Data Communications and Networking Fourth Edition

Forouzan

Chapter 1

Introduction

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1-1 DATA COMMUNICATIONS

- *The term telecommunication means communication at a distance.*
- *The word data refers to information presented in whatever form is agreed upon by the parties creating and using the data.*
- *Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable or in wireless form. Major Characteristics:*
  - *Delivery-System must deliver data to the correct destination*
  - *Accuracy-System must deliver data accurately*
  - *Timeliness-System must deliver data in a timely manner*
  - *Jitter- minimize the jitter of the delivery*

Components- Data Communication

CT

1. **Message.** The **message** is the information (data) to be communicated between sender and receiver. Popular forms of information include text, numbers, pictures, audio, and video.

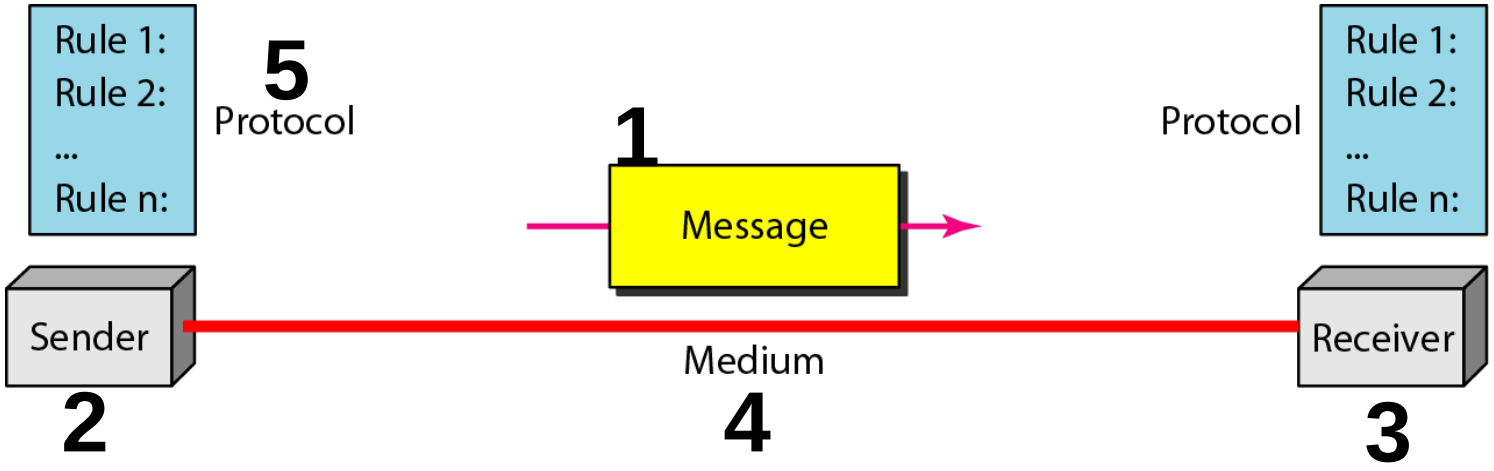
2. **Sender.** The **sender** is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.

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. 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.

Figure 1.1 *Five components of data communication*



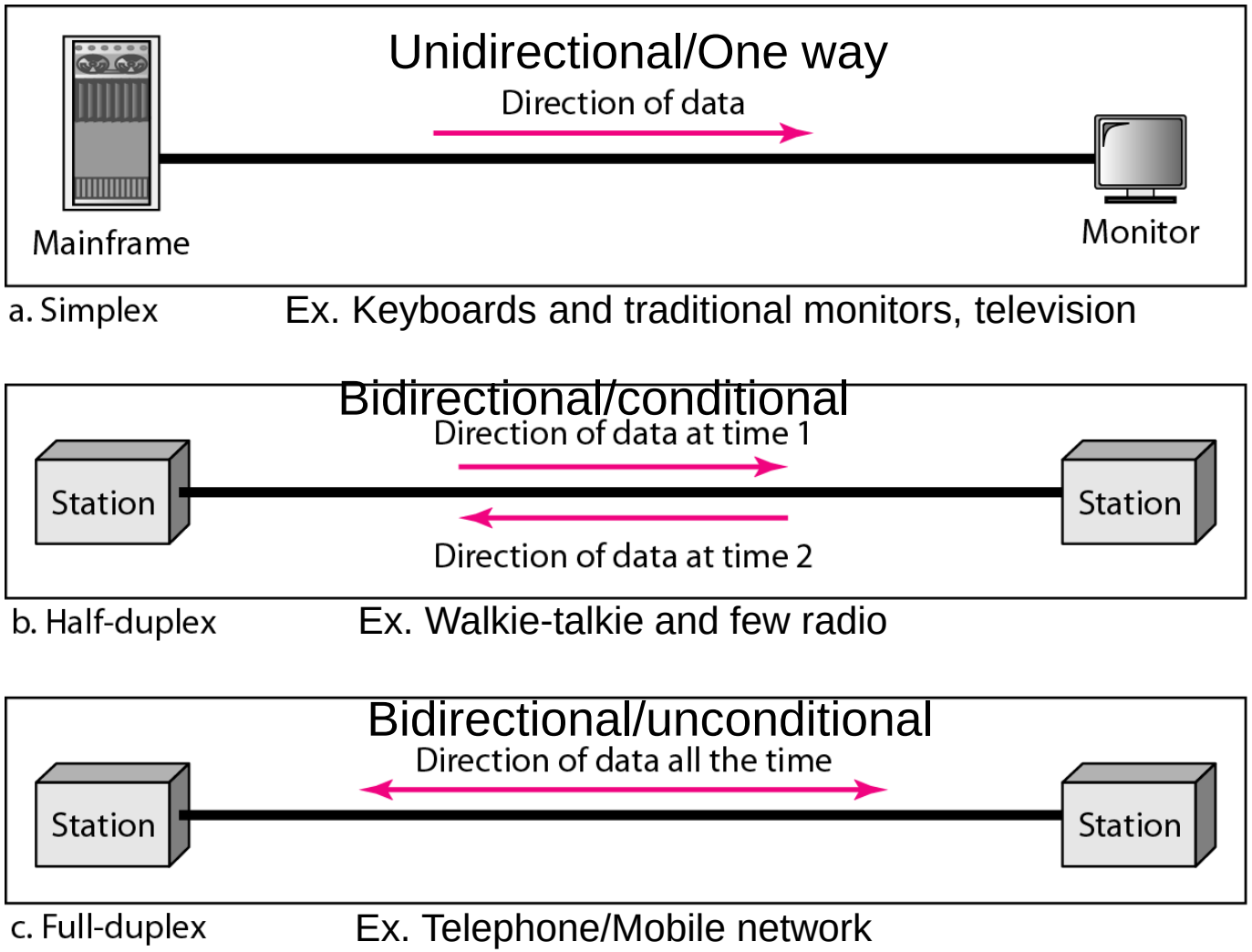
Data Representation

- Text (Unicode, American Standard Code for Information Interchange (ASCII))
- Numbers
- Images (Divided into pixel with size in bit patterns, has color scheme of RGB- *r*ed, *g*reen, and *b*lue or YCM- *y*ellow, *c*yan, and *m*agenta.
- Audio
- Video

Data Flow

- Simplex
- Duplex
  - Half Duplex
  - Full Duplex

Figure 1.2 *Data flow (simplex, half-duplex, and full-duplex)*



1-2 NETWORKS

- ***A network is a set of devices (often referred to as nodes) connected by communication links.***
- ***A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.***

Topics discussed in this section:

- **Network Criteria (performance(throughput and delay), reliability, security)**
- **Physical Structures (Type of Connection: Multipoint, Point to Point.**
- **Topology: Mesh, Star, Bus, Ring, Hybrid)**
- **Network Models (OSI, TCP/IP)**
- **Categories of Networks (PAN, LAN, MAN, WAN)**
- **Interconnection of Networks: Internetwork**

Network Criteria

- Performance can be measured in many ways as **Transit** and **Response** Time and **Throughput** and **Delay**.
- **Transit time** is the amount of time required for a message to travel from one device to another.
- **Response time** is the elapsed time between an inquiry and a response.
- **Throughput** is the amount of data successfully received from a device.
- **Delay** defines the total time of an entire message arrived at the destination after the first bit of the message sent from the source device

Figure 1.3 *Types of connections: point-to-point and multipoint*

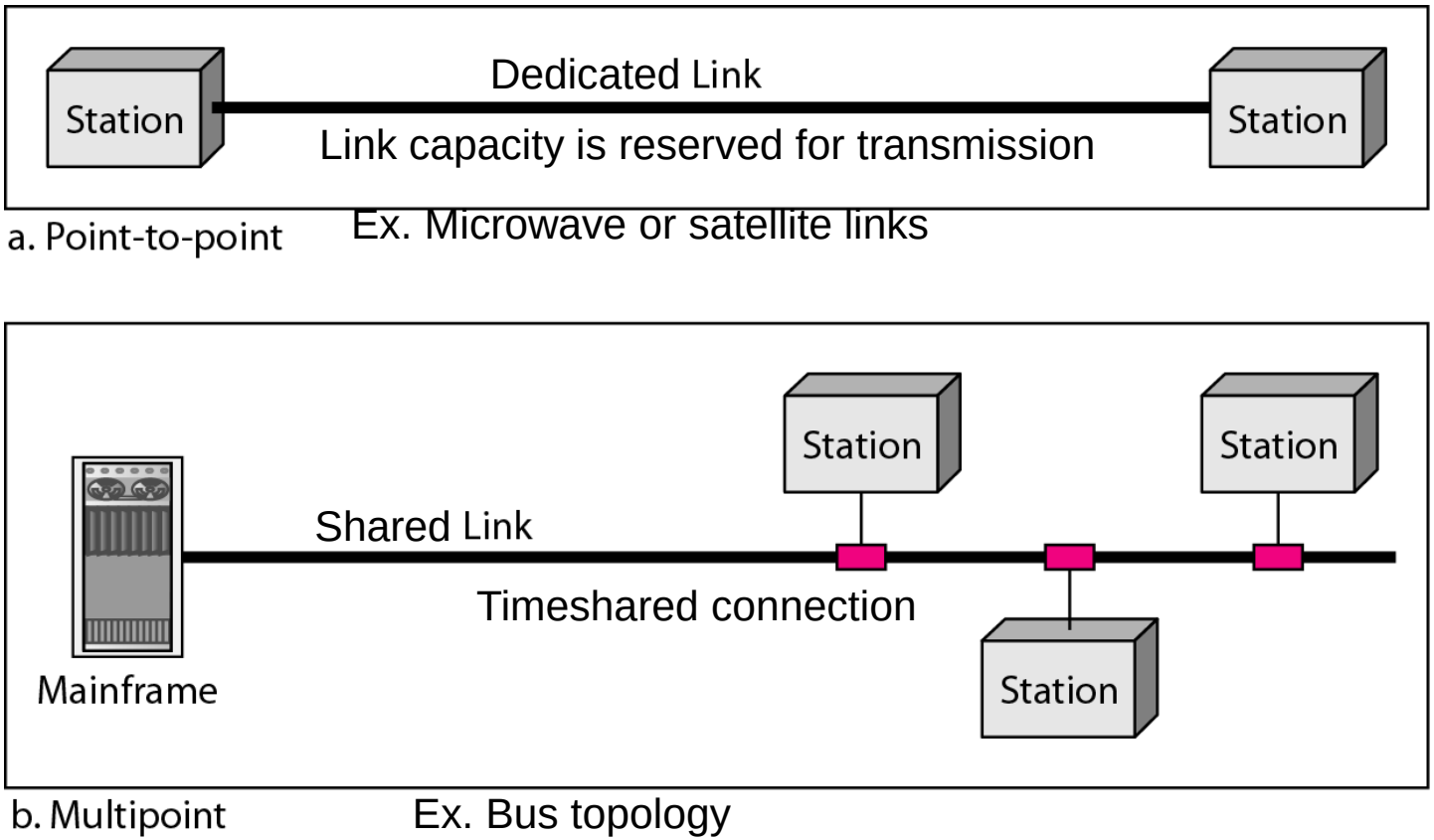
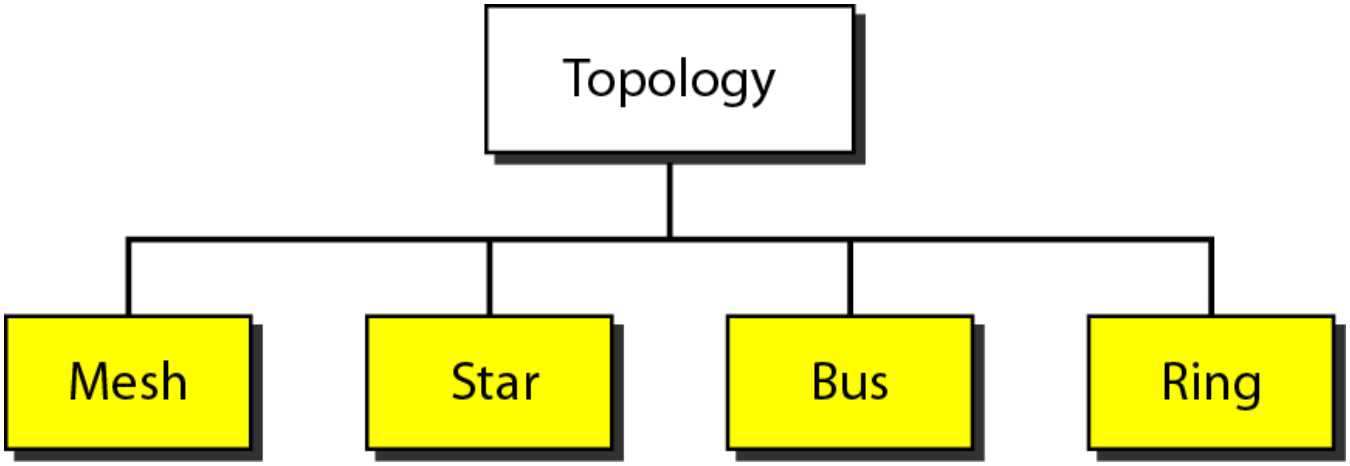


Figure 1.4 *Network topology*

Network topology is the **geometric** representation of all the links and linking devices(usually called **nodes**) to one another.



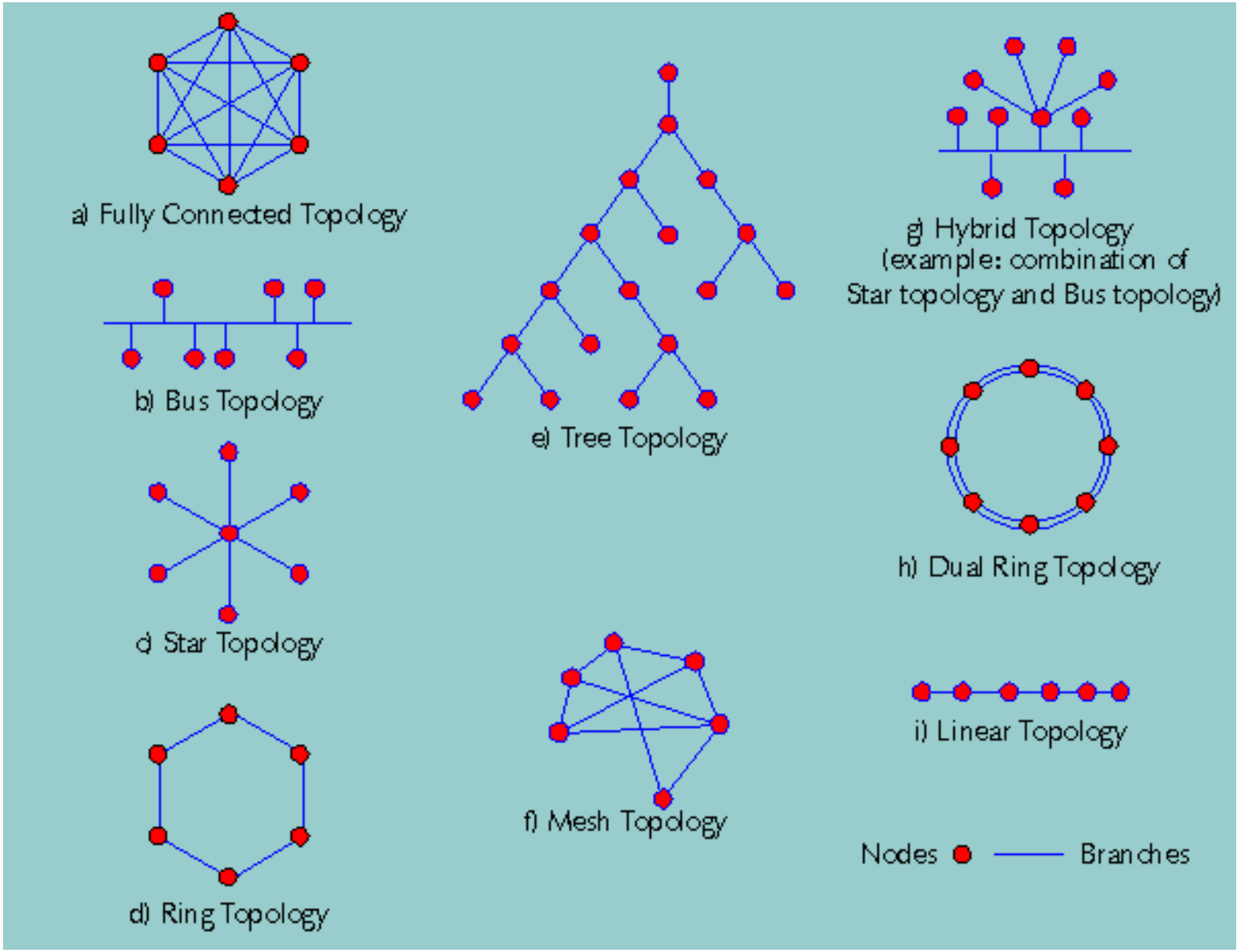

a) Fully Connected Topology
b) Bus Topology
c) Star Topology
d) Ring Topology
e) Tree Topology
f) Mesh Topology
g) Hybrid Topology
(example: combination of
Star topology and Bus topology)
h) Dual Ring Topology
i) Linear Topology
Nodes
Branches

Figure 1.5 *A fully connected mesh topology (five devices)*

- Dedicated point-to-point link
- If n nodes exist, then each node connected n-1 nodes or link.
- So, for n nodes need to connected total n(n-1) physical links
- For duplex mode, divide the total number of links by 2 means

n(n-1)/2

Duplex mode links present in a mesh network

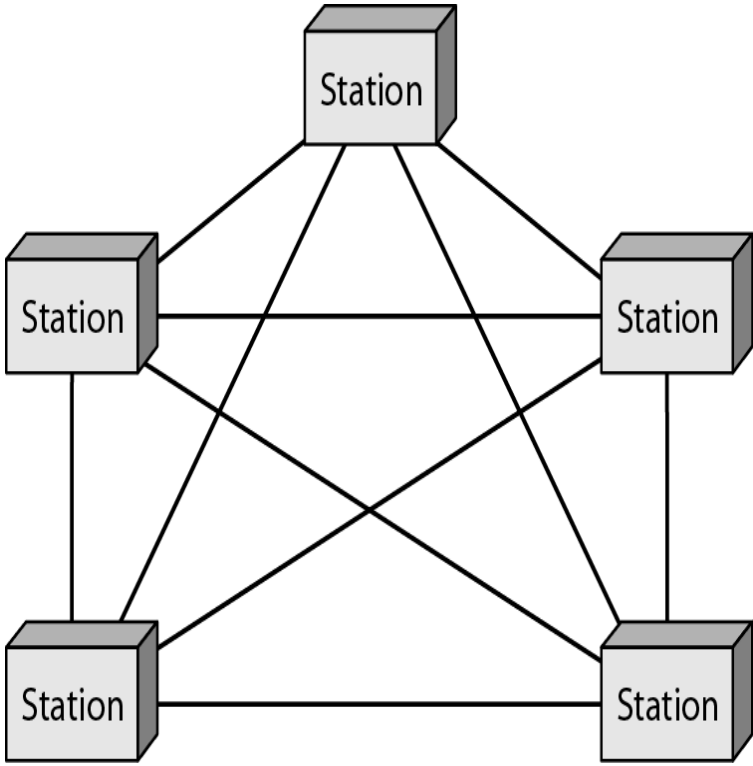


Fig. Mesh Topology

Figure 1.6 *A star topology connecting four stations*

- Dedicated point-to-point link to a central hub
- No direct link between nodes
- Hub or controller acts as media to send data to one another
- Each node connected to the controller via a single (one) links
- If only one link fails, only that links affected.
- This topology used in LAN communication.
- For n number of stations, there are n links to connect.

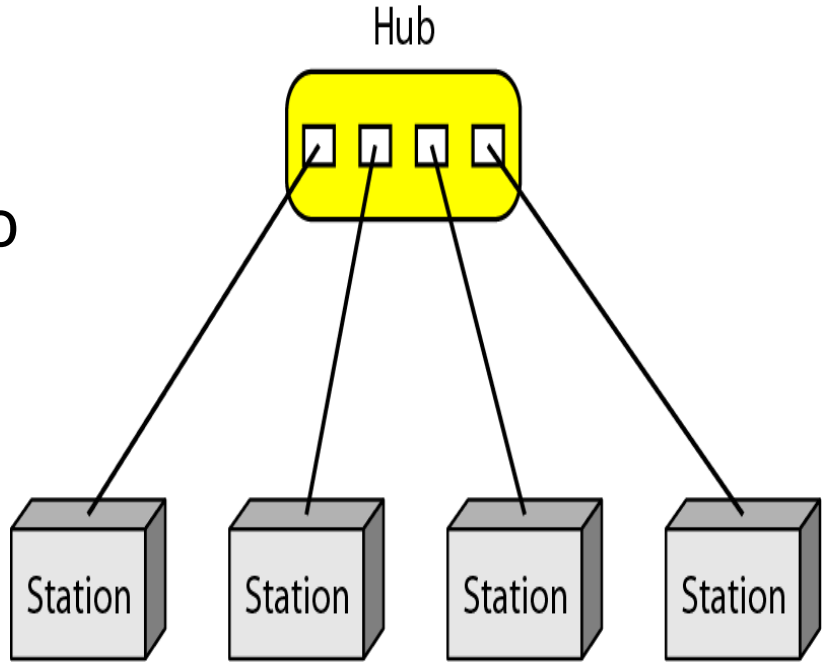
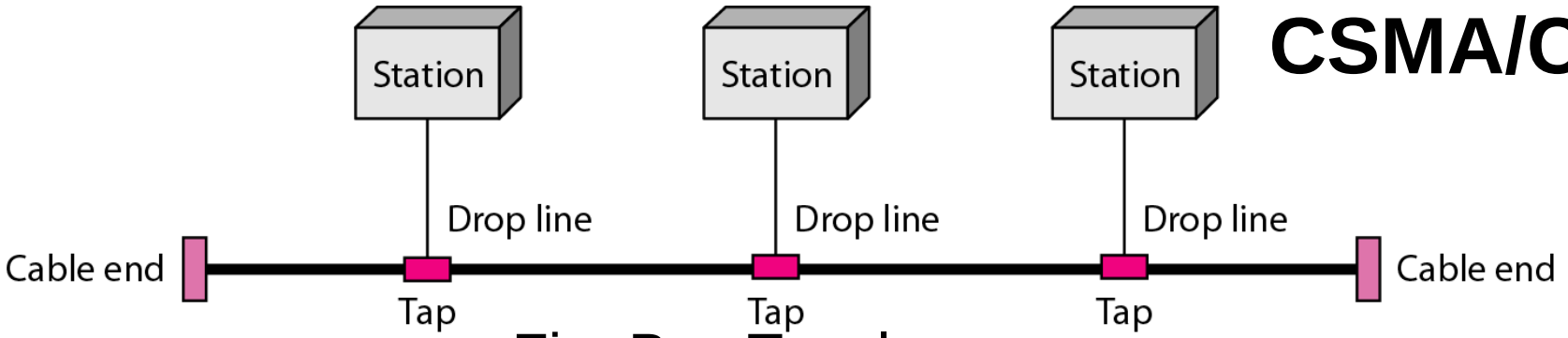


Fig. Star Topology

CSMA/CD,CSMA/CA

Figure 1.7 *A bus topology connecting three stations*



CSMA/CD

Fig. Bus Topology

- Single connection is shared(multipoint) by multiple nodes
- Signal becomes weak as it travels further distance
- Signal reflection at tapes reduces the signal quality.
- A fault or break in the bus cable stops all transmission.
- Advantages:
  - Ease of Installation.
  - Uses less cables.
  - Less complex.
- Disadvantages:
  - Difficult to fault isolation and reconnection.
  - Difficult to add new devices.

Figure 1.8 *A ring topology connecting six stations*

- Dedicated point-to-point connection with two neighbor devices on each side
- Signal passed along the ring in one direction, until it reaches the destination.
- Each device has a repeater to regenerate the bits
- If the signal is not intended to a receiver that repeater regenerate the signal and passes through the ring.
- Advantages:
  - Easy to install and reconfigure
  - Fault isolation is simplified
- Disadvantages:
  - Unidirectional traffic(maximum ring length and number of devices)
  - A break in the ring (such as a disabled station) can disable the entire network. Solution: Dual Ring.

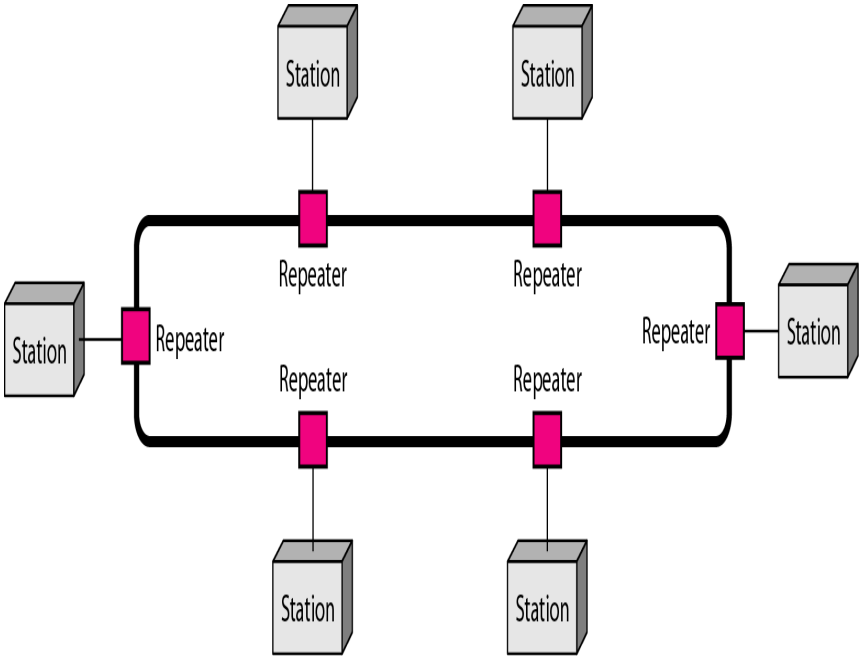
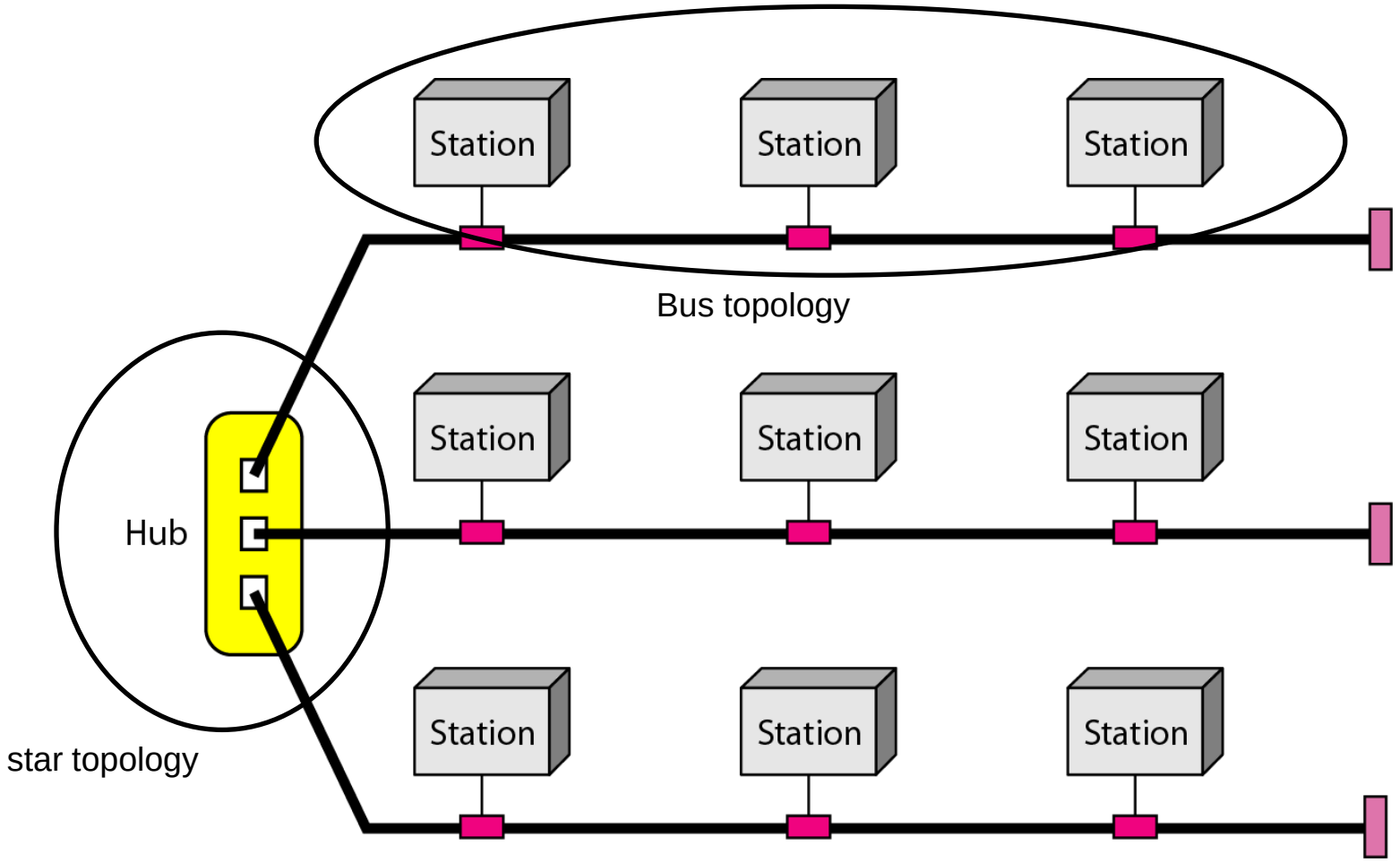


Fig. Ring Topology

Token Ring protocol

Figure 1.9 *A hybrid topology: a star backbone with three bus networks*



A hybrid topology

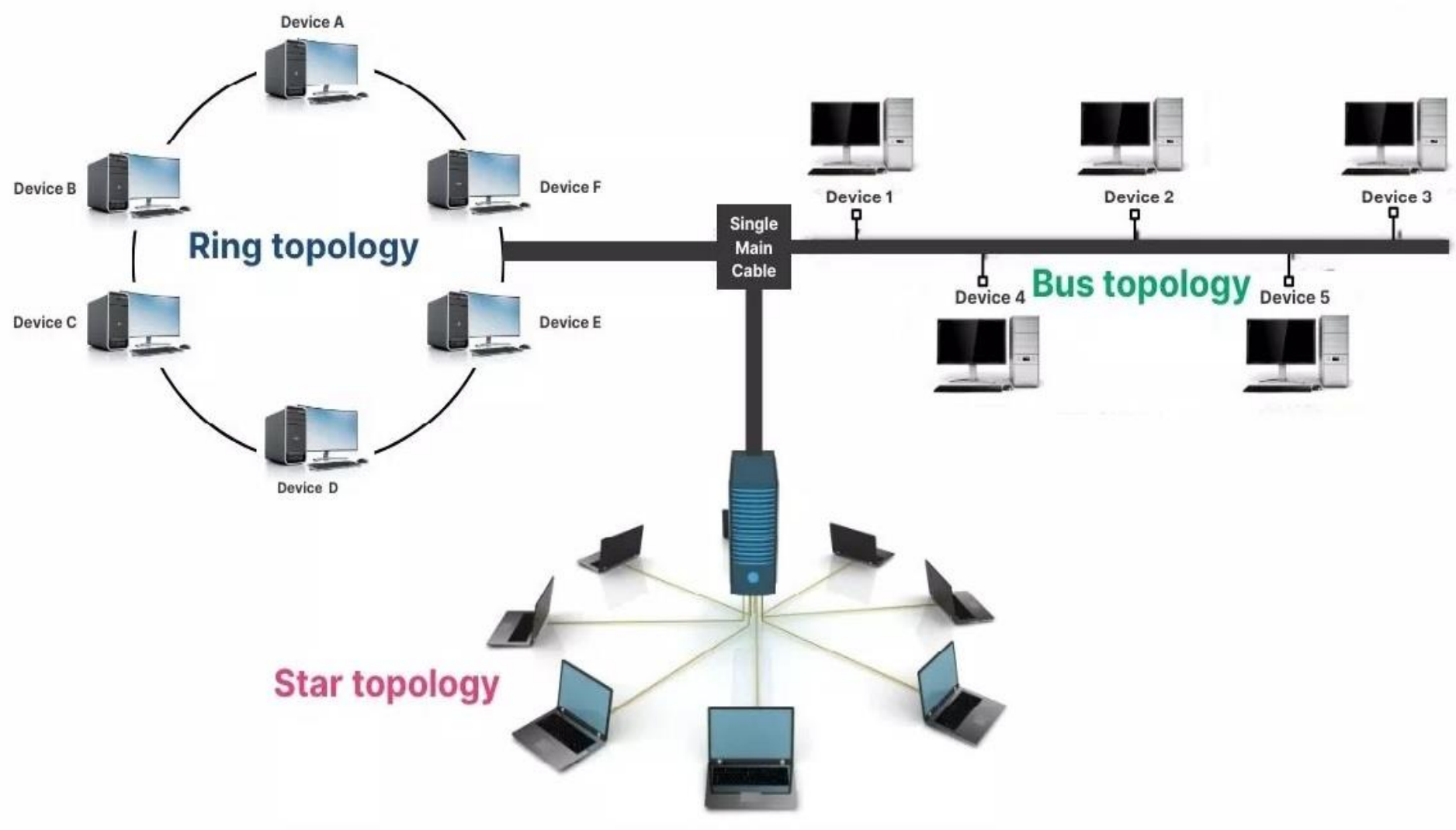
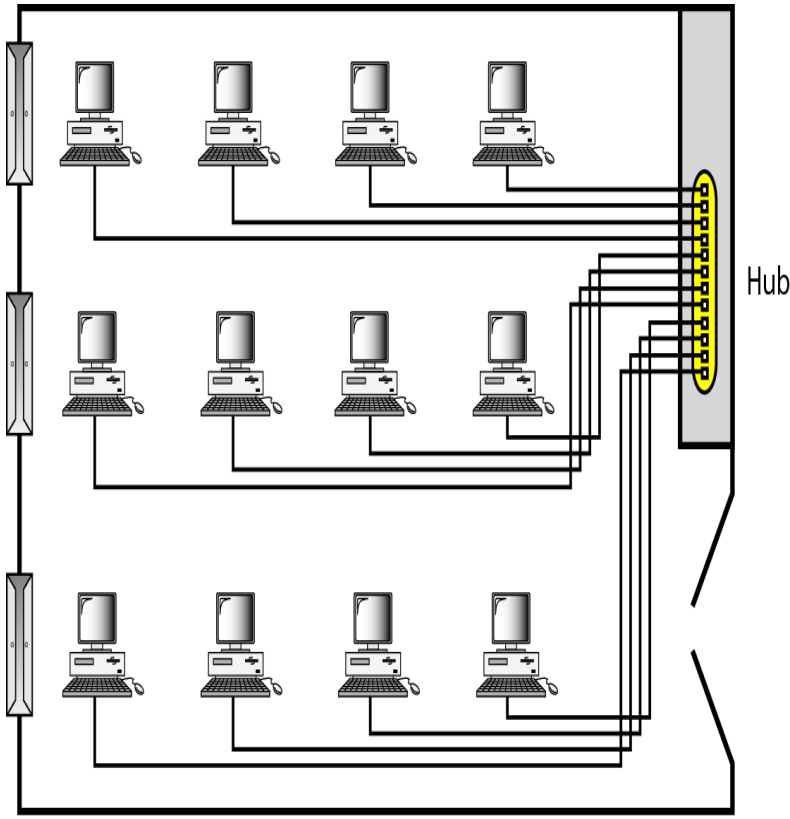


Figure 1.10 *An isolated LAN connecting 12 computers to a hub in a closet*

- Local Area Network(LAN) – Privately owned network and links a single office, building, or campus.
- LANs are designed to share resources among the computers as printers, scanner
- Some LANs connect workstations in a group called domain controller.
- Currently, LAN size is limited to a few kilometers.
- Early LANs had data rates in 4 to 16 Mbps but currently it is 100 or 1000 Mbps



Metropolitan Area Network(MAN)

- Large network that connects different organizations
- It might connect different corporate LANs together
- Controlled or own by multiple organization
- Maintain by a group or single network provider(Link3)
- Share regional resources.
- Apex or different showroom`s are interconnected
- A telephone network which share high speed DSL distributed to customer also a good example of MAN

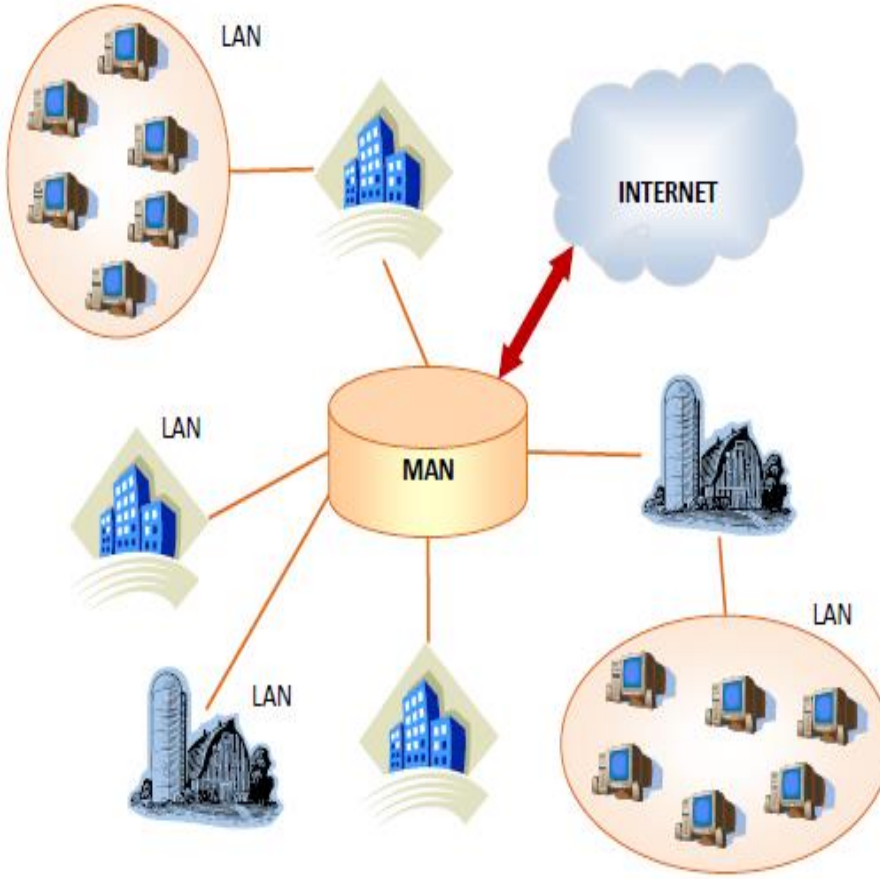
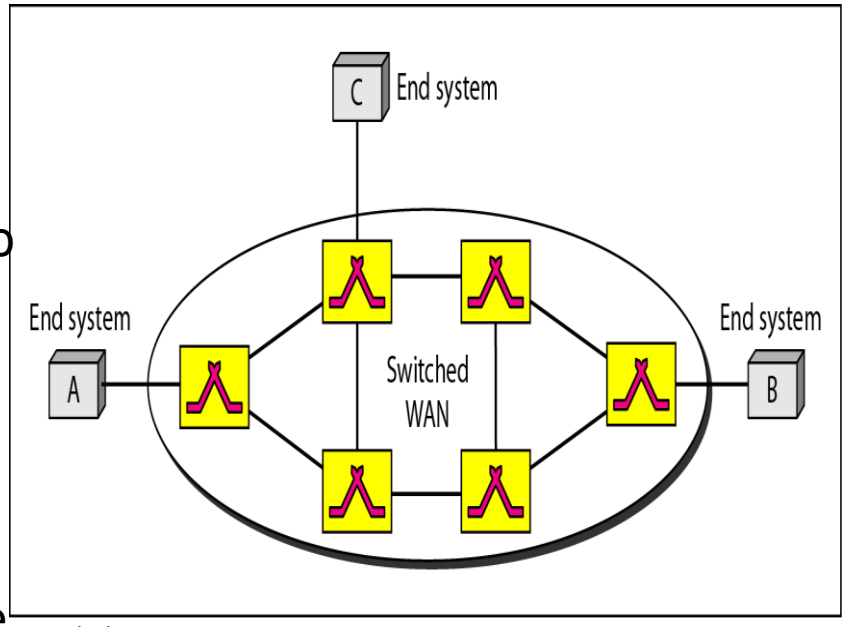
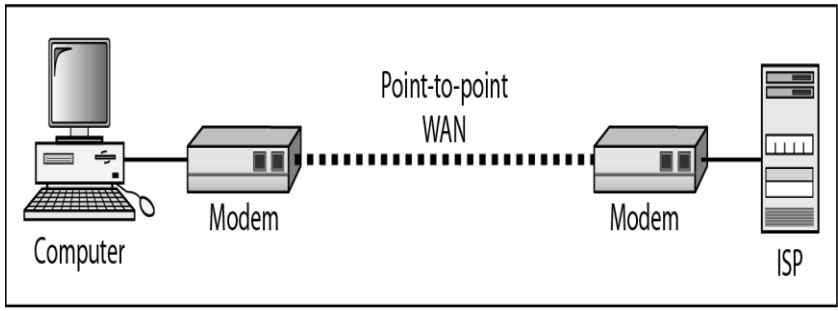


Figure 1.11 *WANs: a switched WAN and a point-to-point WAN*

- Wide Area Network(LAN) – covers large geographical area
- WANs are designed to provide long distance transmission of data, image, audio and video information
- A WAN can be
  - Complex backbone network that connects the internet called switched WAN or
  - Simple dial up line that connects a home computer to the internet called point-to-point WAN
- Early example of switched WAN is X.25 and also current ATM service example of WAN service.



a. Switched WAN



b. Point-to-point WAN

1-3 THE INTERNET

- *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.*
- *The Internet is a communication system that has brought a wealth of information to our fingertips and organized it for our use.*

Topics discussed in this section:

A Brief History
The Internet Today (ISPs)

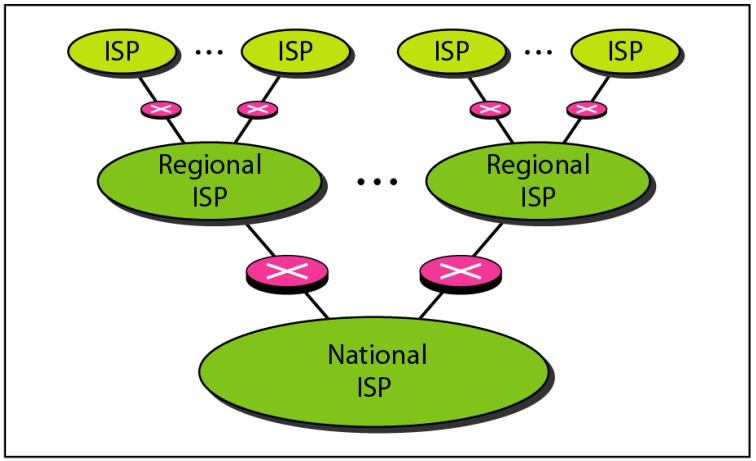
Brief History

- Came into existence in 1969 only after Packet Switched Network was invented in 1961 at MIT by Leonard Kleinrock.
- DoD (Dept of Defense) through ARPA (Advanced Research Projects Agency) represented ARPANET in ACM (Association of Comuting Machinery) meeting in 1967.
- Introduced IMP (Interface Message Processor).
- In 1969, UCLA – UCSB – SRI – UoU got connected.
  - University of California Los Angeles – UCLA
  - University of California Santa Barbara – UCSB
  - University of Utah – UoU
  - Sanford Research Institute (SRI)
- Software Support by NCP – Network Control Protocol.
- 1972, Vint Cerf and Bob Kahn came up with paper on TCP with networking concepts of encapsulation, datagram, gateways, end to end delivery of packets.
- Soon TCP was split into TCP and IP.
- In 1981, UC Berkeley modified the UNIX operating system to include TCP/IP which popularized Internetworking.
- Then came creation of CSNET in 1981. **Computer Science Network (CSNET) was a network sponsored by the National Science Foundation** (NSF).
- In 1983, ARPANET split into two networks: **Military Network (MILNET) for military** users and ARPANET for nonmilitary users.
- Today, it is managed by ISP – Internet Service Providers.

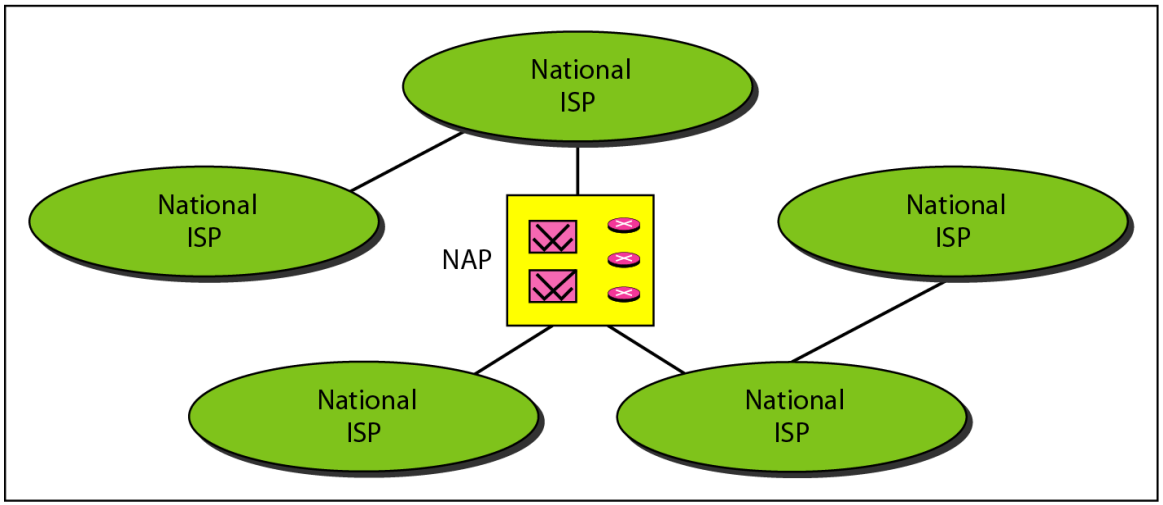
Figure 1.13 *Hierarchical organization of the Internet*

ISP – Internet Service Provider
NAP – Network Access Point

ISP Communicate with each others network through NAP



a. Structure of a national ISP



b. Interconnection of national ISPs

Standards Organization

- ISO – International Organization of Standardization
- ITU-T – International Telecommunication Union Telecommunication Standards formed CCITT in 1993 for research.
- CCITT – Consultative Committee for International Telegraphy and Telephony.
- ANSI – American National Standards Institutions.
- IEEE – Institute of Electric and Electronics Engineers
- EIA – Electronic Industries Association
- FCC – Federal Communication Commission
- RFC – Request for Comment
- How about Controlling body in India?

Number	Topic
802.1	Overview and architecture of LANs
802.2 ↓	Logical link control
802.3 *	Ethernet
802.4 ↓	Token bus (was briefly used in manufacturing plants)
802.5	Token ring (IBM's entry into the LAN world)
802.6 ↓	Dual queue dual bus (early metropolitan area network)
802.7 ↓	Technical advisory group on broadband technologies
802.8 †	Technical advisory group on fiber optic technologies
802.9 ↓	Isochronous LANs (for real-time applications)
802.10 ↓	Virtual LANs and security
802.11 *	Wireless LANs
802.12 ↓	Demand priority (Hewlett-Packard's AnyLAN)
802.13	Unlucky number. Nobody wanted it
802.14 ↓	Cable modems (defunct: an industry consortium got there first)
802.15 *	Personal area networks (Bluetooth)
802.16 *	Broadband wireless
802.17	Resilient packet ring