), smaller, geographically localized networks tend to use broadcasting, whereas larger networks usually are point-to-point.

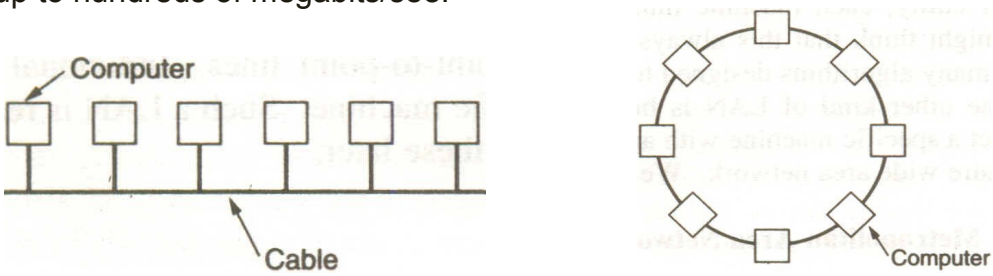
LOCAL AREA NETWORKS

Local area networks, generally called LANs, are privately-owned networks within a single building or campus of up to a few kilometers in size. They are widely used to connect personal computers and workstations in company offices and factories to share resources (e.g., printers) and exchange information. LANs are distinguished from other kinds of networks by three characteristics: (1) their size, (2) their transmission technology, and (3) their topology.

LANs are restricted in size, which means that the worst-case transmission time is bounded and known in advance. Knowing this bound makes it possible to use certain kinds of designs that would not otherwise be possible. It also simplifies network management.

LANs often use a transmission technology consisting of a single cable to which all the machines are attached, like the telephone company party lines once used in rural areas. Traditional LANs run at speeds of 10 to 100 Mbps, have low delay (tens of microseconds), and make very few errors. Newer LANs may operate at higher

speeds, up to hundreds of megabits/see.



[Two broadcast networks. (a) Bus. (b) Ring]

Various topologies are possible for broadcast LANs. Figure shows two of them. In a bus (i.e., a linear cable) network, at any instant one machine is the master and is allowed to transmit. All other machines are required to refrain from sending. An arbitration mechanism is needed to resolve conflicts when two or more machines want to transmit simultaneously. The arbitration mechanism may be centralized or distributed. IEEE 802.3, popularly called Ethernet, for example, is a bus-based broadcast network with decentralized control operating at 10 or 100 Mbps. Computers on an Ethernet can transmit whenever they want to; if two or more packets collide, each computer just waits a random time and tries again later.

A second type of broadcast system is the ring. In a ring, each bit propagates around on its own, not waiting for the rest of the packet to which it belongs. Typically, each bit circumnavigates the entire ring in the time it takes to transmit a few bits, often before the complete packet has even been transmitted. Like all other broadcast systems, some rule is needed for arbitrating simultaneous accesses to the ring. Various methods are in use and will be discussed later in this book. IEEE 802.5 (the IBM token ring), is a popular ring-based LAN operating at 4 and16 Mbps.

Broadcast networks can be further divided into static and dynamic, depending on how the channel is allocated. A typical static allocation would be to divide up time into discrete intervals and run a round robin algorithm, allowing each machine to broadcast only when its time slot comes up. Static allocation wastes channel capacity when a machine has nothing to say during its allocated slot, so most systems attempt to allocate the channel dynamically (i.e., on demand).

Dynamic allocation methods for a common channel are either centralized or decentralized. In the centralized channel allocation method, there is a single entity, for example a bus arbitration unit, which determines who goes next. It might do this by accepting requests and making a decision according to some internal algorithm. In the decentralized channel allocation method, there is no central entity; each machine must decide for itself whether or not to transmit. You might think that this always leads to chaos, but it does not. Later we will study many algorithms designed to bring order out of the potential chaos.

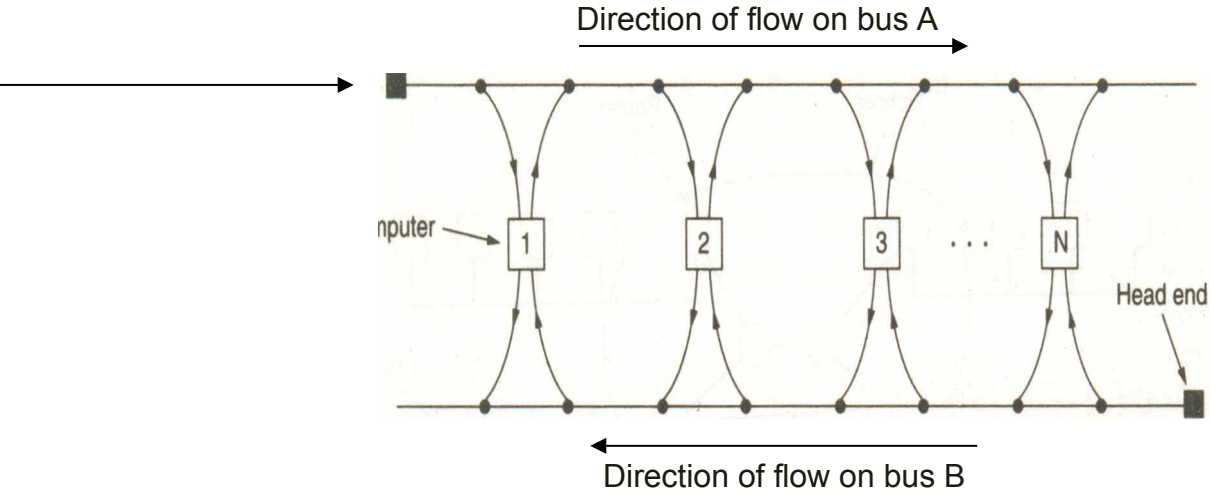
The other kind of LAN is built using point-to-point lines. Individual lines connect a specific machine with another specific machine. Such a LAN is really a miniature wide area network.

METROPOLITAN AREA NETWORKS

A metropolitan area network, or MAN (plural: MANs, not MEN) is basically a bigger version of a LAN and normally uses similar technology. It might cover a group of nearby corporate offices or a city and might be either private or public. A MAN can support both data and voice, and might even be related to the local cable television

network. A MAN just has one or two cables and does not contain switching elements, which shunt packets over one of several potential output lines. Not having to switch simplifies the design.

The main reason for even distinguishing MANs as a special category is that a standard has been adopted for them, and this standard is now being implemented. It is called DQDB (Distributed Queue Dual Bus) or for people who prefer numbers to letters, 802.6 (the number of the IEEE standard that defines it). DQDB consists of two unidirectional buses (cables) to which all the computers are connected, as shown in Fig. Each bus has a head-end, a device that initiates transmission activity. Traffic that is destined for a computer to the right of the sender uses the upper bus. Traffic to the left uses the lower one.



[Architecture of the DQDB metropolitan area network]

A key aspect of a MAN is that there is a broadcast medium (for 802.6, two cables) to which all the computers are attached. This greatly simplifies the design compared to other kinds of networks.

WIDE AREA NETWORKS

A wide area network, or WAN, spans a large geographical area, often a country or continent. It contains a collection of machines intended for running j
user (i.e., application) programs. We will follow traditional usage and call these machines hosts. The term end system is sometimes also used in the literature. The hosts are connected by a communication subnet, or just subnet for short. The job of the subnet is to carry messages from host to host, just as the telephone system carries words from speaker to listener. By separating the pure communication aspects of the network (the subnet) from the application aspects (the hosts), the complete network design is greatly simplified.

In most wide area networks, the subnet consists of two distinct components: transmission lines and switching elements. Transmission lines (also called circuits, channels, or trunks) move bits between machines.

The switching elements are specialized computers used to connect two or more transmission lines. When data arrive on an incoming line, the switching element must choose an outgoing line to forward them on. Unfortunately, there is no standard terminology used to name these computers. They are variously called packet switching nodes, intermediate systems, and data switching exchanges, among other things. As a generic term for the switching computers, we will use the word router,

but the reader should be aware that no consensus on terminology exists here. In this model, shown in Fig., each host is generally connected to a LAN on which a router is present, although in some cases a host can be connected directly to a router. The collection of communication lines and routers (but not the hosts) form the subnet.

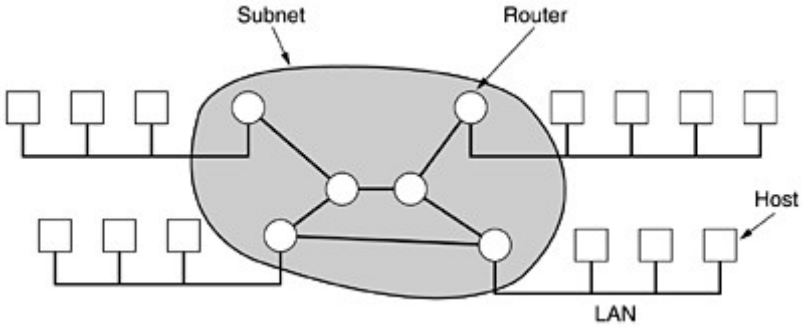
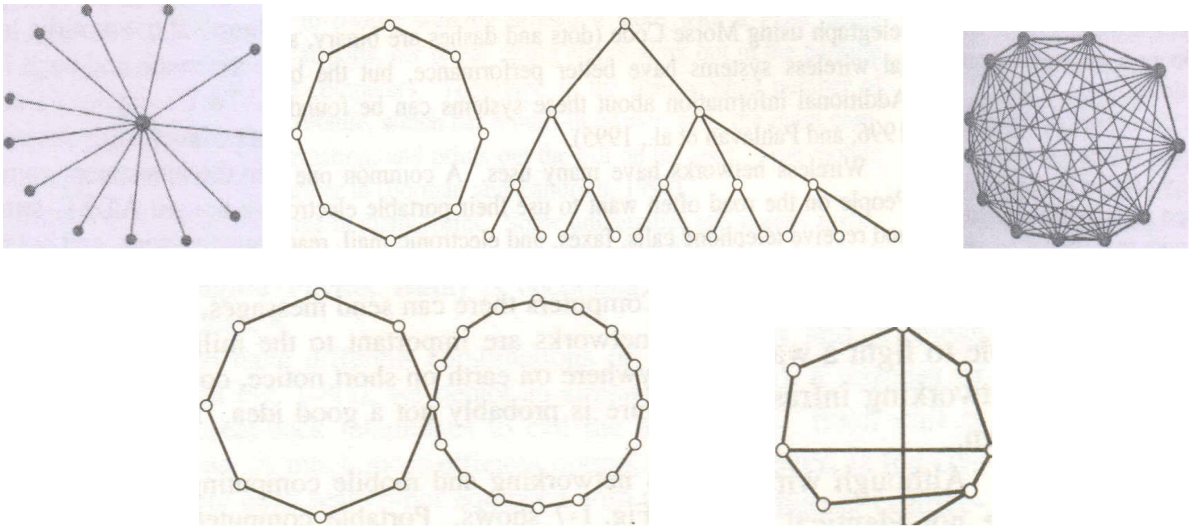


Figure: Relations between hosts on LANs and the subnet.

An aside about the term "subnet" is worth making. Originally, its only meaning was the collection of routers and communication lines that moved packets from the source host to the destination host. However, some years later, it also acquired a second meaning in conjunction with network addressing. Hence the term has a certain ambiguity about it.

In most WANs, the network contains numerous cables or telephone lines, each one connecting a pair of routers. If two routers that do not share a cable nevertheless wish to communicate, they must do this indirectly, via other routers. When a packet is sent from one router to another via one or more intermediate routers, the packet is received at each intermediate router in its entirety, stored there until the required output line is free, and then forwarded. A subnet using this principle is called a point-to-point, store-and-forward, or 'packet-swjtched subnet. Nearly all wide area networks (except those using satellites) have storeand-forward subnets. When the packets are small and all the same size, they are often called cells.

When a point-to-point subnet is used, an important design issue is what the router interconnection topology should look like. Figure shows several possible topologies. Local networks that were designed as such usually have a symmetric topology. In contrast, wide area networks typically have irregular topologies.



Some possible topologies for a point-to-point subnet. (a) Star. (b) Ring. (c) Tree. (d) Complete. (e) Intersecting rings. (f) Irregular.

A second possibility for a WAN is a satellite or ground radio system. Each router has an antenna through which it can send and receive. All routers can hear the output *from* the satellite, and in some cases they can also hear the upward transmissions of their fellow routers *to* the satellite as well. Sometimes the routers are connected to a substantial point-to-point subnet, with only some of them having a satellite antenna. Satellite networks are inherently broadcast and are most useful when the broadcast property is important.

USES OF COMPUTER NETWORKS

Many organizations have a substantial number of computers in operation, often located far apart. For example, a company with many factories may have a computer at each location to keep track of inventories, monitor productivity, and do the local payroll. Initially, each of these computers may have worked in isolation from the others, but at some point, management may have decided to connect them to be able to extract and correlate information about the entire company. Put in slightly more general form, the issue here is resource sharing, and the goal is to make all programs, equipment, and especially data available to anyone on the network without regard to the physical location of the resource and the user. In other words, the mere fact that a user happens to be 1000 km away from his data should not prevent him from using the data as though they were local. Saying that it is an attempt to end the “tyranny of geography” may summarize this goal.

A second goal is to provide high reliability by having alternative sources of supply. For example, all files could be replicated on two or three machines, so if one of them is unavailable (due to a hardware failure), the other copies could be used. In addition, the presence of multiple CPUs means that if one goes down, the others may be able to take over its work, although at reduced performance. For military, banking, air traffic control, nuclear reactor safety, and many other applications, the ability to continue operating in the face of hardware problems is of utmost importance.

Another goal is saving money. Small computers have a much better price/performance ratio than large ones. Mainframes (room-size computers) are roughly a factor of ten faster than personal computers, but they cost a thousand times more. This imbalance has caused many systems designers to build systems consisting of personal computers, one per user, with data kept on one or more shared tile server machines. In this model, the users are called clients, and the whole arrangement is called the client-server model.

In the client-server model, communication generally takes the form of a request message from the client to the server asking for some work to be done.
The server then does the work and sends back the reply. Usually, there are many clients using a small number of servers.

Another networking goal is scalability, the ability to increase system performance gradually as the workload grows just by adding more processors. With centralized mainframes, when the system is full, it must be replaced by a larger one, usually at great expense and even greater disruption to the users. With the client-server model, new clients and new servers can be added as needed.

Yet another goal of setting up a computer network has little to do with technology at all. A computer network can provide a powerful communication medium among widely separated employees. Using a network, it is easy for two or more people who live far apart to write a report together. When one worker makes a change to an on-

line document, the others can see the change immediately, instead of waiting several days for a letter. Such a speedup makes cooperation among far-flung groups of people easy where it previously had been impossible. In the long run, the use of networks to enhance human-to-human communication will probably prove more important than technical goals such as improved reliability.

TERMINOLOGY

Network topology is the arrangement of the various elements of a computer or biological network. Essentially, it is the topological structure of a network, and may be depicted physically or logically. *Physical* topology refers to the placement of the network's various components, including device location and cable installation, while *logical* topology shows how data flows within a network, regardless of its physical design. Distances between nodes, physical interconnections, transmission rates, and/or signal types may differ between two networks, yet their topologies may be identical.

Data rate: data rate is refers to bit rate or data transfer rate means how many bits transfer from one device to another in a second. Data rate is count in Kbps, Mbps and Gbps.

Modulation rate: modulation rate is the number of symbol changes (waveform changes or signaling events) made to the transmission medium per second using a digitally modulated signal or a line code. The Symbol rate is measured in baud (Bd) or symbols/second. In the case of a line code, the symbol rate is the pulse rate in pulses/second. Each symbol can represent or convey one or several bits of data. The symbol rate is related to, but should not be confused with, the gross bitrate expressed in bit/second.

Spectrum: The frequency spectrum of a signal is the collection of all the component frequencies it contains in other word frequency spectrum refers to the elements within that range.

Bandwidth: the bandwidth of a signal is the width if the frequency spectrum. In other words, bandwidth refers to the range of component frequency.

Server: a server is a program running on the remote machine providing service to the clients. When it starts, it opens the door for incoming request from client but it never initiate a service until it is requested to do so.
A server program is an infinite program. When it starts, it runs infinitely unless a problem arises. It waits for incoming requests from other clients. When a request arrives, it responds to the request.

Host: A network host is a computer connected to a computer network. A network host may offer information resources, services, and applications to users