DATA COMMUNICATIONS AND NETWORKING

Introduction

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BIT 2nd Year, 2nd Semester

Outline

- Data Communications
    - Components
    - Data Flow
- Networks
    - Type of Connection
    - Physical Topology
    - Categories of Networks
- Internetwork
    - The Internet
    - Internet Today
    - Protocols
    - Standards
- Summary

➢ Data Communications

• When we communicate, we are sharing information. This sharing can be local or remote. Between individuals, local communication usually occurs face to face.

• While remote communication takes place over distance. The term *telecommunication,* which includes telephony, telegraphy, and television, means communication at a distance (tele is Greek for "far").

• Data :- Information presented in whatever form is agreed upon by the parties creating and using the data.

• Data communication :- Exchange of data between two devices via some form of transmission medium such as a wire cable.

➤ Data Communications (continue…)

• Fundamental characteristics of data communication:-

1. Delivery. The system must deliver data to the correct destination. Data must be received by the intended device or user and only by that device or user.

2. Accuracy. The system must deliver the data accurately. Data that have been altered in transmission and left uncorrected are unusable.

3. Timeliness. The system must deliver data in a timely manner. Data delivered late are useless. In the case of video and audio, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay. This kind of delivery is called *real-time* transmission.

4. Jitter. Jitter refers to the variation in the packet arrival time. It is the uneven delay in the delivery of audio or video packets.

➤ **Data Communications (continue…)**

- **Five Components of Data Communication**
1. **Message.** The message is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.
2. **Sender.** The sender is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.
3. **Receiver.** The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.
4. **Transmission medium.** The transmission medium is the physical path by which a message travels from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves.
5. **Protocol.** A protocol is a set of rules that govern data communications. It represents an agreement between the communicating devices, As shown in figure 1. Without a protocol, two devices may be connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.

- **Five Components of Data Communication (continue…)**
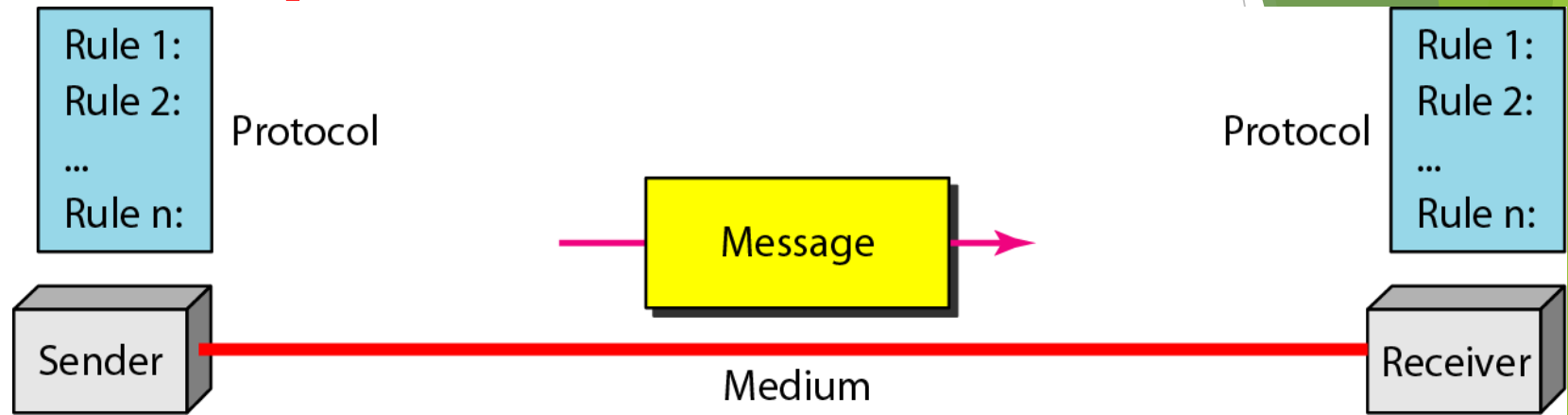

Figure 1. Five components of data communication

- **Data Flow**

  Communication between two devices can be simplex, half-duplex, or full-duplex as shown in Figure 2.

  - **Simplex** : In the simplex mode the communication is unidirectional, as on a one-way street. Only one of the two devices on a link can transmit; the other can only receive. Keyboards and traditional monitors are examples of simplex devices.

6

- Data Flow (continue…)
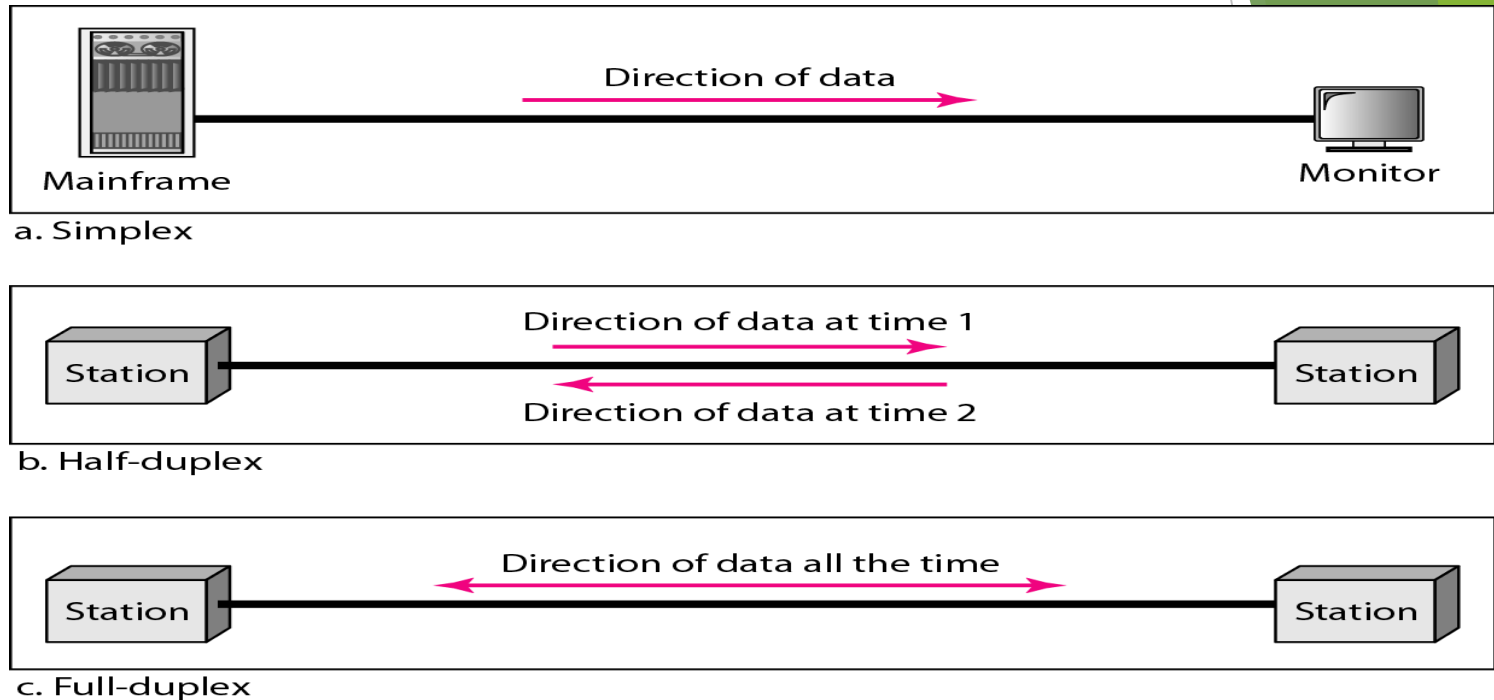

a. Simplex

b. Half-duplex

c. Full-duplex

Figure 2. Data flow (simplex, half-duplex, andfull-duplex)

- Half-Duplex

- In half-duplex mode, each station can both transmit and receive, but not at the same time. When one device is sending, the other can only receive, and vice versa. Like a one-lane road with two-directional traffic , Walkie-talkie, CB radio

- Data Flow (continue…)
- Full-Duplex : In full-duplex mode, both stations can transmit and receive simultaneously.
- The full-duplex mode is like a two-way street with traffic flowing in both directions at the same time.
- One common example of full-duplex communication is the telephone network. When two people are communicating by a telephone line, both can talk and listen at the same time.
- The full-duplex mode is used when communication in both directions is required all the time.

➢ Network

• Network: A set of devices (nodes) connected by communication links.

• Node: Computer, printer, or any device capable of sending and/or receiving data.

• To be considered effective and efficient, a network must meet a number of criteria.

• Network Criteria

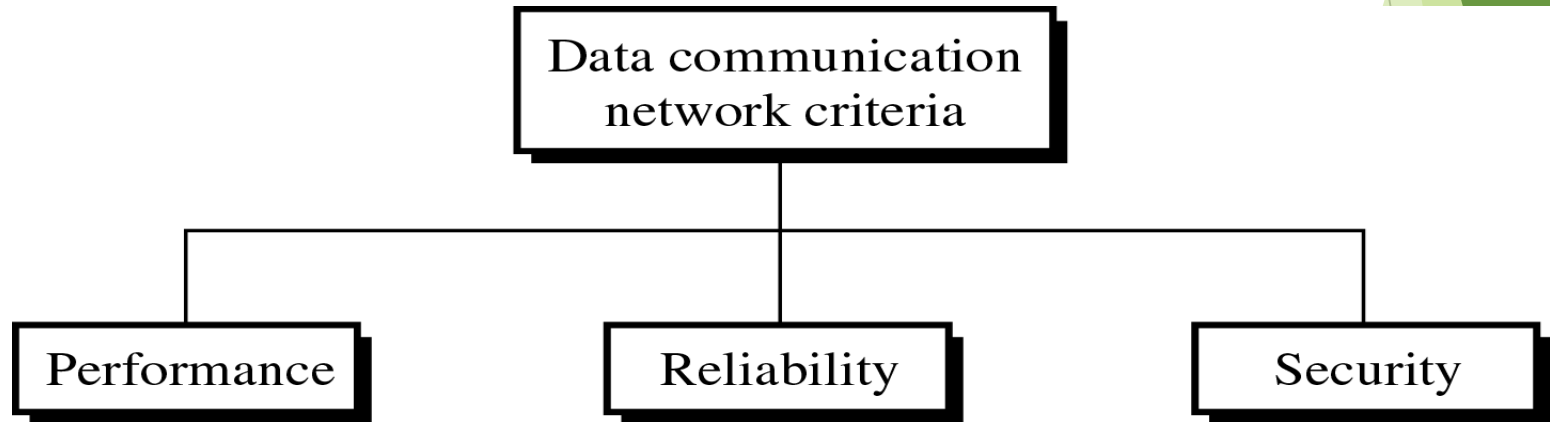The most important of network criteria are performance, reliability, and security.

Figure 3. Network Criteria

9

➤ Networks Criteria (continue…)

• Performance:-

Performance can be measured in many ways, including transit time and response time.

- Transit time is the amount of time required for a message to travel from one device to another.

- Response time is elapsed time between an inquiry and a response.

• The performance of a network depends on a number of factors which are :

- The number of users.
- The type of transmission medium.
- The capabilities of the connected hardware.
- The efficiency of the software.

• Performance is often evaluated by two networking metrics: throughput and delay. We often need more throughput and less delay.

10

➤ Network Criteria (continue…)

- Reliability
- Network reliability is measured by the frequency of failure.
- The time it takes a link to recover from a failure.
- The network's robustness in a catastrophe.

- Security

  Network security issues are:-
- Protecting data from unauthorized access.
- Protecting data from damage and development.
- Implementing policies and procedures for recovery from breaches and data losses.

➢ **Physical Structures**

(Type of 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

    - Multipoint

➢ **Physical Structures (continue…)**

• **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.

13

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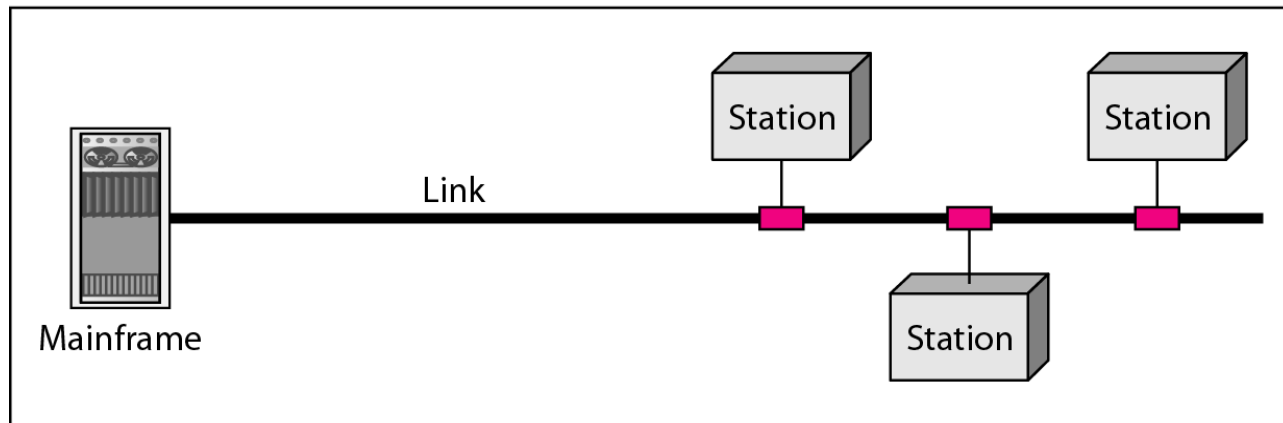➢ Physical Structures (continue…)

• 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.
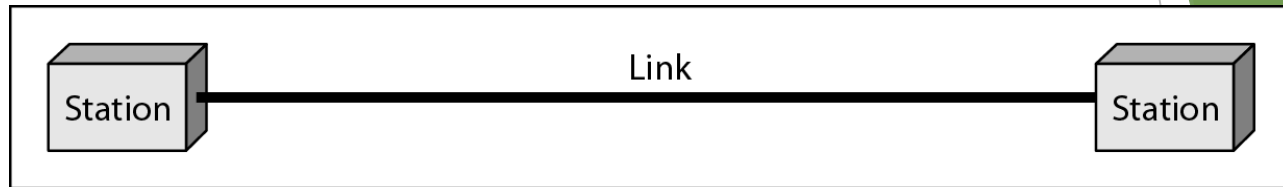
> ## Physical Structures (continue…)

Figure 4. Types of connections: point-to-point and multipoint

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➢ **Physical Structures (continue…)**

- **Point-to-point**
  - Dedicated link between two devices
  - The entire capacity of the channel is reserved Ex) Microwave link, TV remote control

- **Multipoint**
  - More than two devices share a single link
  - Capacity of the channel is either
    - ▪ **Spatially shared:** Devices can use the link simultaneously
    - ▪ **Timeshare:** Users take turns

➢ **Physical Topology**

There are four basic topologies possible: mesh, star, bus, and ring.

• **Mesh Topology**
- Dedicated point-to-point link to every other nodes
- A mesh network with n nodes has n(n-1)/2 links. A node has n-1 I/O ports (links)
- Advantages: No traffic problems, robust, security, easy fault identification & isolation
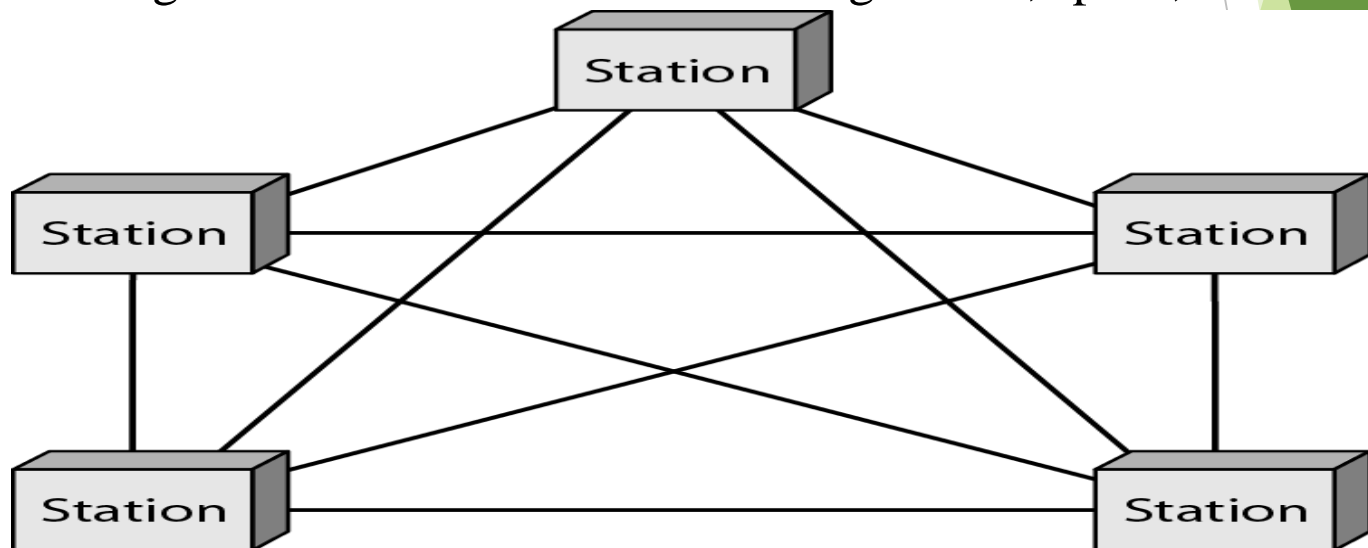- Disadvantages: Difficult installation/reconfiguration, space, cost.

Figure 5. A fully connected mesh topology (five devices)

➤ **Physical Topology (continue…)**

• **Star Topology**

- Dedicated point-to-point link only to a central controller, called a hub

- Hub acts as an exchange: No direct traffic between devices

- Advantages: Less expensive, robust

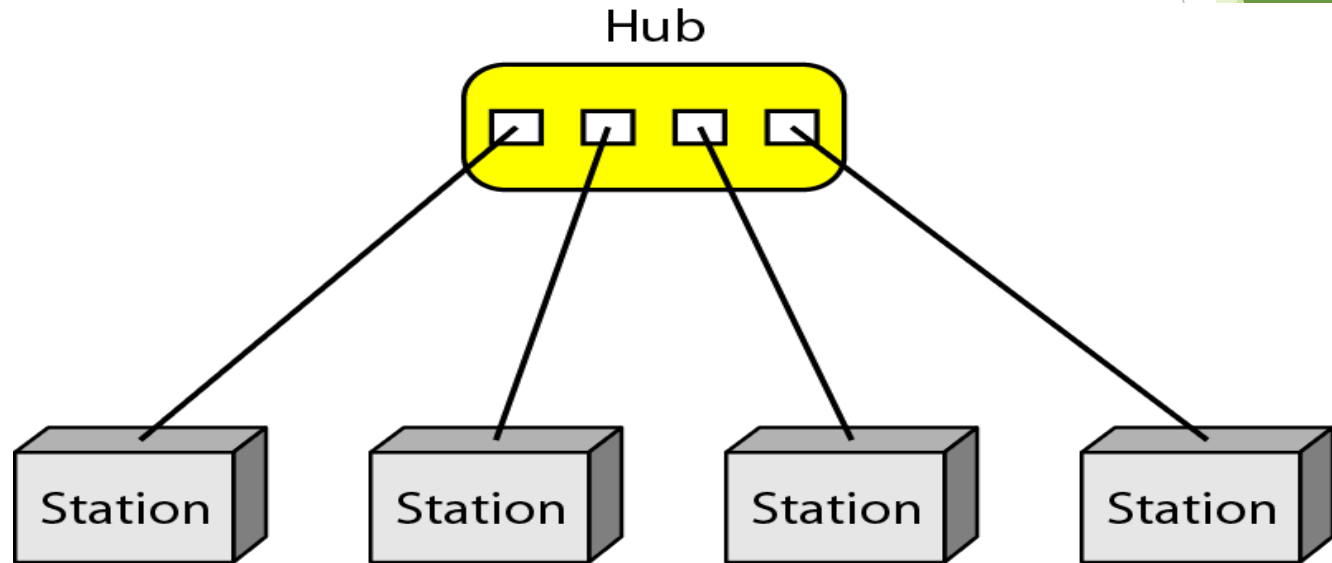- Disadvantages: dependency of the whole on one single point, the hub

Figure 6. A star topology connecting four stations

➢ Physical Topology (continue…)

• Bus Topology

- One long cable that links all nodes
- tap, drop line, cable end
- limit on the number of devices, distance between nodes
- Advantages: Easy installation, cheap
- Disadvantages: Difficult reconfiguration, no fault isolation, a fault or break in the bus stops all transmission
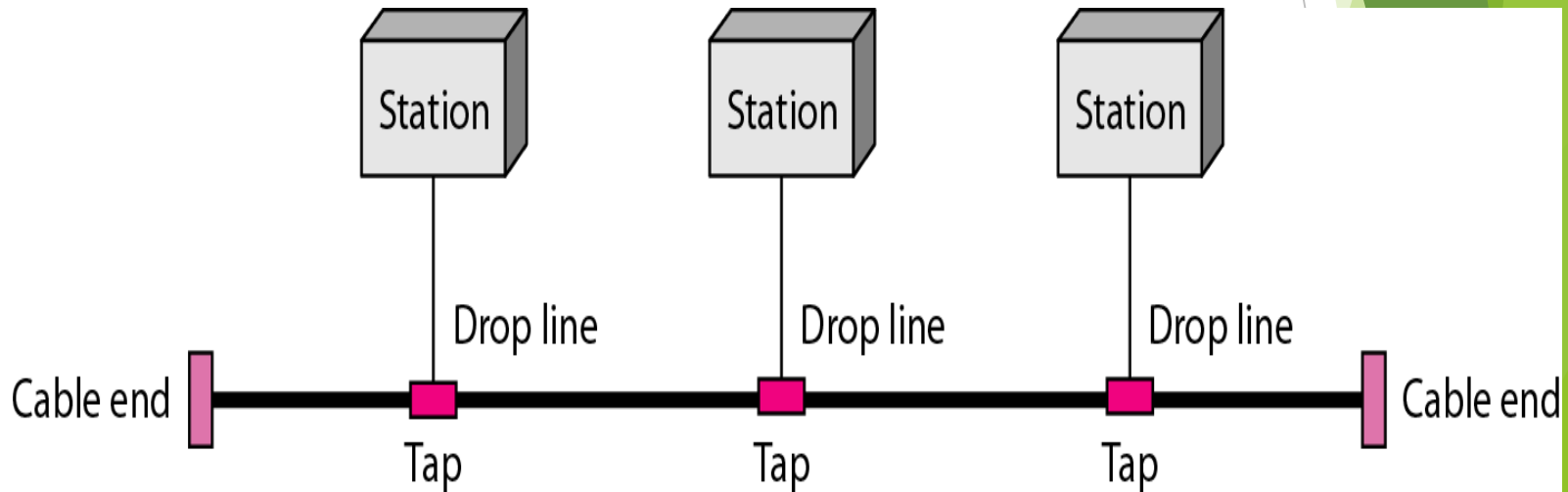

Figure 7. A bus topology connecting three stations

19

➢ Physical Topology (continue…)

• Ring Topology

- Dedicated point-to-point link only with the two nodes on each sides
- One direction, repeater
- Advantages: Easy reconfiguration, fault isolation
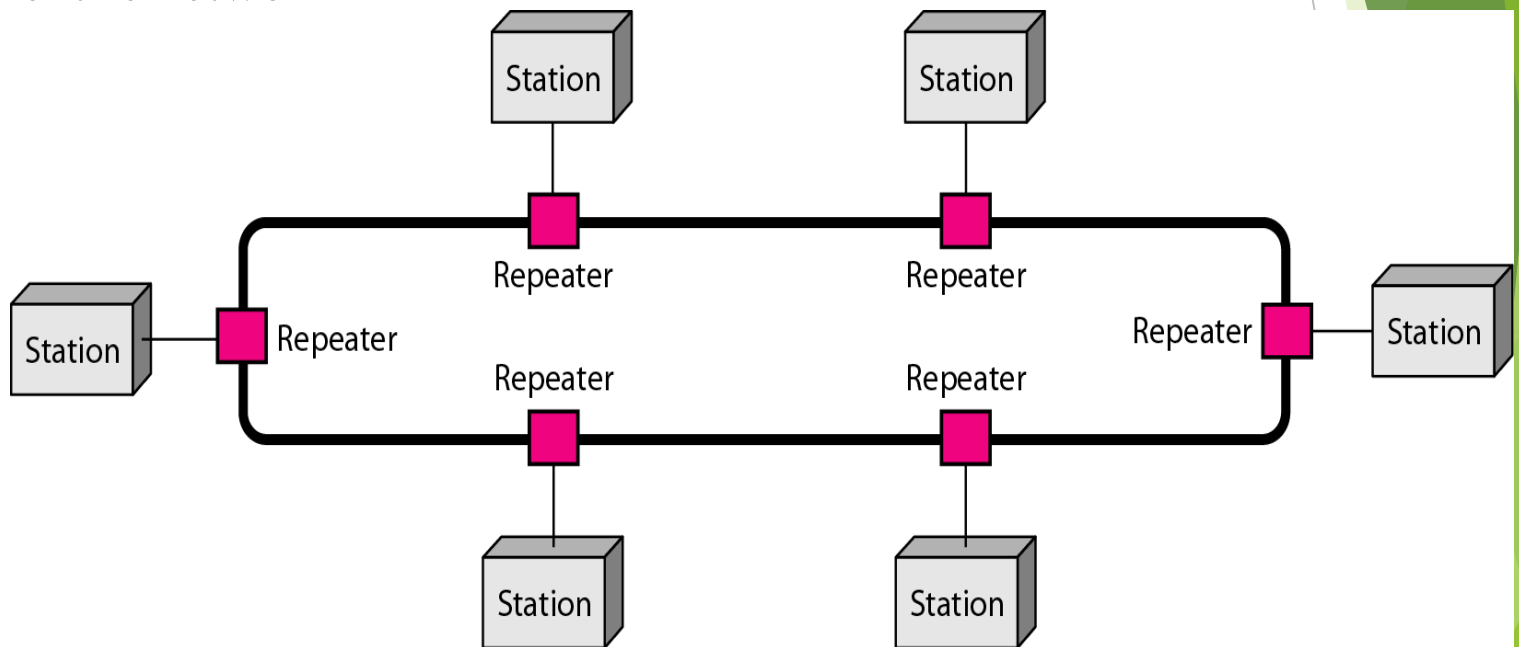- Disadvantage: Unidirectional traffic, a break in the ring can disable the entire network

Figure 8. A ring topology connecting six stations

➤ Physical Topology (continue…)

• Hybrid Topology

- Example: Main star topology with each branch connecting several stations in a bus topology

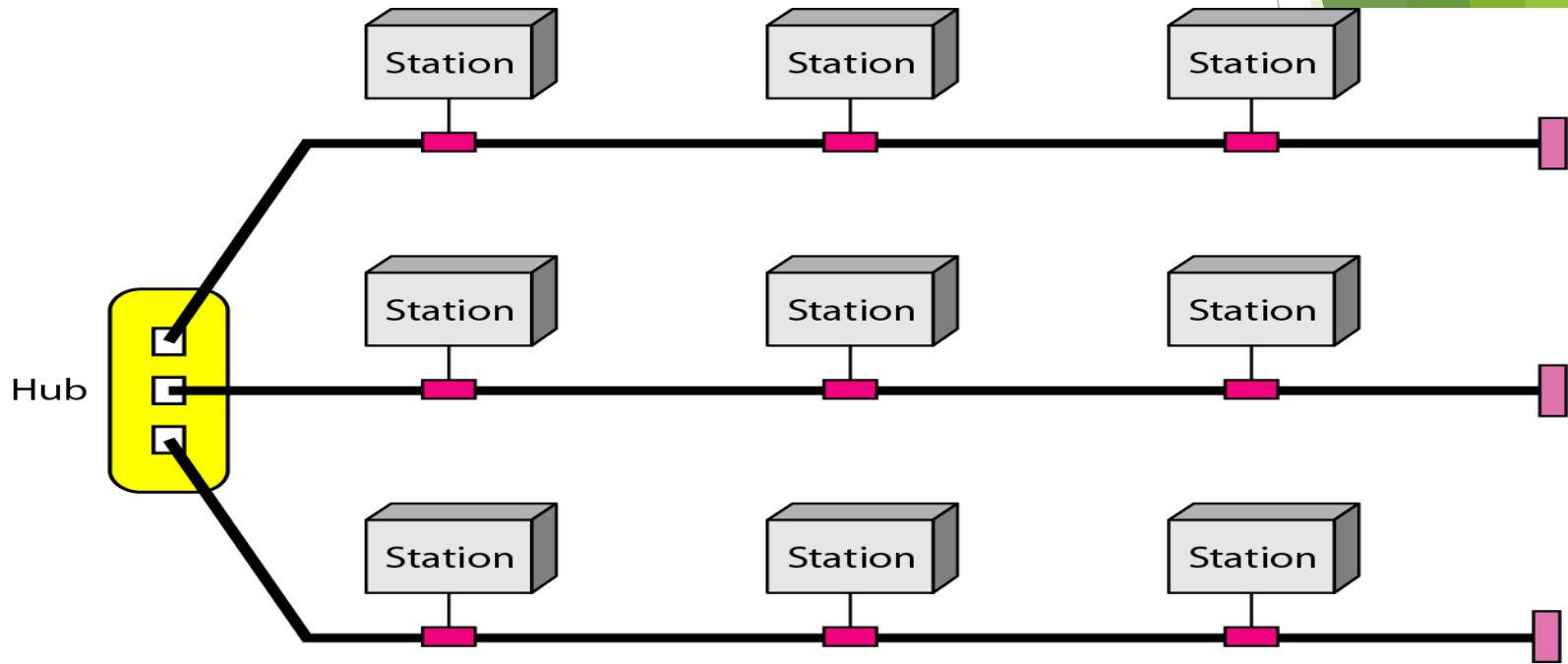- To share the advantages from various topologies

Figure 9. A hybrid topology: a star backbone with three bus networks

21

Networks (continue…)

➢ Categories of Networks

There are three categories of network which are Local- area network (LAN), Metropolitan- area network(MAN), Wide-area network (WAN):
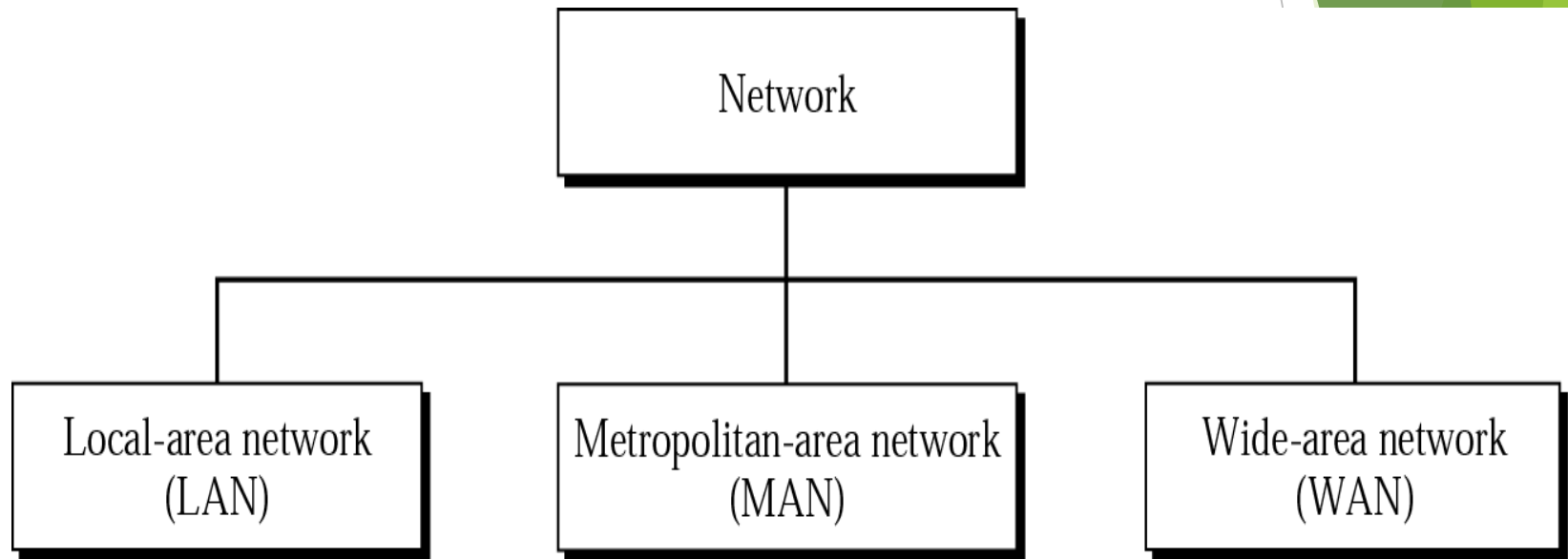
Figure 10. Categories of Networks

➢ Categories of Networks (continue…)

• LAN
- Usually privately owned
- A network for a single office, building, or campus ≤ a few Km
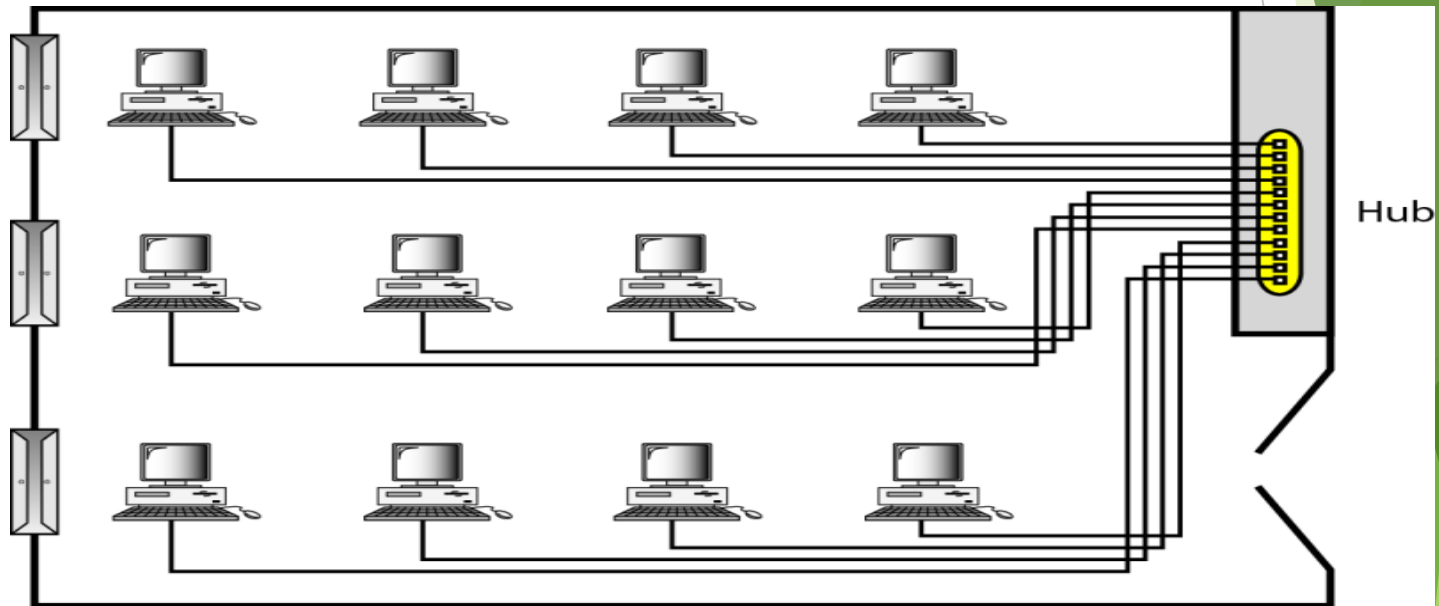- Common LAN topologies: bus, ring, star

Figure 11. An isolated IAN connecting 12 computers to a hub in a closet

23

➢ Categories of Networks (continue…)

• MAN
- Designed to extend to an entire city
- Cable TV network, a company's connected LANs
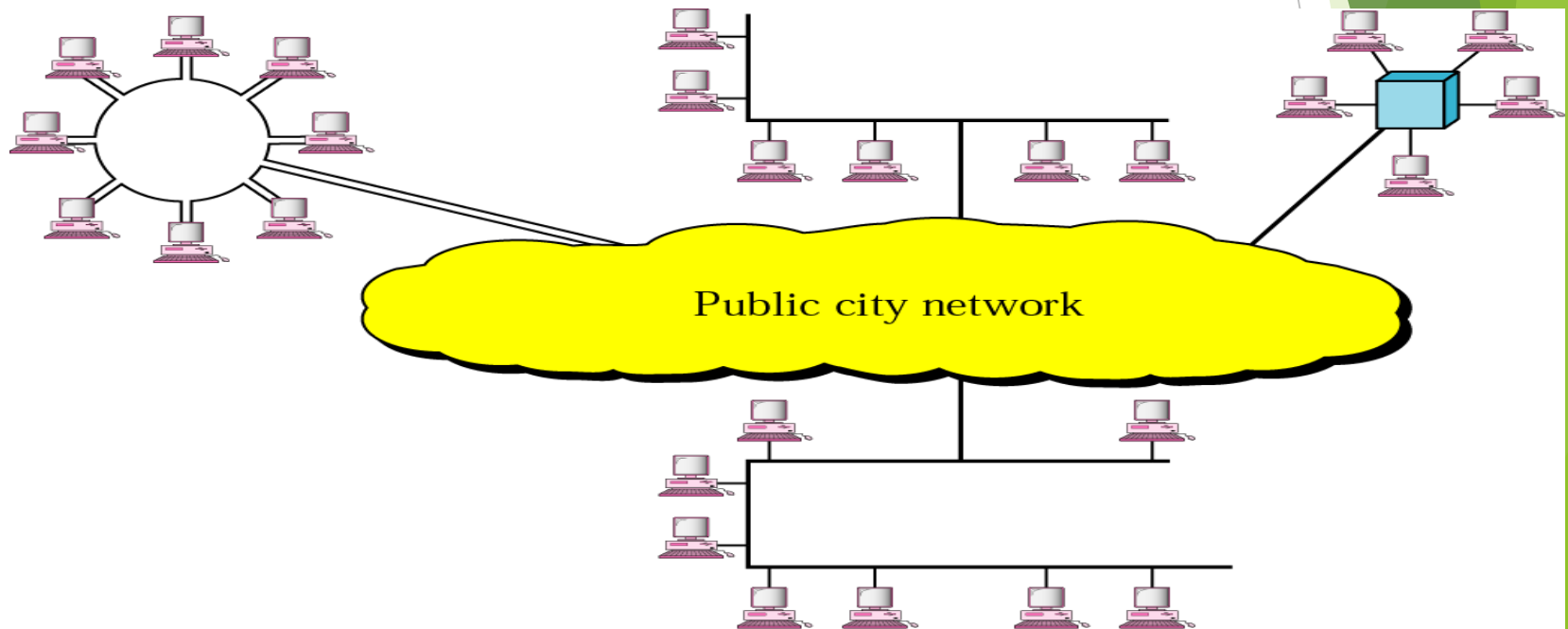- Owned by a private or a public company

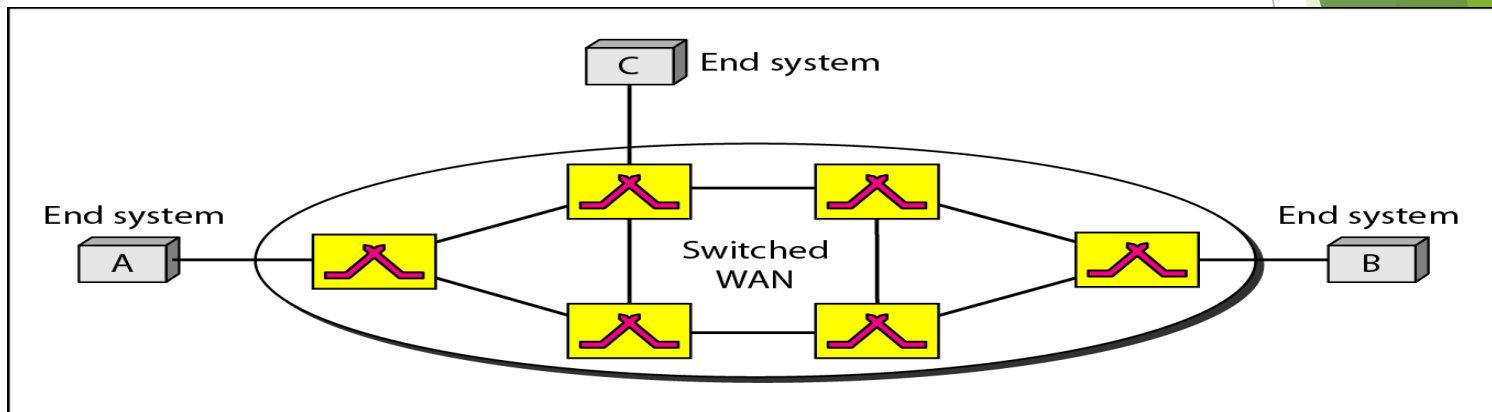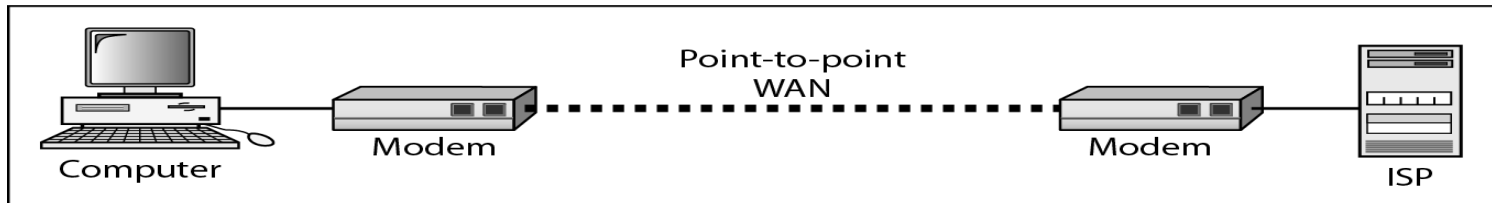Figure 12. Metropolitan Area Networks (MAN)

- Categories of Networks (continue…)
- WAN
- Long distance transmission, e.g., a country, a continent, the world
- Enterprise network: A WAN that is owned and used by one company

a. Switched WAN

b. Point-to-point WAN

Figure 13. WANs: a switched WAN and a point-to-point WAN

➢ 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.

• Internetwork (internet) : two or more networks are connected by internetworking devices

• Internetworking devices: router, gateway, etc.

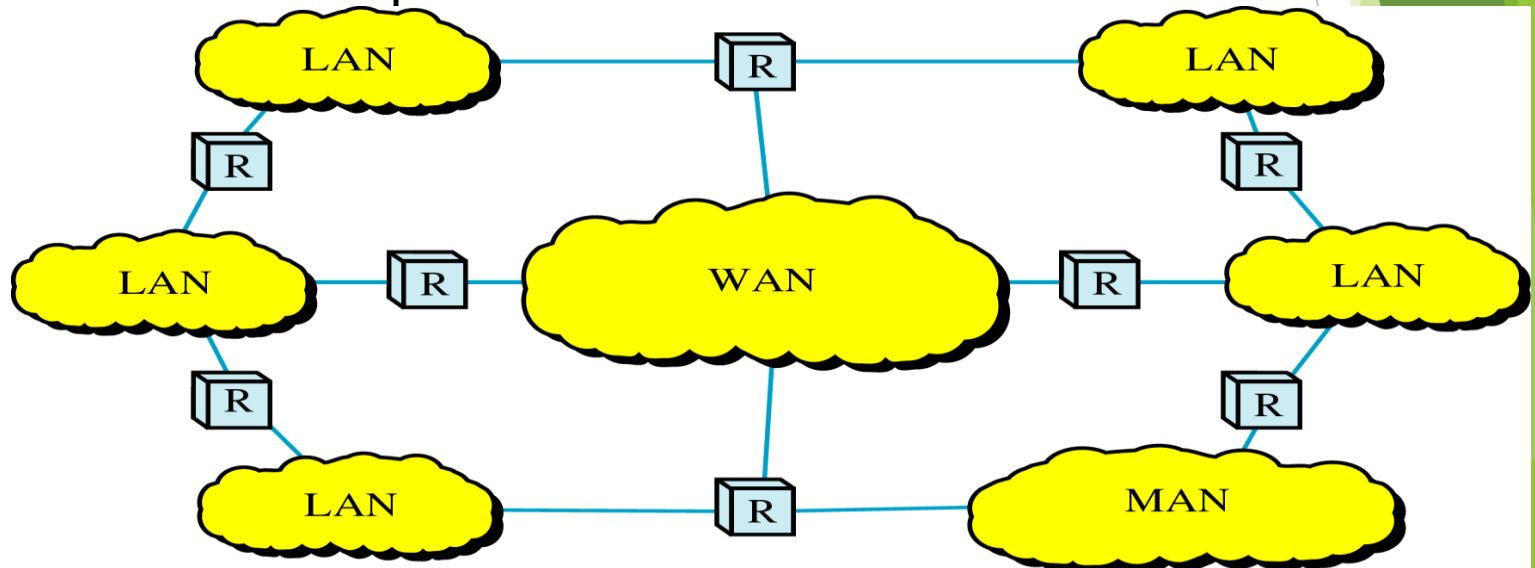• The Internet: a specific worldwide network

Figure 14. Interconnection of Networks

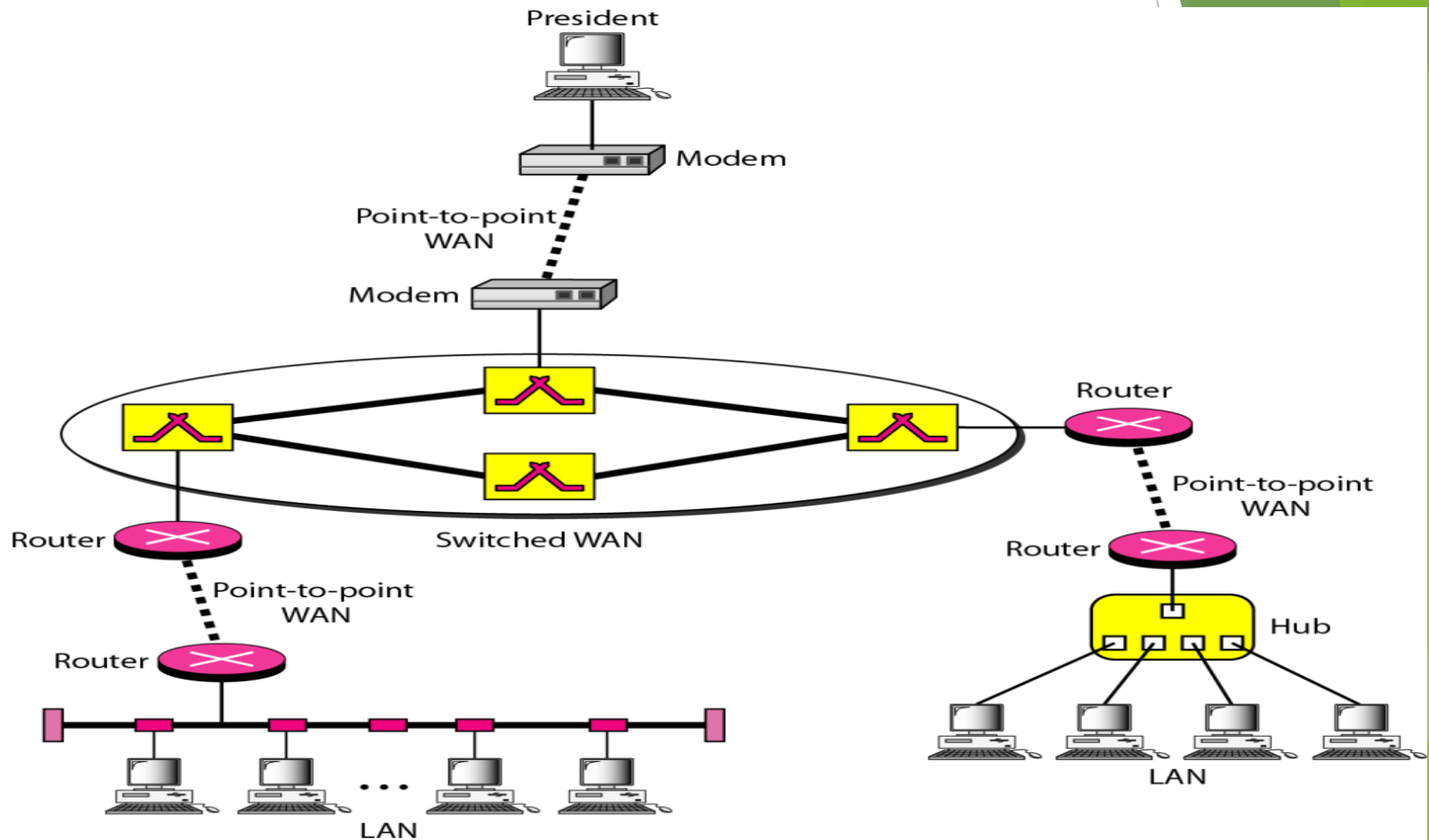➢ Interconnection of Networks: Internetwork (continue…)

• Internetwork Example

Figure 15. A heterogeneous network : four WANs and two LANs

➢ **Interconnection of Networks: Internetwork**

The Internet has revolutionized many aspects of our daily lives. It has affected the way we do business as well as the way we spend our leisure time.

• **A Brief History**
• In the mid-1960s: Mainframe computers in research organizations were standalone devices. Computers from different manufacturers were unable to communicate with one another.
• ARPANET proposed by in the Department of Defense (DoD's) DRPA (Advanced Research Project Agency)
• In 1967, at an Association for Computing Machinery (ACM) meeting, ARPA presented its ideas for ARPANET, a small network of connected computers. The idea was that each host computer (not necessarily from the same manufacturer) would be attached to a specialized computer, called an interface message processor (IMP).
• 1969: ARPANET in a reality: Four nodes, at the University of California at Los Angeles (UCLA), the University of California at Santa Barbara (UCSB), Stanford Research Institute (SRI), and the University of Utah, were connected via the IMPs to form a network. Software called the Network Control Protocol (NCP)

- A Brief History (continue…)
- 1973:Vint Cerf and Bob Kahn propose Transmission Control Protocol (TCP), To split TCP into two protocols TCP and Internetworking Protocol (IP)
- Internet Today
- ISP (Internet service providers)
- NISP (national ISP)
- NAP (network access point)
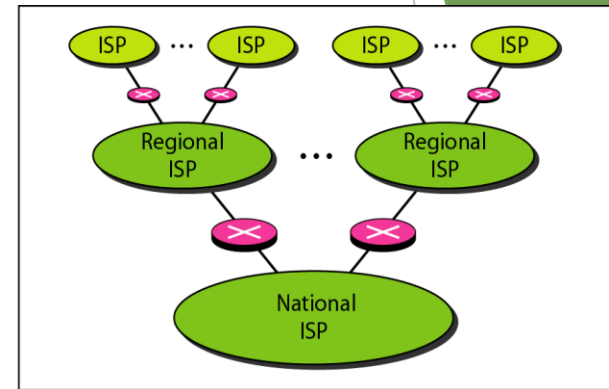
a. Structure of a national ISP
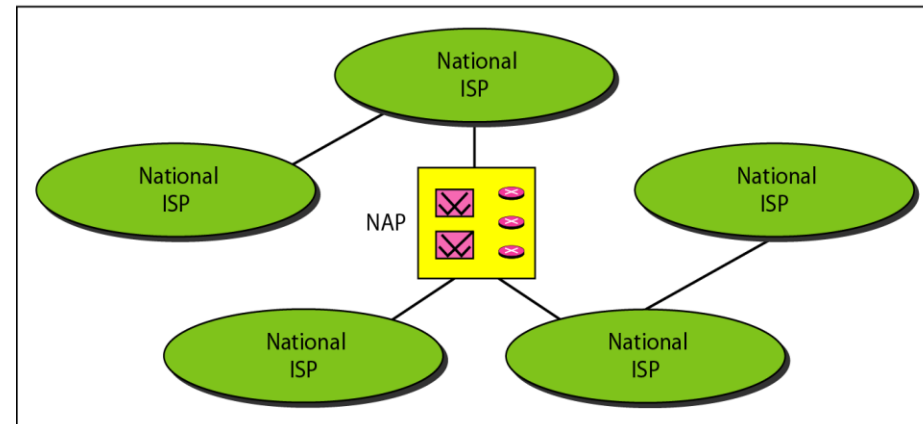
b. Interconnection of national ISPs

Figure 16. Hierarchical organization of the Internet

Protocols

- **Protocol : rule**
- A set of rules that govern data communication
- For communication to occur, entities must agree upon a protocol

- Key elements of a protocol
- Syntax: structure or format of data
- Semantics: meaning of each section in the structure
- Timing: when and how fast data should be sent

- **Standards: agreed-upon rules**
- Standards is essential in
- Creating/maintaining open and competitive markets
- Guaranteeing national/international interoperability

- Two categories
- De jure ("by law" or "by regulation') standards
- De facto ("by fact" or 'by convention') standards
- Proprietary standards: closed standards
- Nonproprietary standards: open standards

30

- **Standards Organizations**

- Standards are developed by
  - Standards creation committees
  - Forums
  - Regulatory agencies

- Standards committees & forums
  - Standards committees are slow moving
  - Forums are made up of interested corporations
  - Forum are able to speed acceptance of a particular technology

- **Standards Committees**
- ISO
  - Voluntary international organization
- ITU-T
  - Formerly, CCITT formed by UN
- ANSI
  - Private non-profit corporation in the US
- IEEE
  - The largest engineering society in the world
- EIA
  - Non-profit organization in the US

- **Internet Standards**
- IETF (Internet Engineering Task Force)
- Internet Draft
  - working document with no official status
  - with a 6-month lifetime
- RFC (Request for Comment)
  - Edited, assigned a number, and made available to all interested parties

Summary

➢ Data communications are the transfer of data from one device to another via some form of transmission medium.

➢ A data communications system must transmit data to the correct destination in an accurate and timely manner.

➢ The five components that make up a data communications system are the message, sender, receiver, medium, and protocol.

➢ Text, numbers, images, audio, and video are different forms of information.

➢ Data flow between two devices can occur in one of three ways: simplex, half-duplex, or full-duplex.

➢ A network is a set of communication devices connected by media links.

➢ In a point-to-point connection, two and only two devices are connected by a dedicated link. In a multipoint connection, three or more devices share a link.

➢ Topology refers to the physical or logical arrangement of a network. Devices may be arranged in a mesh, star, bus, or ring topology.

> ➢ A network can be categorized as a local area network or a wide area network.
> ➢ A LAN is a data communication system within a building, plant, or campus, or between nearby buildings.
> ➢ A WAN is a data communication system spanning states, countries, or the whole world.
> ➢ An internet is a network of networks.
> ➢ The Internet is a collection of many separate networks.
> ➢ There are local, regional, national, and international Internet service providers.
> ➢ A protocol is a set of rules that govern data communication; the key elements of a protocol are syntax, semantics, and timing.
> ➢ Standards are necessary to ensure that products from different manufacturers can work together as expected.
> ➢ o The ISO, ITD-T, ANSI, IEEE, and EIA are some of the organizations involved in standards creation.
> ➢ o Forums are special-interest groups that quickly evaluate and standardize new technologies.
> ➢ o A Request for Comment is an idea or concept that is a precursor to an Internet standard.