Chapter Three

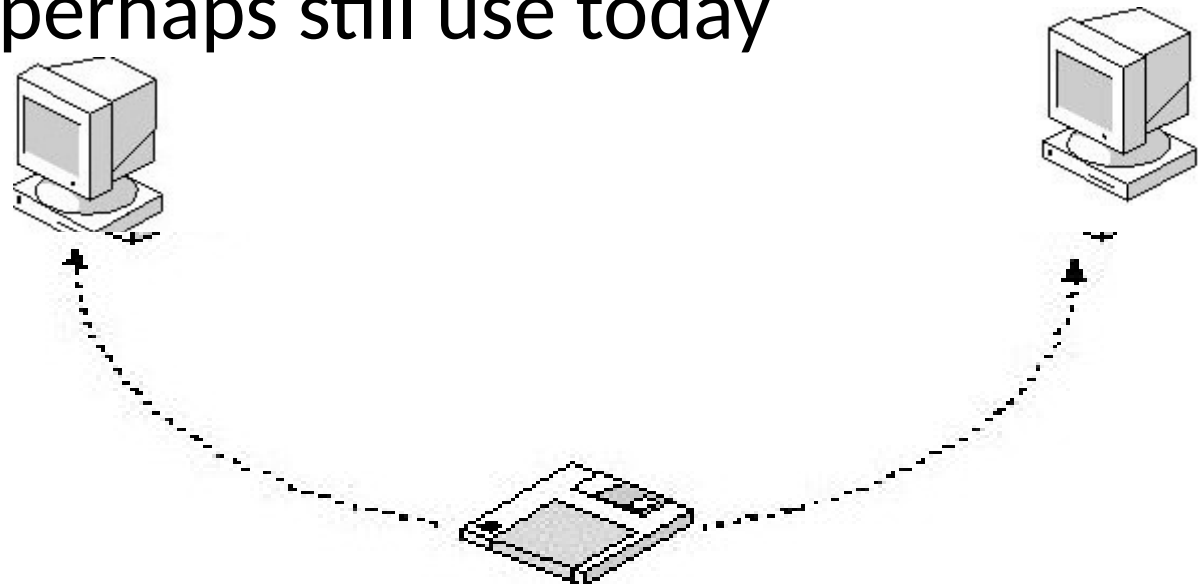
- Introduction to Computer Networks

Computer Network and its Applications

- **Computer Networking**
  - At its most elementary level, a computer network consists of **two computers** connected to each other by a cable that allows them to share data. All computer networking, no matter how sophisticated, stems from that simple system.
  - Computer networking arose as an answer to the need to share data in a timely fashion. Personal computers are powerful tools that can process and manipulate large amounts of data quickly, but they do not allow users to share that data efficiently. Before networks, users needed either to print out documents or copy document files to a disk for others to edit or use them. If others made changes to the document, there was no easy way to merge the changes. This was, and still is, known as "working in a stand-alone environment."

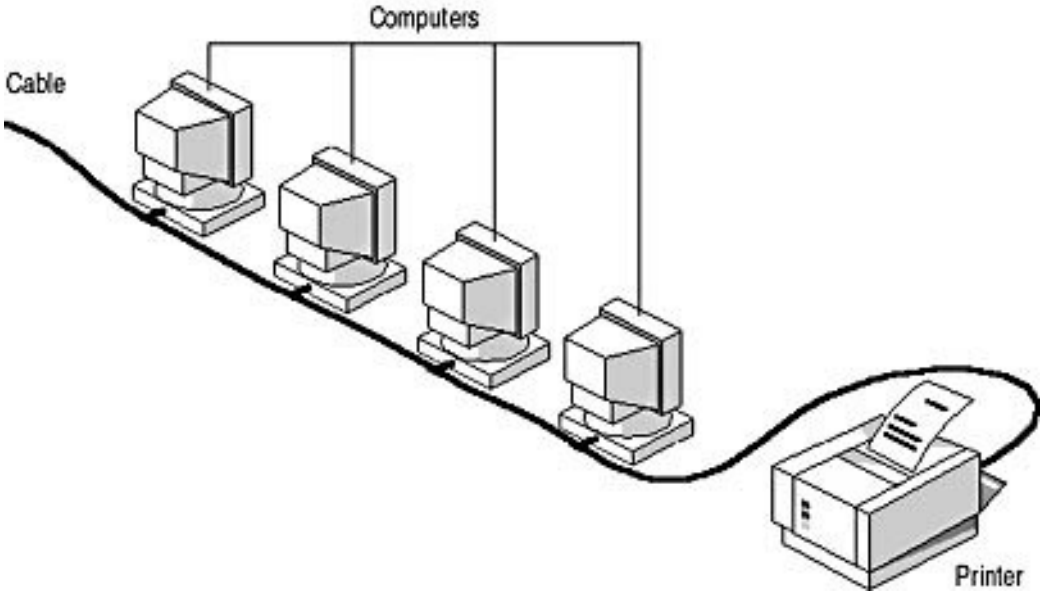
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- Copying files onto floppy disks and giving them to others to copy onto their computers was sometimes referred to as the "**sneakernet**." This early form of computer networking is one that many of us have used and perhaps still use today



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- connecting together of computers and other devices is called a ***network***, and the concept of connected computers sharing resources is called ***networking***.



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- Two computers are said to be interconnected if they are able to exchange information
- Components of a compute networks

Hardware:
- *Computer*
- *Network card*
- *Routers*
- *Modem …*

Media:
- *Cable*
- *Wire*
- *Microwave …*

Software:
- *Network OS*
- *Utilities …*

Network Design:
- *Logical layout*
- *Physical layout …*

Uses of Computer Networks



Telephone-related services



Fax messages



Voice mail

Video/voice communication



Videoconferencing



Picture phone

Online information services



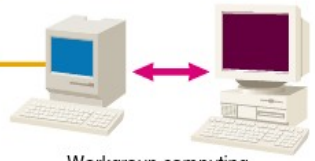
Research and news
E-mail, BBSs, chat
Games, entertainment
Travel services
Shopping
Other

The Internet

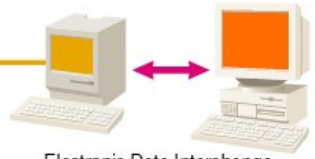


E-mail
Usenet news groups
Mailing lists
FTP
Telenet
Gopherspace
World Wide Web
Services offered by online information service

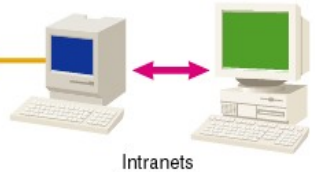
Shared resources



Workgroup computing



Electronic Data Interchange



Intranets
Extranets

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- resource sharing
  - the goal of network 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. An obvious and widespread example is having a group of office workers share a common **printer**. None of the individuals really needs a private printer, and a high-volume networked printer is often cheaper, faster, and easier to maintain than a large collection of individual printers.
  - **Information sharing** is more important than physical resource sharing

- Means of communication
  - E-mail
  - Videoconferencing
  - Chatting
  - E-commerce
  - Game
  - ….

- Centralizing administration and support
  - Database
  - Banks
  - ….

Network Types

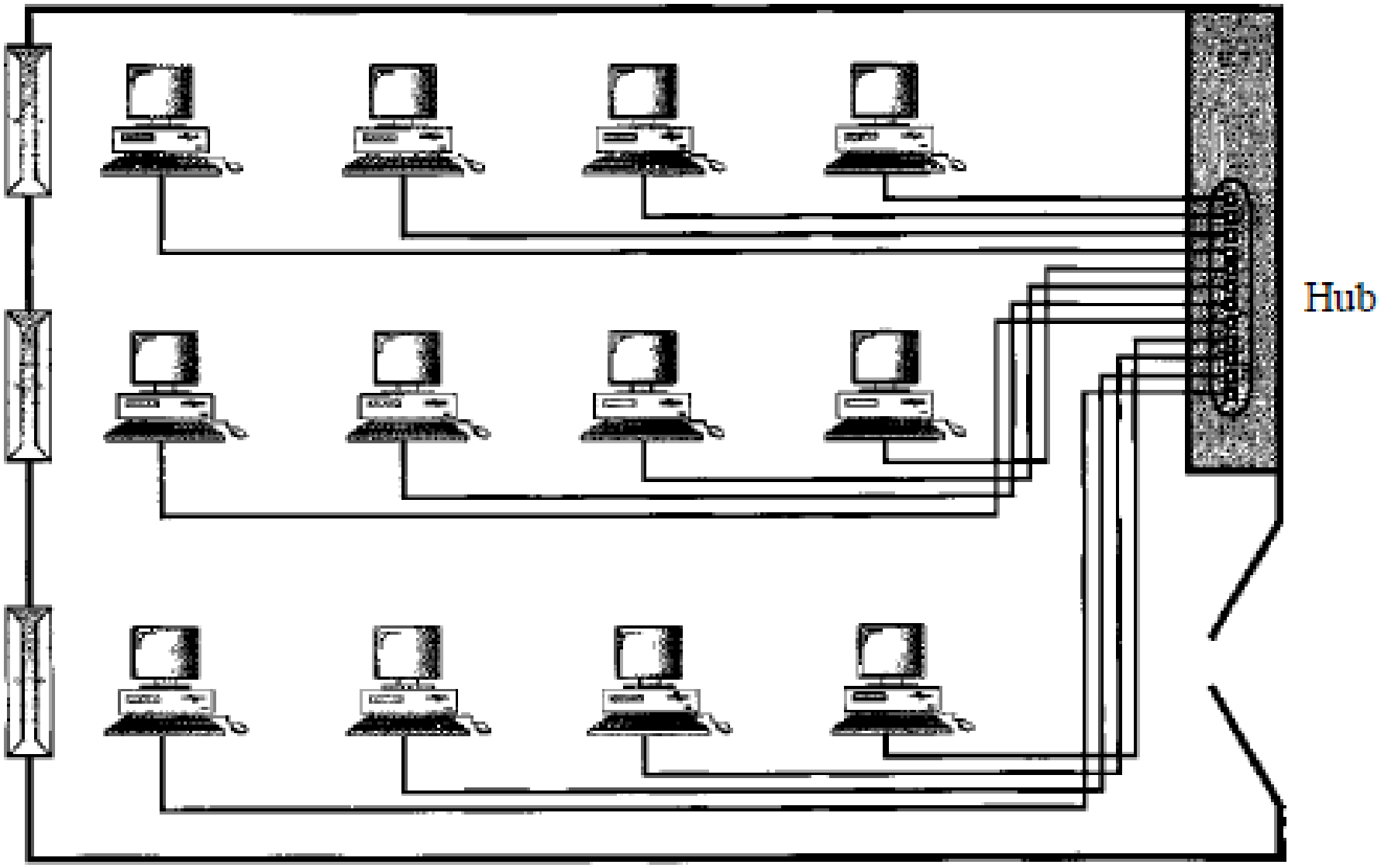
- There are basically three categories of networks based on its size and geographical coverage
  - Local Area Network (LAN)
  - Metropolitan Area Network (MAN)
  - Wide Area Network (WAN)

LAN

- A ***local area network (LAN)*** is the basic building block of any computer network. A LAN can range from simple (two computers connected by a cable) to complex (hundreds of connected computers and peripherals throughout a major corporation).
- The distinguishing feature of a LAN is that it is confined to a ***limited geographic area.***

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- A local area network (LAN) is usually privately owned and links the devices in a single office, building, or campus.
- Depending on the needs of an organization and the type of technology used, a LAN can be as simple as two PCs and a printer in someone's home office; or it can extend throughout a company and include audio and video peripherals.
- Currently, LAN size is limited to a few ***kilometers***


Hub

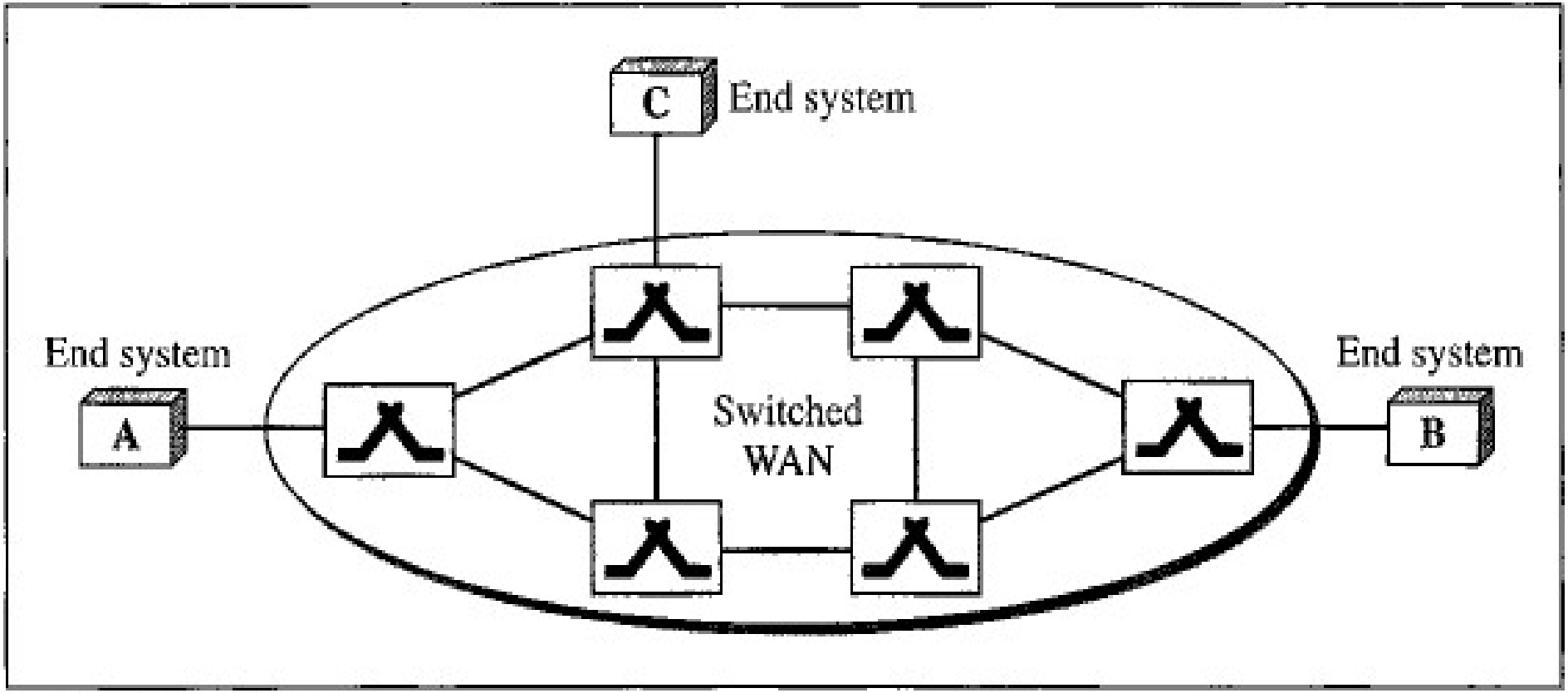
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- LANs are designed to allow resources to be shared between personal computers or workstations. The resources to be shared can include hardware (e.g., a printer), software (e.g., an application program), or data.
- In addition to size, LANs are distinguished from other types of networks by their ***transmission media*** and ***topology***.
- In general, a given LAN will use only **one type of transmission medium**. The most common LAN topologies are bus, ring, and star.
- Early LANs had data rates in the 4 to 16 megabits per second (Mbps) range. Today, however, speeds are normally 100 or 1000 Mbps.
- Wireless LANs are the newest evolution in LAN technology.

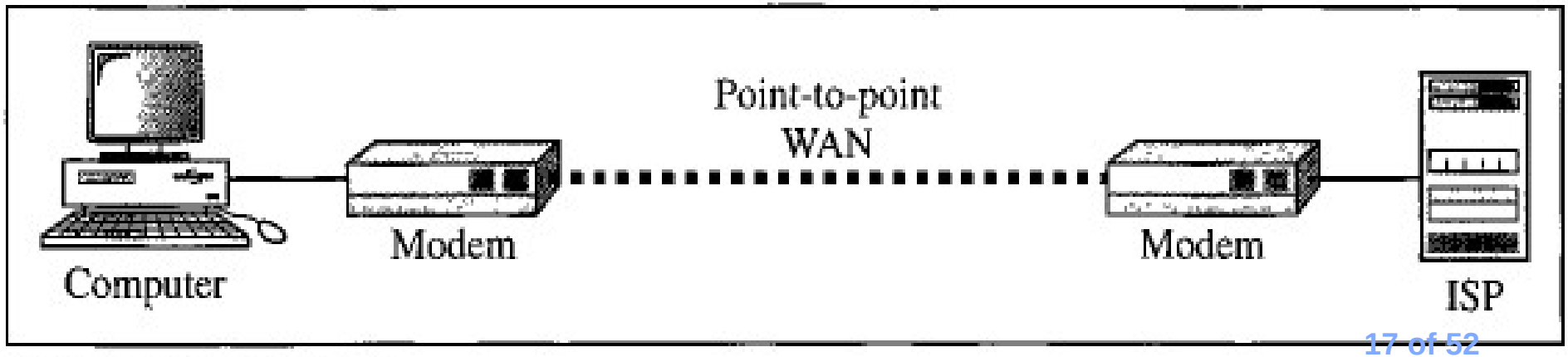
WAN

- A **wide area network (WAN)** provides long-distance transmission of data, image, audio, and video information over large geographic areas that may comprise a country, a continent, or even the whole world.
- A WAN can be as complex as the **backbones** that connect the Internet or as simple as a **dial-up line** that connects a home computer to the Internet. We normally refer to the first as a **switched WAN** and to the second as a **point-to-point WAN**

- The switched WAN connects the end systems, which usually comprise a router (internetworking connecting device) that connects to another LAN or WAN.
- The point-to-point WAN is normally a line leased from a telephone or cable TV provider that connects a home computer or a small LAN to an Internet service provider (ISP). This type of WAN is often used to provide Internet access.



a. Switched WAN



b. Point-to-point WAN

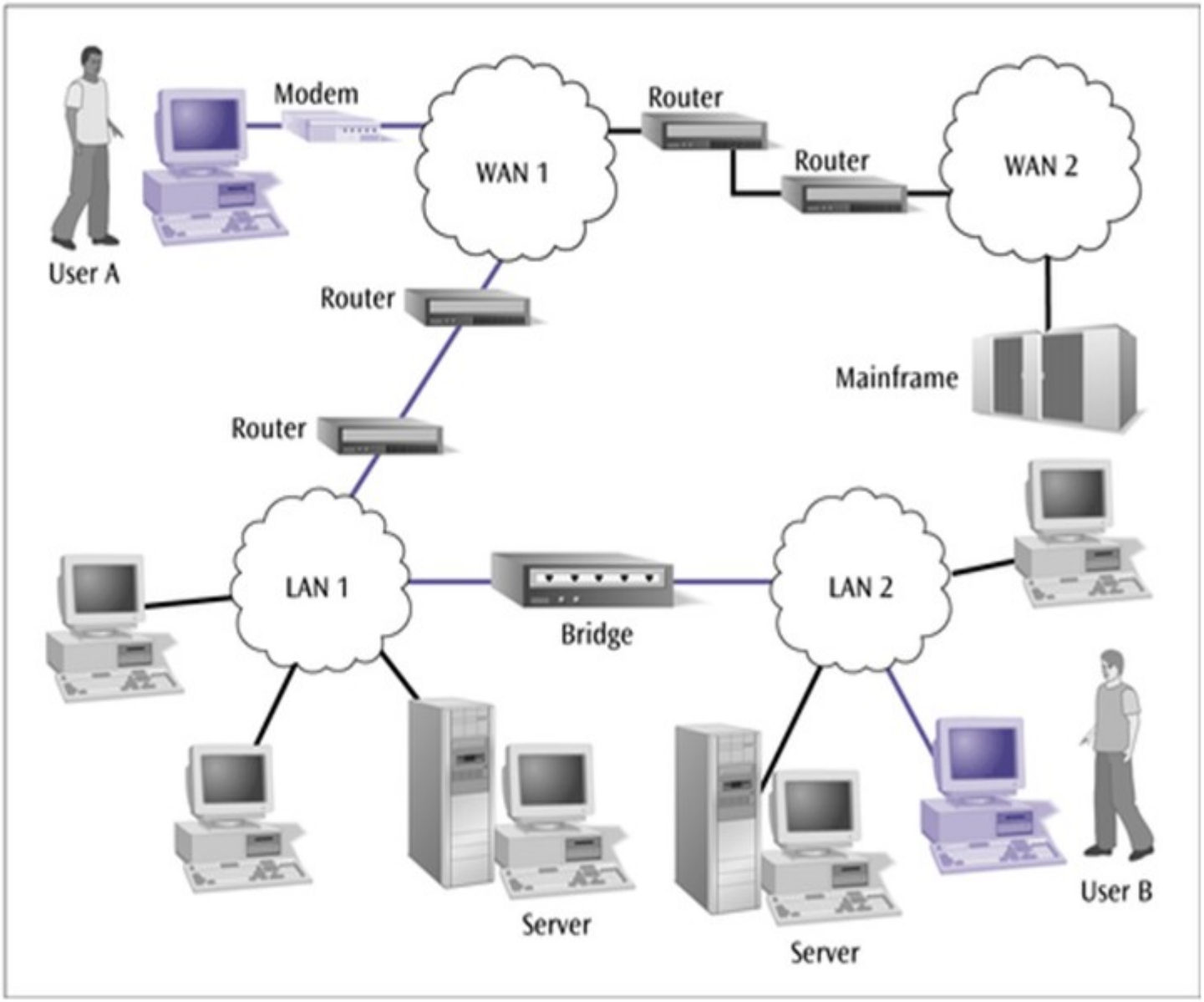
MAN

- A metropolitan area network (MAN) is a network with a size between a LAN and a WAN.
- It normally covers the area inside a **town or a city.**
- It is designed for customers who need a **high-speed connectivity**, normally to the Internet, and have endpoints spread over a city or part of city.
- A good example of a MAN is the part of the telephone company network that can provide a high-speed **DSL line** to the customer (we will discuss DSL in later chapters) .
- Another example is the **cable TV** network that originally was designed for cable TV, but today can also be used for high-speed data connection to the Internet.

Interconnection of Networks: Internetwork

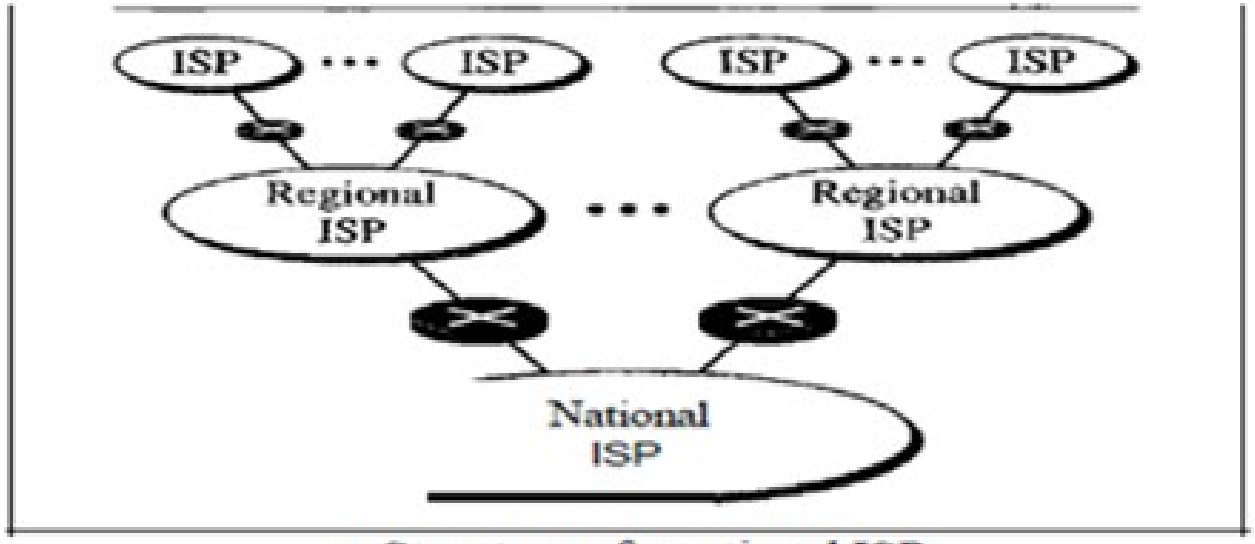
- Today, it is very rare to see a LAN, a MAN, or a LAN in isolation; they are connected to one another.
- When two or more networks are connected, they become an internetwork, or **internet**.

An overall view of the interconnection between local area networks and wide area networks

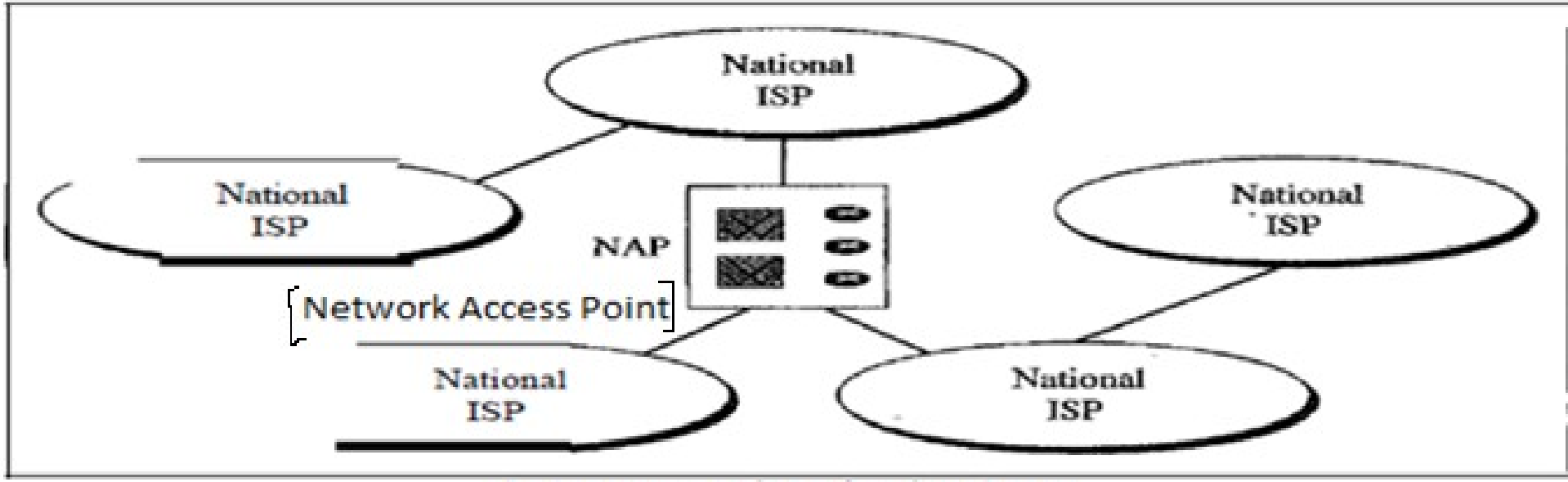


Network, internet, and Internet

- A **network** is a group of connected communicating devices such as computers and printers.
- An **internet** (note the lowercase letter i) is two or more networks that can communicate with each other.
- The most notable internet is called the **Internet** (uppercase letter I), a collaboration of more than hundreds of thousands of interconnected networks.
- Private individuals as well as various organizations such as government agencies, schools, research facilities, corporations, and libraries in more than 100 countries use the Internet.



a. Structure of a national ISP



b. Interconnection of national ISPs

Network Type based on connection

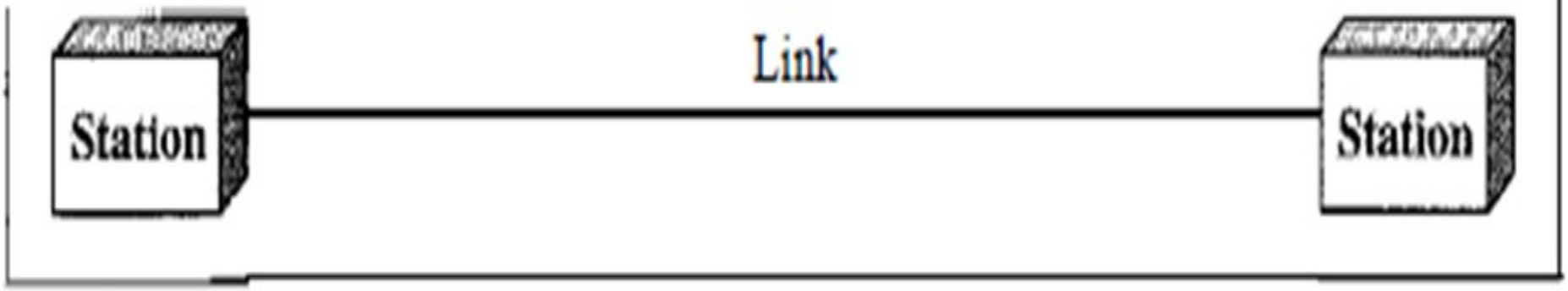
- A network is two or more devices connected through **links**.
- A link is a communications pathway that transfers data from one device to another.
- For visualization purposes, it is simplest to imagine any link as a line drawn between two points.
- For communication to occur, two devices must be connected in some way to the same link at the same time.
- There are two possible types of connections: **point-to-point** and **multipoint.**

Point-to-Point

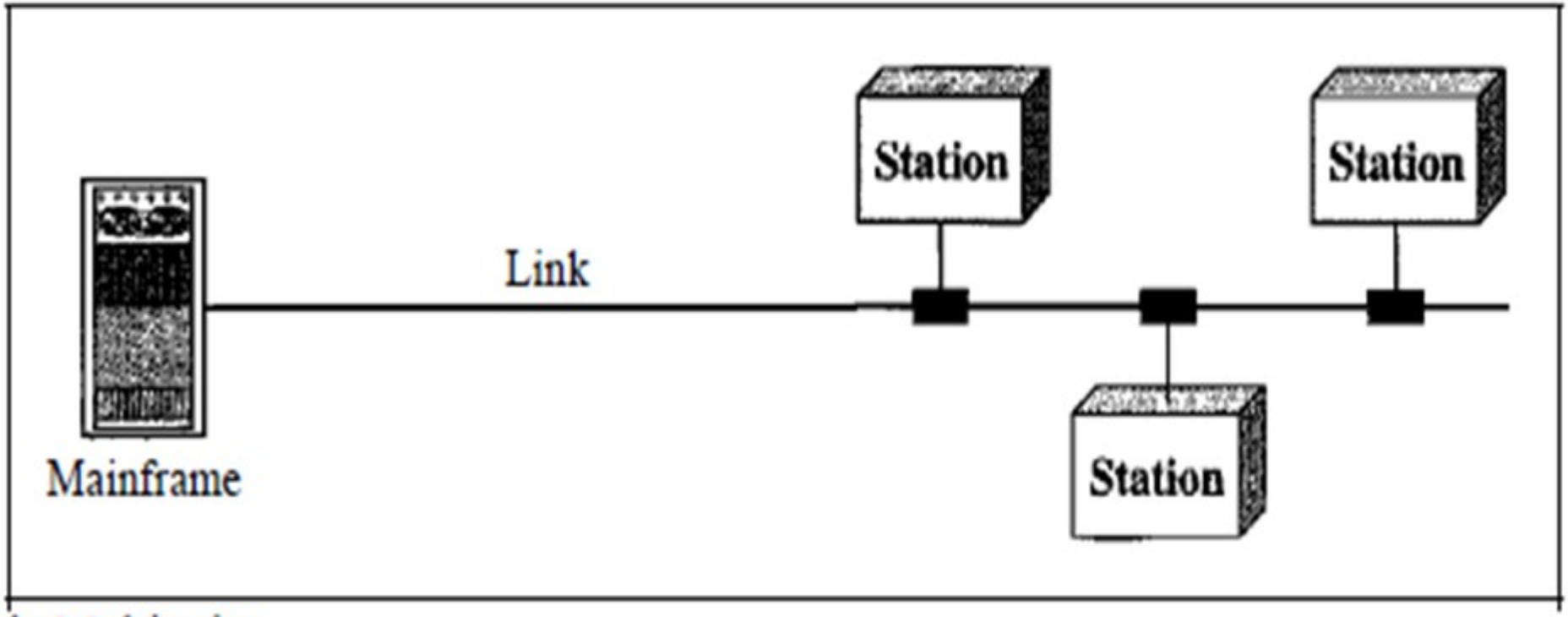
- A point-to-point connection provides a **dedicated link** between two devices.
- The entire capacity of the link is reserved for transmission between those two devices.
- Most point-to-point connections use an actual length of wire or cable to connect the two ends, but other options, such as microwave or satellite links, are also possible.
- When you change television channels by **infrared remote control**, you are establishing a point-to-point connection between the remote control and the television's control system.

Multipoint

- A multipoint (also called multidrop) connection is one in which more than two specific devices **share a single link**.
- In a multipoint environment, the capacity of the channel is shared, either **spatially** or **temporally**.
- If several devices can use the link simultaneously, it is a *spatially shared* connection.
- If users must take turns, it is a *timeshared connection*.



a. Point-to-point



b. Multipoint

Network Topology

- The term ***topology*** *refers to the way in which a network is laid out physically.* Two or more devices connect to a link; two or more links form a topology. The topology of a network is the **geometric representation** of the relationship of all the links and linking devices (usually called **nodes**) to one another.
- There are four basic topologies possible: mesh, star, bus, and ring

Star Topology

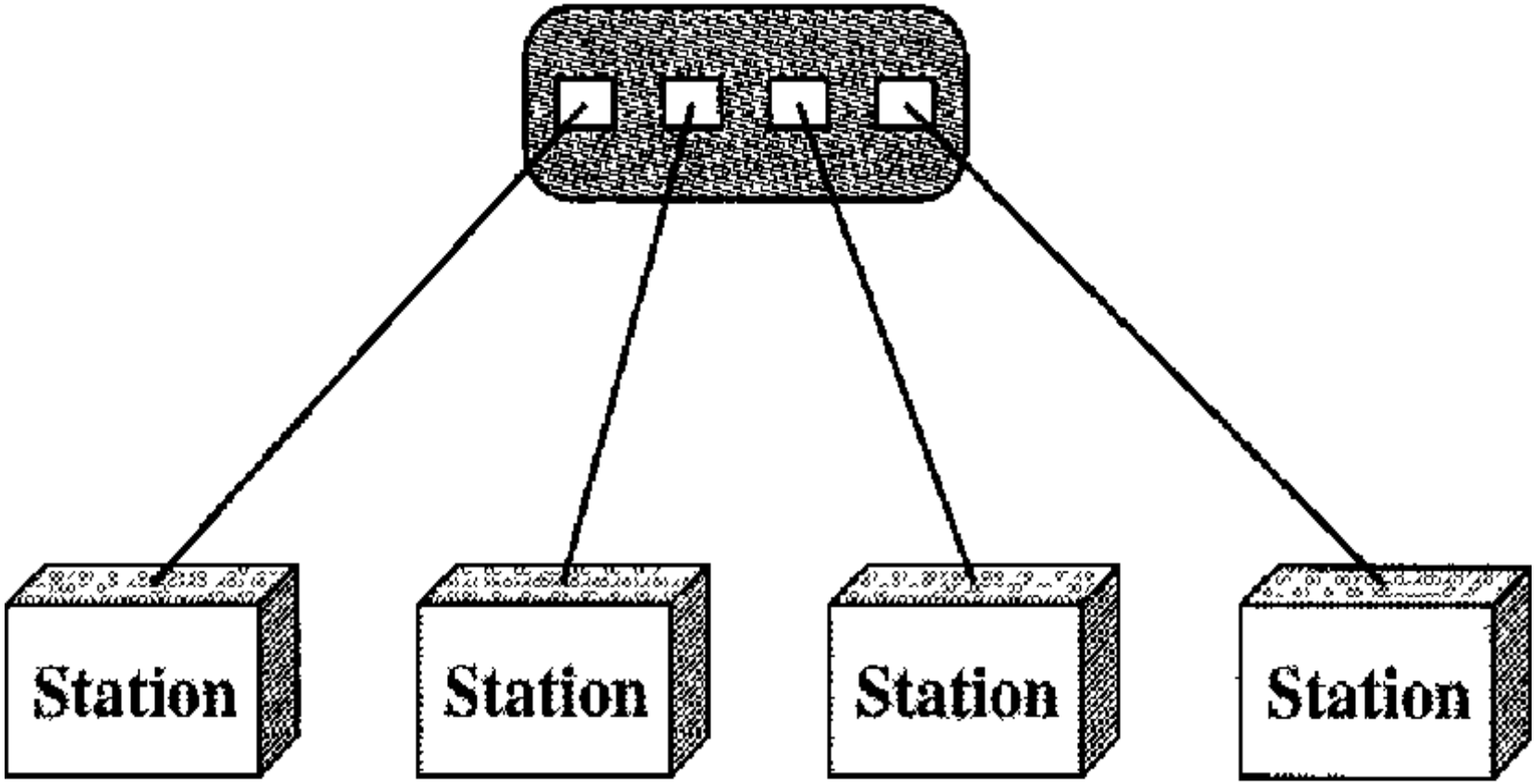
- In a **star topology**, each device has a dedicated point-to-point link only to a central controller, usually called a hub.
- The term *dedicated* *means that the link carries traffic only between the* two devices it connects.
- The devices are not directly linked to one another.
- Unlike a mesh topology, a star topology does not allow direct traffic between devices.
- The controller acts as an exchange: If one device wants to send data to another, it sends the data to the controller, which then relays the data to the other connected device

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- A star topology is less expensive than a mesh topology.
- In a star, each device needs only one link and one I/O port to connect it to any number of others.
- This factor also makes it **easy to install and reconfigure**. Far **less cabling** needs to be housed, and additions, moves, and deletions involve **only one connection**: between that device and the hub.
- Other advantages include **robustness**. If one link fails, only that link is affected. All other links remain active. This factor also lends itself to **easy fault identification** and **fault isolation**. As long as the hub is working, it can be used to monitor link problems and bypass defective links.

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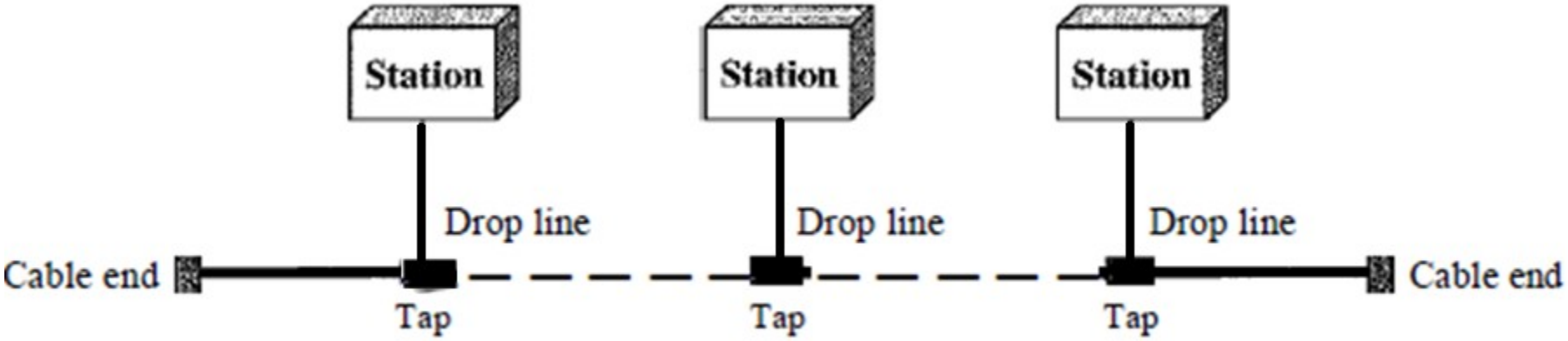
- One big disadvantage of a star topology is the dependency of the whole topology on one single point, the hub.
- If the hub goes down, the whole system is dead.
- Although a star requires far less cable than a mesh, each node must be linked to a central hub.
- For this reason, often more cabling is required in a star than in some other topologies (such as ring or bus).
- The star topology is used in local-area networks (LANs).
- High-speed LANs often use a star topology with a central hub.



Star topology

Bus Topology

- A bus topology, is multipoint connection.
- One long cable acts as a **backbone** to link all the devices in a network



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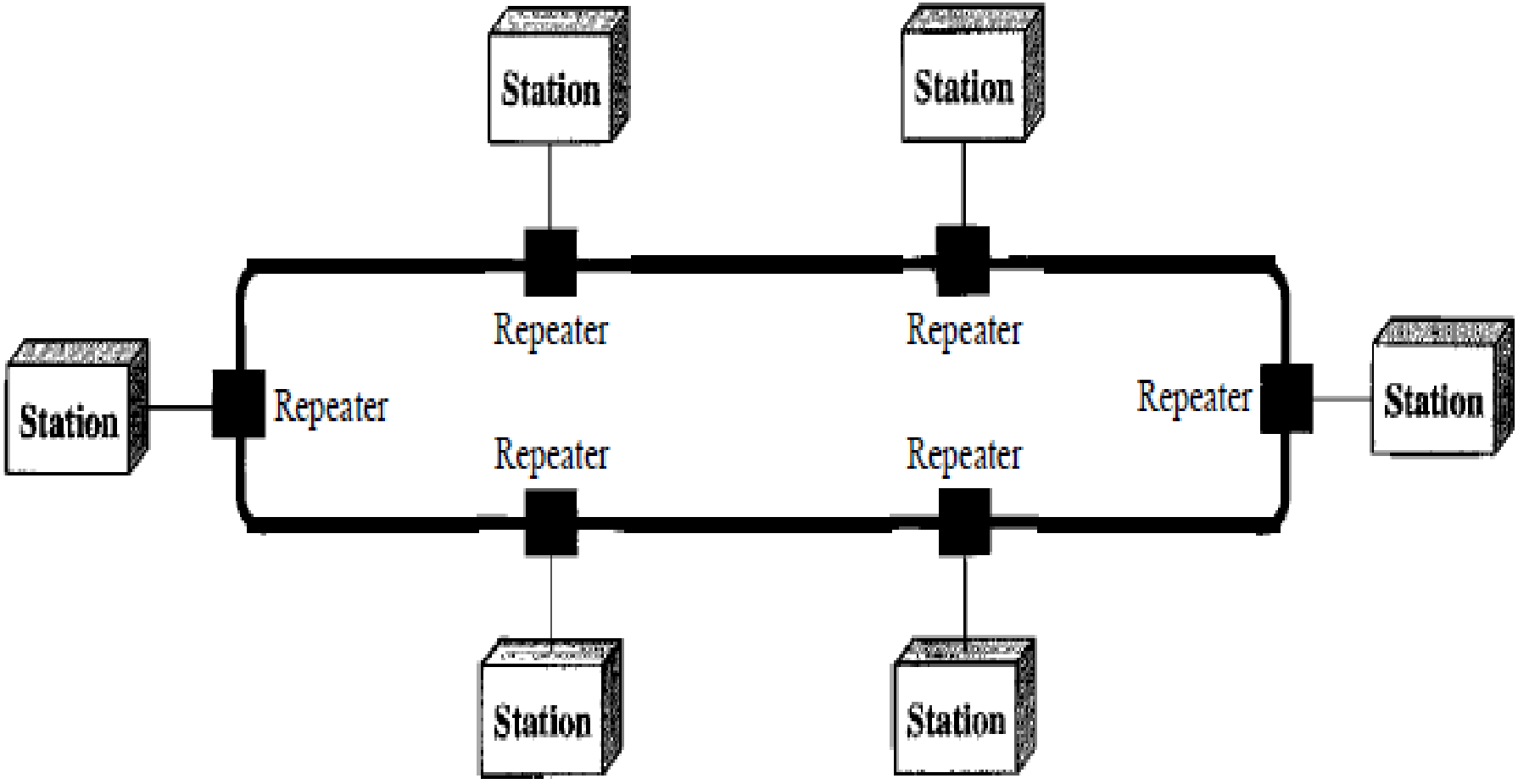
- Nodes are connected to the bus cable by drop lines and taps.
- A drop line is a connection running between the device and the main cable.
- A tap is a connector that either splices into the main cable or punctures the sheathing of a cable to create a contact with the metallic core.
- As a signal travels along the backbone, some of its energy is transformed into heat.
- Therefore, it becomes weaker and weaker as it travels farther and farther.
- For this reason there is a limit on the number of taps a bus can support and on the distance between those taps.

- Advantages of a bus topology include ease of installation.
- Backbone cable can be laid along the most efficient path, then connected to the nodes by drop lines of various lengths.
- In this way, a bus uses less cabling than mesh or star topologies.
- In a star, for example, four network devices in the same room require four lengths of cable reaching all the way to the hub.
- In a bus, this redundancy is eliminated. Only the backbone cable stretches through the entire facility.
- Each drop line has to reach only as far as the nearest point on the backbone.

- Disadvantages include difficult reconnection and fault isolation. A bus is usually designed to be optimally efficient at installation.
- It can therefore be difficult to add new devices.
- Signal reflection at the taps can cause degradation in quality. This degradation can be controlled by limiting the number and spacing of devices connected to a given length of cable.
- Adding new devices may therefore require modification or replacement of the backbone.
- In addition, a fault or break in the bus cable stops all transmission, even between devices on the same side of the problem.
- The damaged area reflects signals back in the direction of origin, creating noise in both directions.
- Bus topology was one of the first topologies used in the design of early local area networks. Ethernet LANs can use a bus topology, but they are less popular now.

Ring Topology

- In a ring topology, each device has a dedicated point-to-point connection with only the two devices on either side of it.
- A signal is passed along the ring in one direction, from device to device, until it reaches its destination.
- Each device in the ring incorporates a repeater. When a device receives a signal intended for another device, its repeater regenerates the bits and passes them along



Ring topology

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- A ring is relatively easy to install and reconfigure. Each device is linked to only its immediate neighbors (either physically or logically).
- To add or delete a device requires changing only two connections.
- The only constraints are media and traffic considerations (maximum ring length and number of devices).
- In addition, fault isolation is simplified.
- Generally in a ring, a signal is circulating at all times.

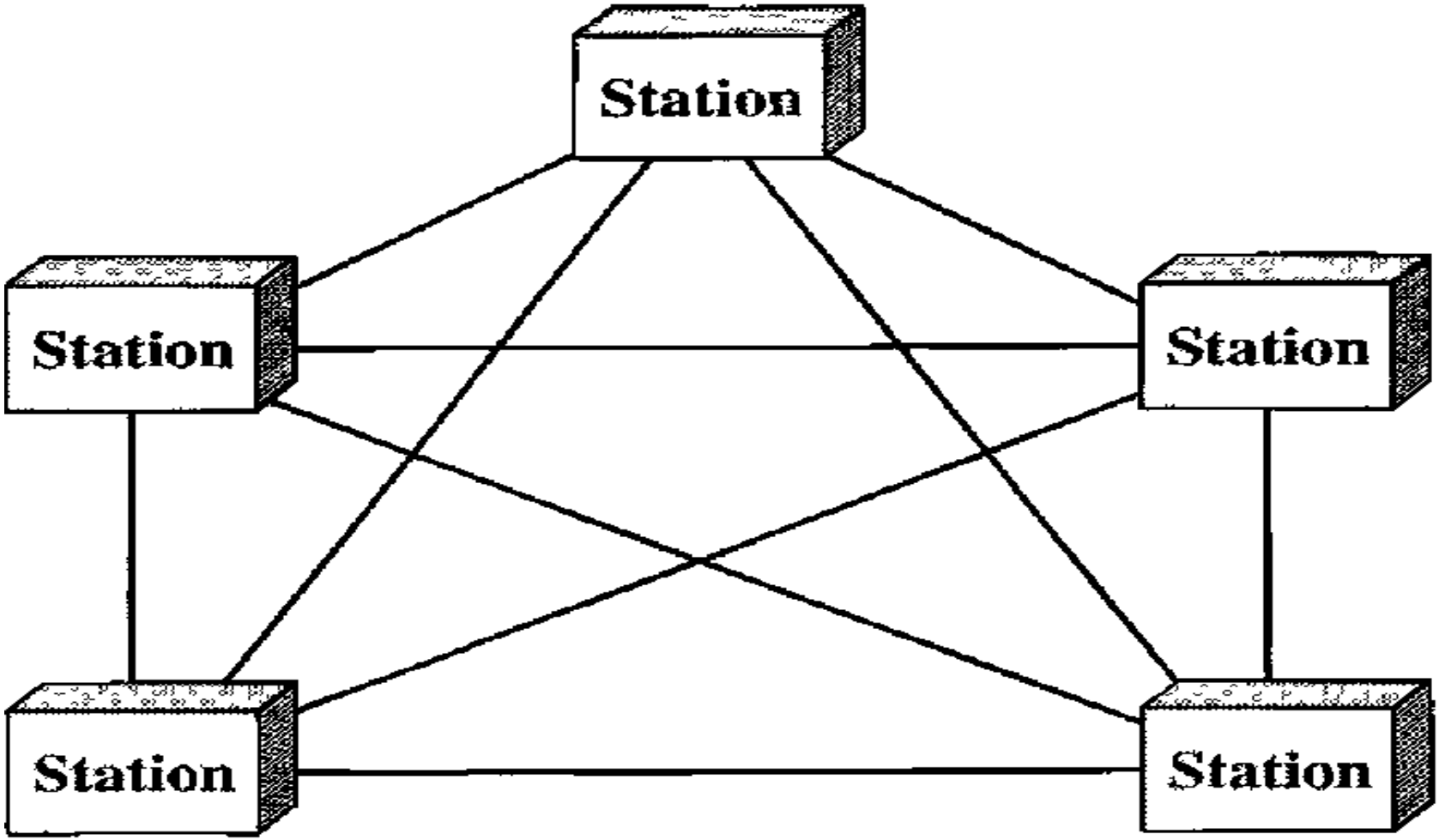
- In a simple ring, a break in the ring (such as a disabled station) can disable the entire network.
- This weakness can be solved by using a dual ring or a switch capable of closing off the break.
- Ring topology was prevalent when IBM introduced its local-area network Token Ring.
- Today, the need for higher-speed LANs has made this topology less popular.

Mesh topology

- In a mesh topology, every device has a dedicated point-to-point link to every other device.
- To find the number of physical links in a fully connected mesh network with *n nodes, we first consider that each node must be connected to every* other node.
- *Node 1* must be connected to *n - I nodes, node 2 must be connected to n – 1* nodes, and finally *node n must be connected* to *n - 1 nodes. We need n(n - 1) physical* links.
- However, if each physical link allows communication in both directions (duplex mode), we can divide the number of links by 2. In other words, we can say that in a mesh topology, we need *n(n -1) /2* duplex-mode links.
- To accommodate that many links, every device on the network must have *n – 1* input/output *(I/O) ports to be connected to the other n - 1 stations*.

- A mesh offers several advantages over other network topologies.
- First, the use of dedicated links guarantees that each connection can carry its own data load, thus eliminating the traffic problems that can occur when links must be shared by multiple devices.
- Second, a mesh topology is robust. If one link becomes unusable, it does not incapacitate the entire system.
- Third, there is the advantage of privacy or security. When every message travels along a dedicated line, only the intended recipient sees it. Physical boundaries prevent other users from gaining access to messages.
- Finally, point-to-point links make fault identification and fault isolation easy.
- Traffic can be routed to avoid links with suspected problems. This facility enables the network manager to discover the precise location of the fault and aids in finding its cause and solution.

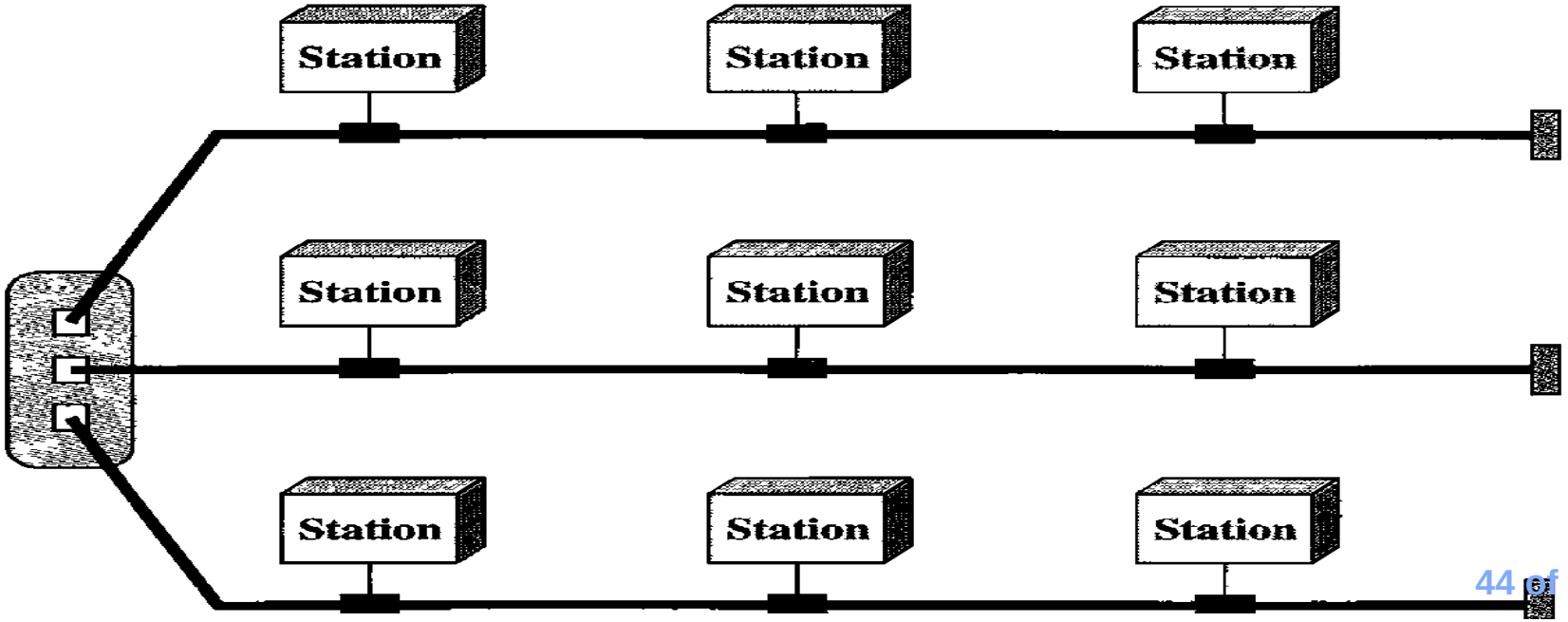
- The main disadvantages of a mesh are related to the amount of cabling and the number of I/O ports required.
- First, because every device must be connected to every other device, installation and reconnection are difficult.
- Second, the sheer bulk of the wiring can be greater than the available space (in walls, ceilings, or floors) can accommodate.
- Finally, the hardware required to connect each link (I/O ports and cable) can be prohibitively expensive.
- For these reasons a mesh topology is usually implemented in a limited fashion, for example, as a backbone connecting the main computers of a hybrid network that can include several other topologies.
- One practical example of a mesh topology is the connection of telephone regional offices in which each regional office needs to be connected to every other regional office



Mesh topology

Hybrid Topology

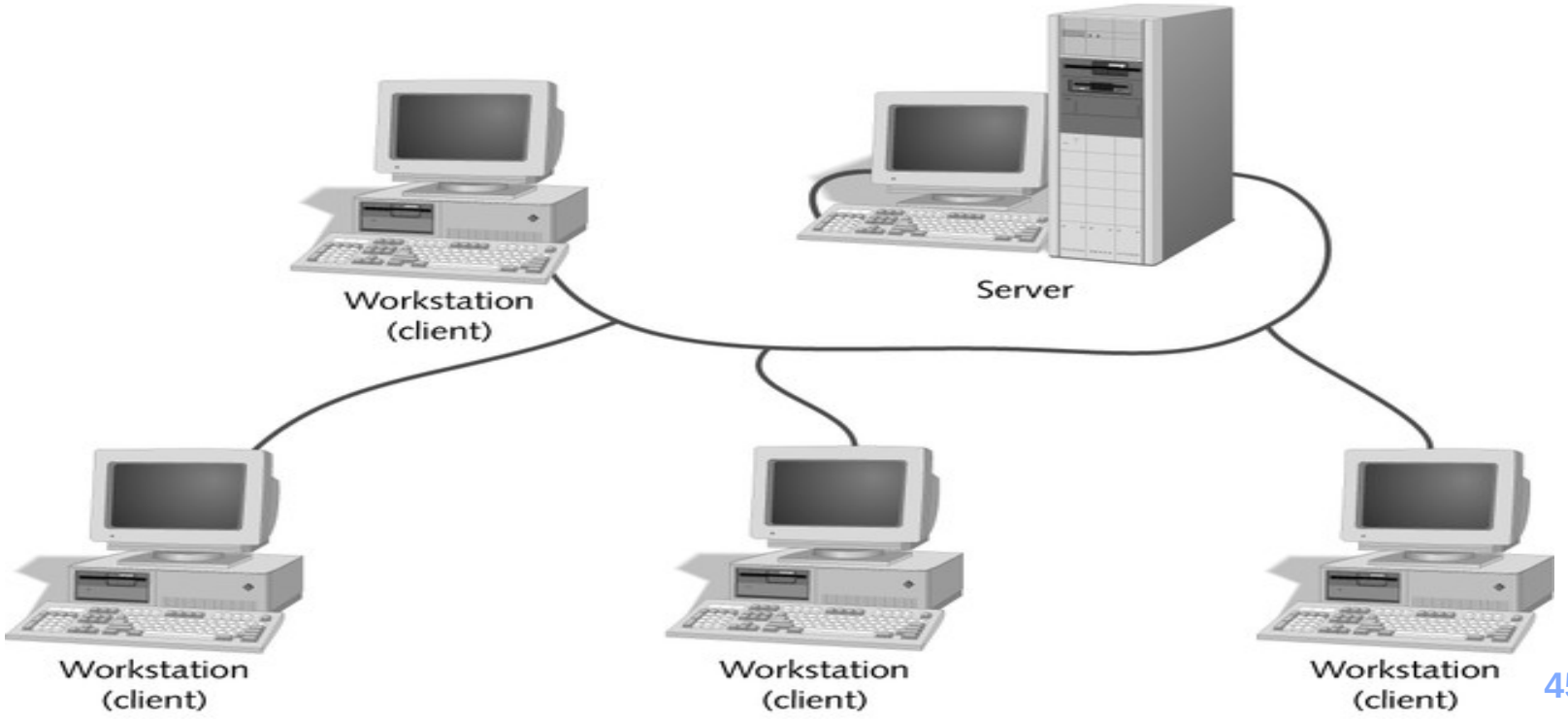
- A network can be hybrid. For example, we can have a main star topology with each branch connecting several stations in a bus topology (star-bus topology)



Network Models by Capability

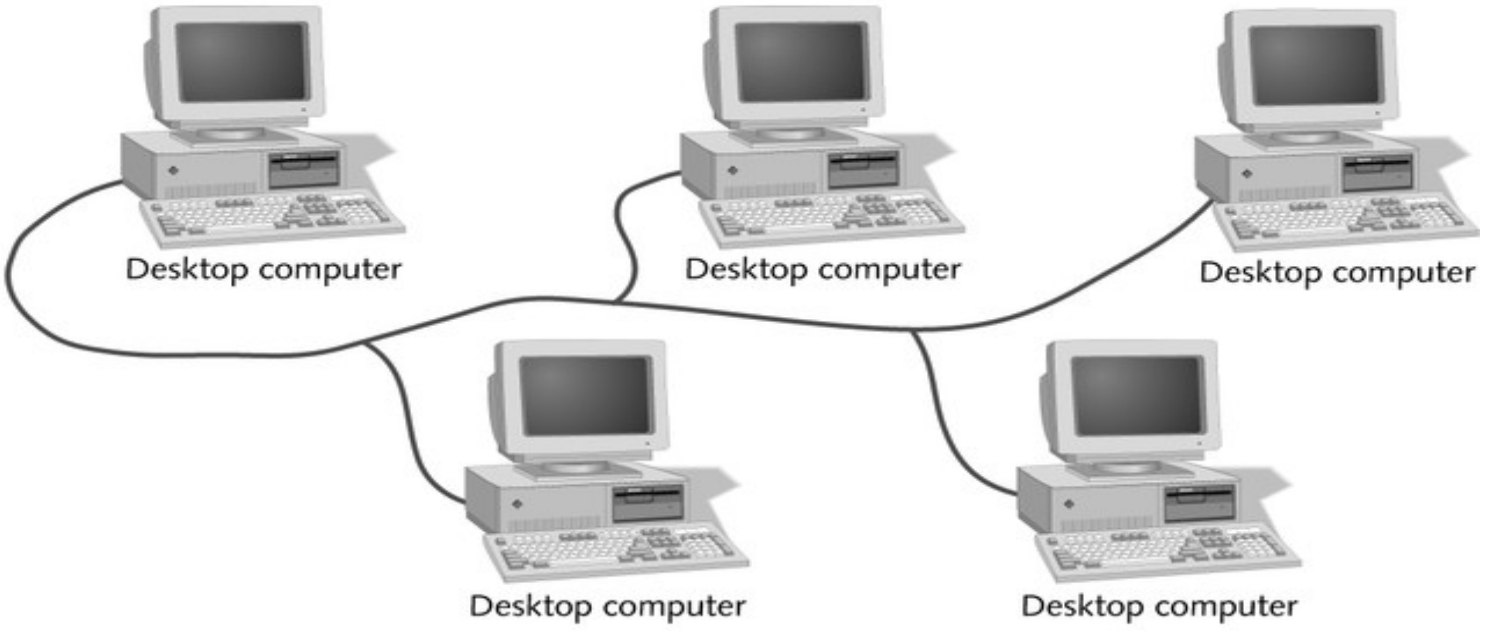
Client/Server Model

- Microcomputer users, or *clients*, share services of a centralized computer called a *server*.

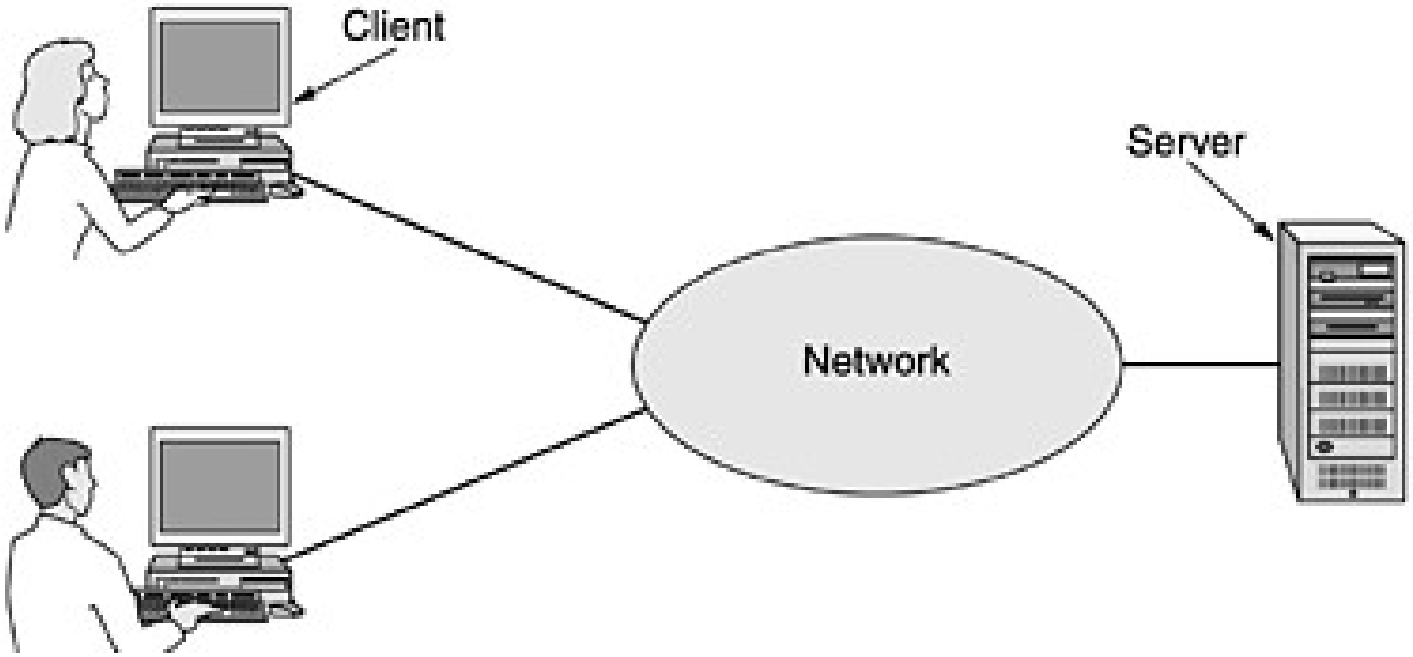


Peer-to-Peer Model

- Computers share equally with one another without having to rely on a central server.



Client-server model



- Two clients using a single server at a time

Client/Server

A distinction exists between computers that make available network resources (servers) and those computers that use the resources (clients or workstations).

Pros:

- Very secure
  - Centralized servers easy to manage
  - Physically centralized
  - Secure OS
- Better performance
- Centralized backups
- Reliability
  - Simple job to do plus built in redundancy

Cons:

- Require professional administration
- More hardware intensive

Peer-to-Peer (p2p)

Computers on the network communicate with each others as equals and each computer is responsible for making its own resources available to other computers on the network.

Pros:

- Uses less expensive computer networks
- Easy to administer
- No NOS (network operating system) required
- More built-in redundancy
  - Shared resources – some machine will have what you need

Cons:

- Individual user performance easily affected
- Not very secure
  - Tragedy of the commons – no guarantee others will administer their resources properly (almost guaranteed with over 10 machines)
- Hard to back up.

Client/Server vs. Peer-to-Peer: Advantages and Disadvantages

Client/Server Model

Advantages:

- Very secure OS.
- Better performance.
- Centralized servers, easy to manage.
- Centralized backups.
- High reliability.

Disadvantages:

- Expensive administration.
- More hardware intensive.

Peer-to-Peer Model

Advantages:

- Uses less expensive networks.
- Easy to administer.
- Contain both network operating system and application software.
- Ideal for small business and home users (up to 10 computers).

Disadvantages:

- Individual user performance easily affected.
- Not very secure.
- Hard to back up.