



# Data Communications and Networking

Fourth Edition

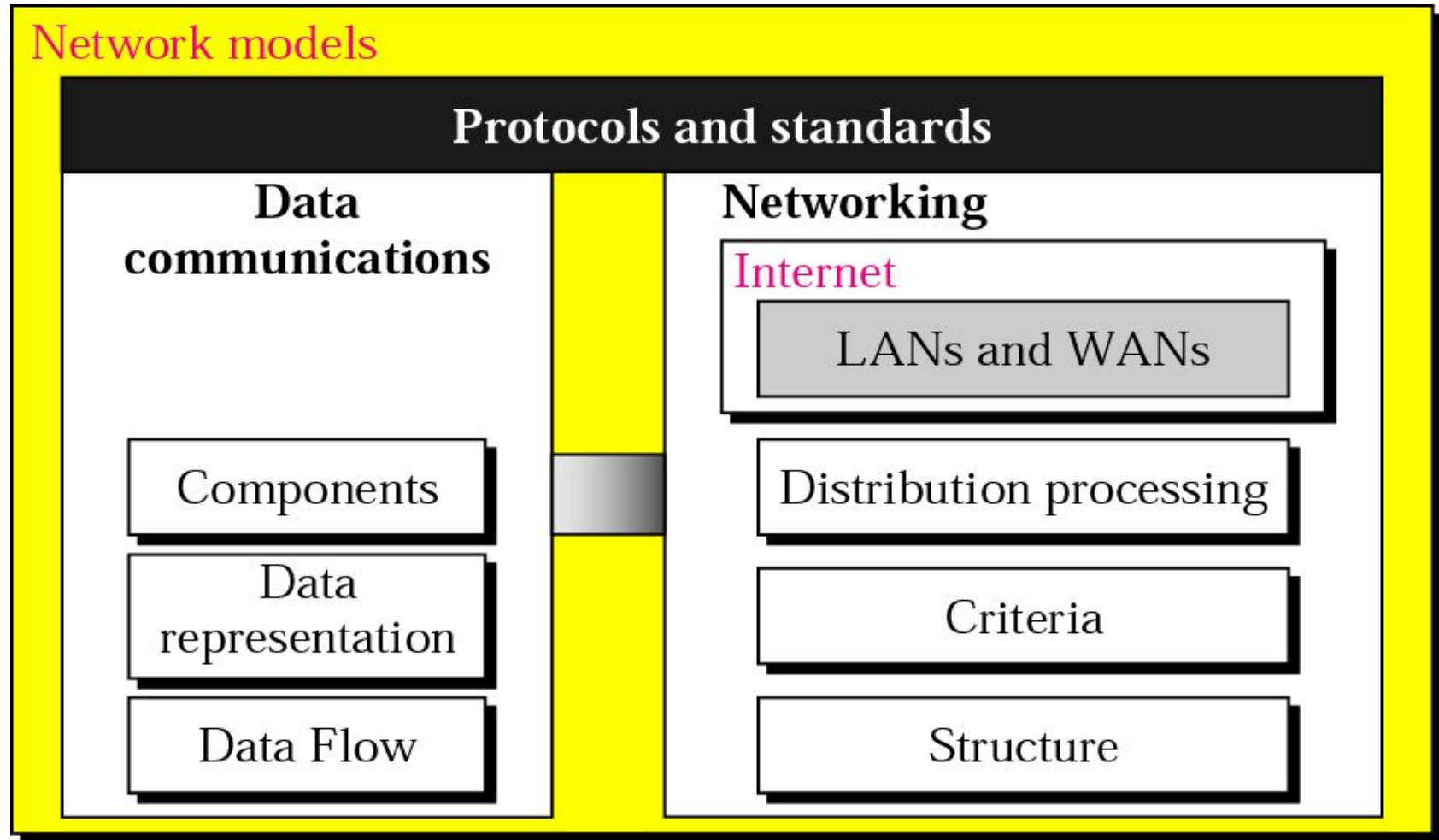
## Chapter 1

# Introduction



# Data Communications and Networking

## Network models



# 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.*

## *Topics discussed in this section:*

Components

Data Representation

Data Flow



# Fundamental Characteristics

□ The effectiveness of a data communication system depends on three fundamental characteristics

◆ **Delivery**

- must deliver data to the correct destination
- (the intended device or user)

◆ **Accuracy**

- must deliver data accurately

◆ **Timeliness**

- must deliver data in a timely manner

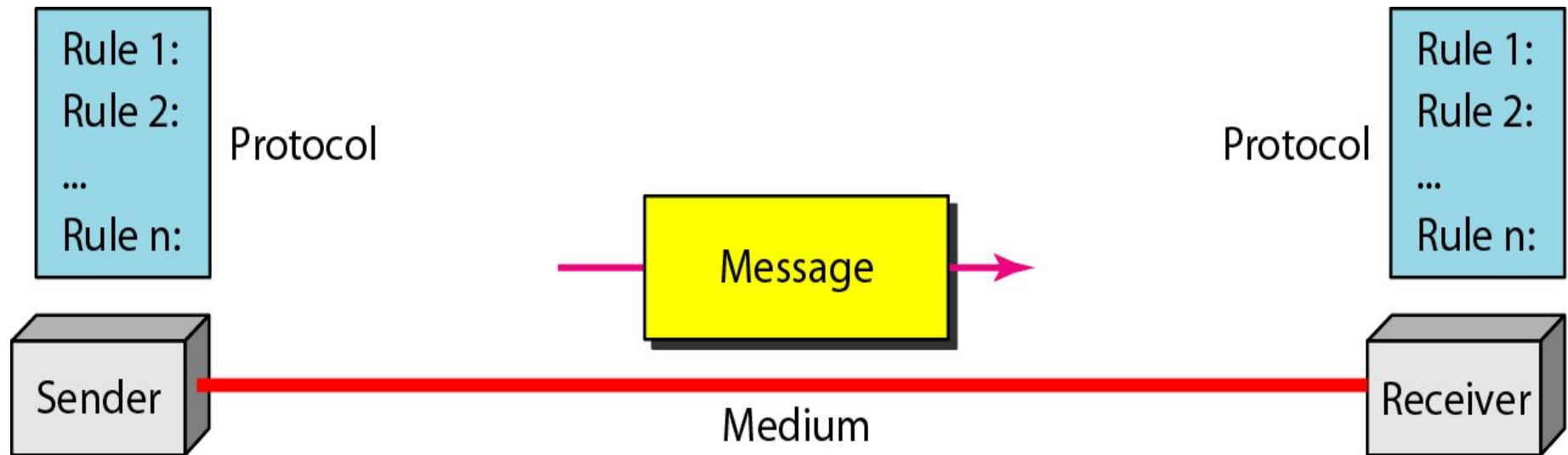
◆ **Jitter**

- Refers to the variation in the packet arrival time.



# Data communication system components

**Figure 1.1** *Five components of data communication*



# Data communication system components (cont'd)

## □ Message

- ◆ is the information(data) to be communicated.

(text, numbers, pictures, sound, video or any combination of these)

## □ Sender

- ◆ is the device that sends the data message.

(computer, workstation, telephone handset, video camera)

## □ Receiver

- ◆ is the device that receives the message.

(computer, workstation, telephone handset, video camera)

# Data communication system components (cont'd)

## □ Medium

- ◆ is the physically path by which a message travels from sender to receiver.

(twisted pair wire, coaxial cable, fiber- optic cable, laser , or radio waves(terrestrial or satellite microwave))

## □ Protocol

- ◆ is a set of rules that govern data communication.



# Data Presentation

## ❑ Text is represented as a bit pattern.

- Code : Each sets of bit patterns to represent text symbols.
- ASCII : by ANSI, 7bits
- Extended ASCII, 8bits
- Unicode : 16 bits
- ISO : 32bits

## ❑ Numbers : also represented by bit patterns.

## ❑ Images : also represented by bit patterns. (Picture)

## ❑ Audio : It is continuous, not discrete. (Voice or music)

## ❑ Video : The recording or broadcasting of a picture or movie.



# Direction of Data Flow

- ◆ is used to define the direction of signal flow between two link devices

## □ Simplex

- unidirectional, as on a one-way street (keyboard, monitor)

## □ Half-Duplex

- each station can both transmit and receive, but not at the same time

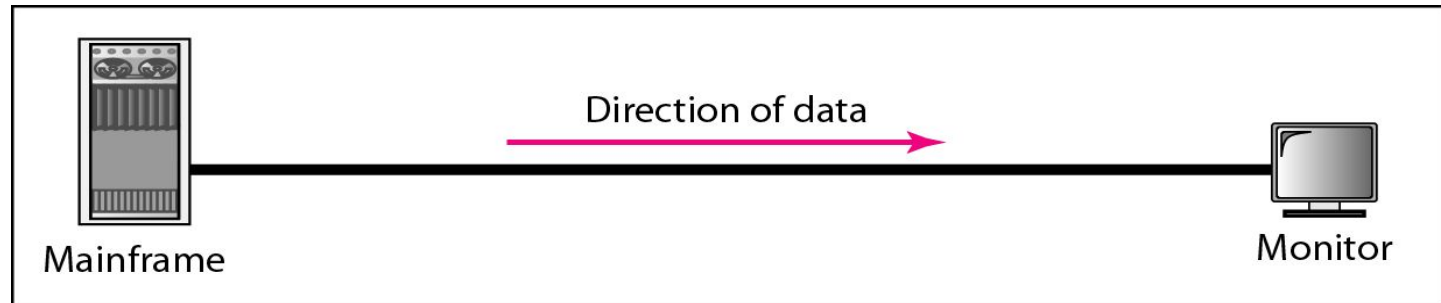
## □ Full-Duplex

- both stations can transmit and receive simultaneously

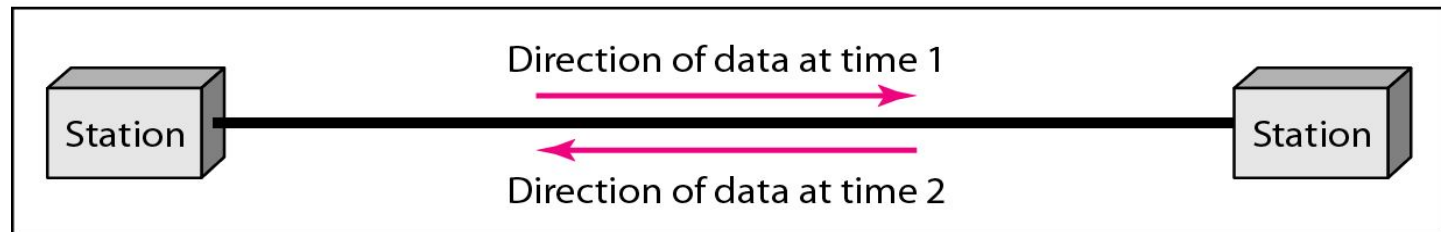


# Direction of Data Flow (cont'd)

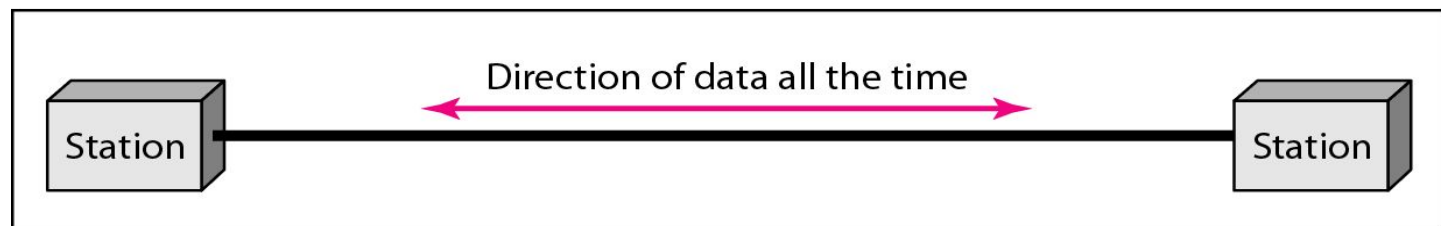
**Figure 1.2** *Data flow (simplex, half-duplex, and full-duplex)*



a. Simplex



b. Half-duplex



c. 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:*

**Distributed Processing**

**Network Criteria**

**Physical Structures**

**Network Models**

**Categories of Networks**

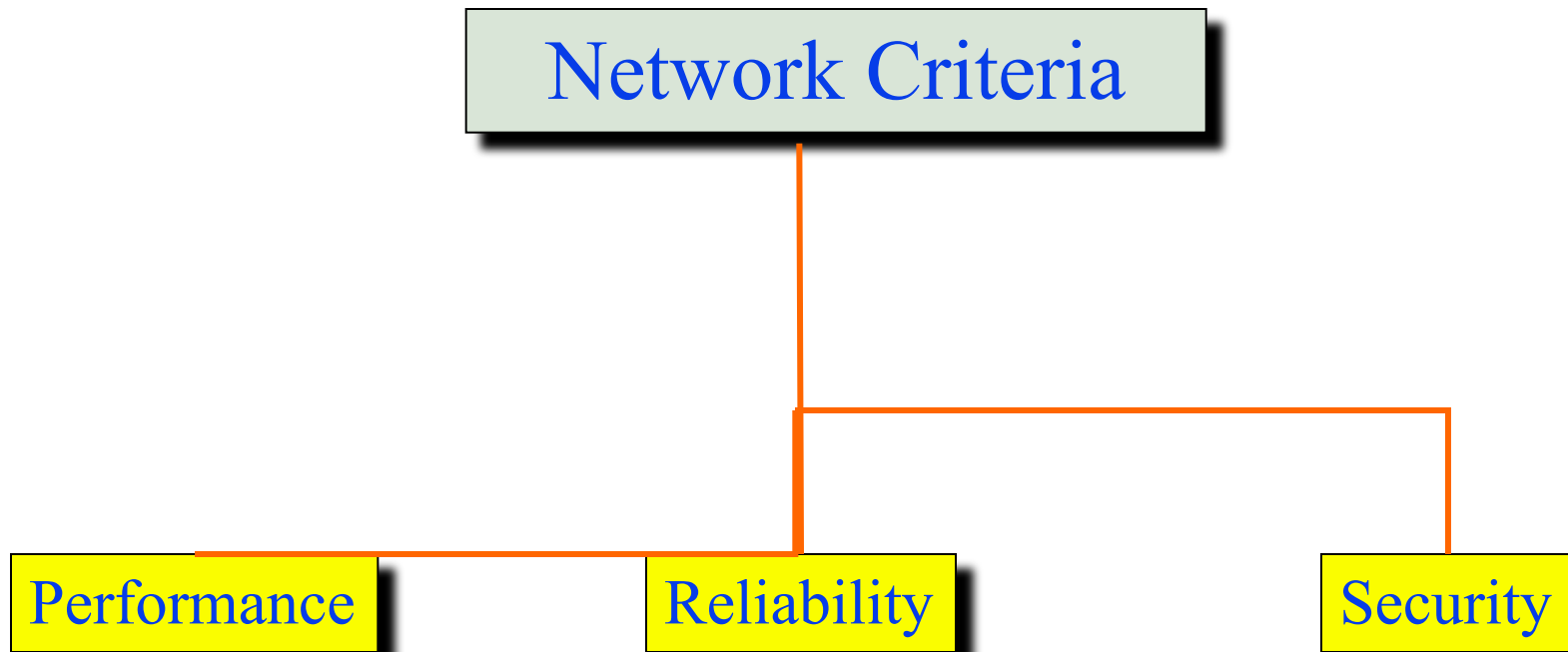
**Interconnection of Networks: Internetwork**



# Distributed processing

- ❑ A task is divided among multiple computers.
- ❑ Instead of one single large machine being responsible for all aspects of a process, separate computers handle a subset.

# Network Criteria



# Performance

- ❑ **Depends on a number of factors.**
  - number of users
  - type of transmission medium(data rate)
  - hardware
  - software : error-free delivery
- ❑ **Evaluated by two networking metrics:**
  - ◆ **Throughput and Delay.**

# Reliability

- ❑ **Frequency of failure**
- ❑ **Recovery time of a network after a failure**
- ❑ **Catastrophe**
  - ◆ **Networks must be protected from catastrophic events such as fire, earthquake, or theft.**

# Security

- ❑ **Protecting data from Unauthorized access**
- ❑ **Protecting data from Viruses and Worms**





# Physical Structures

## □ Type of Network Connection

### ◆ Point-to-point

- provides a dedicated link between two devices.

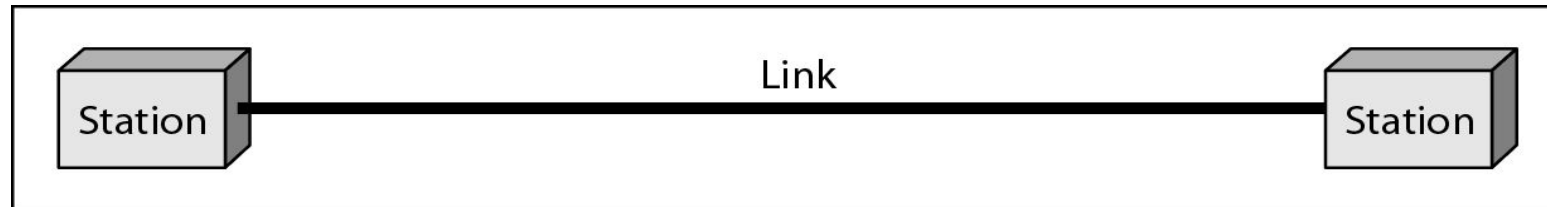
### ◆ Multipoint : multi-drop

- is configuration in which more than two specific devices share a single link

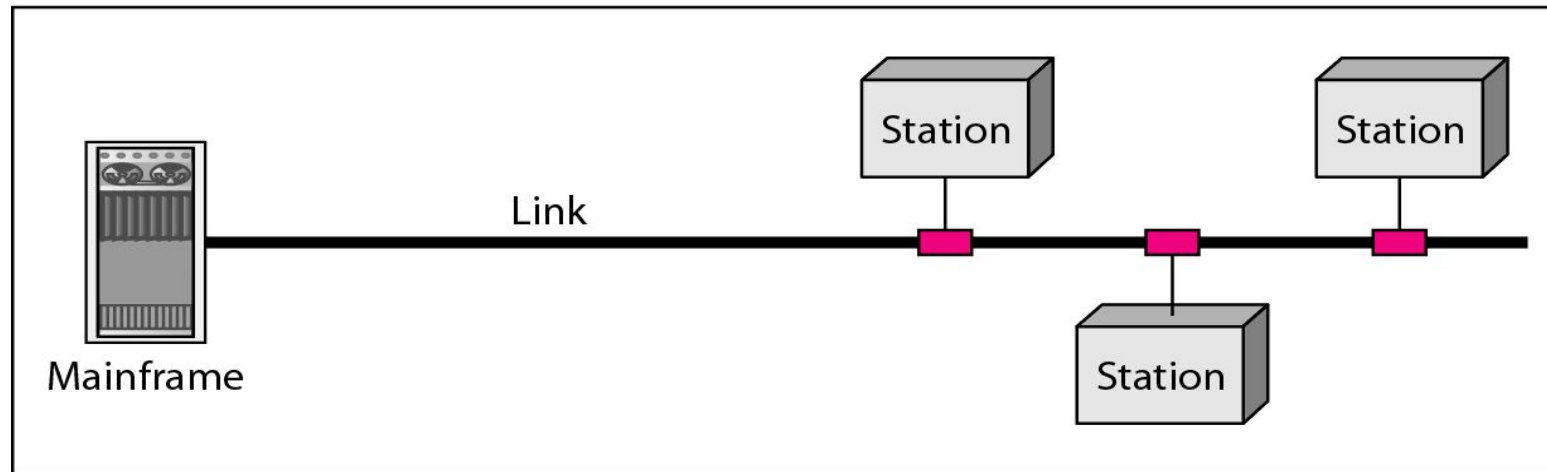


# Physical Structures (cont'd)

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

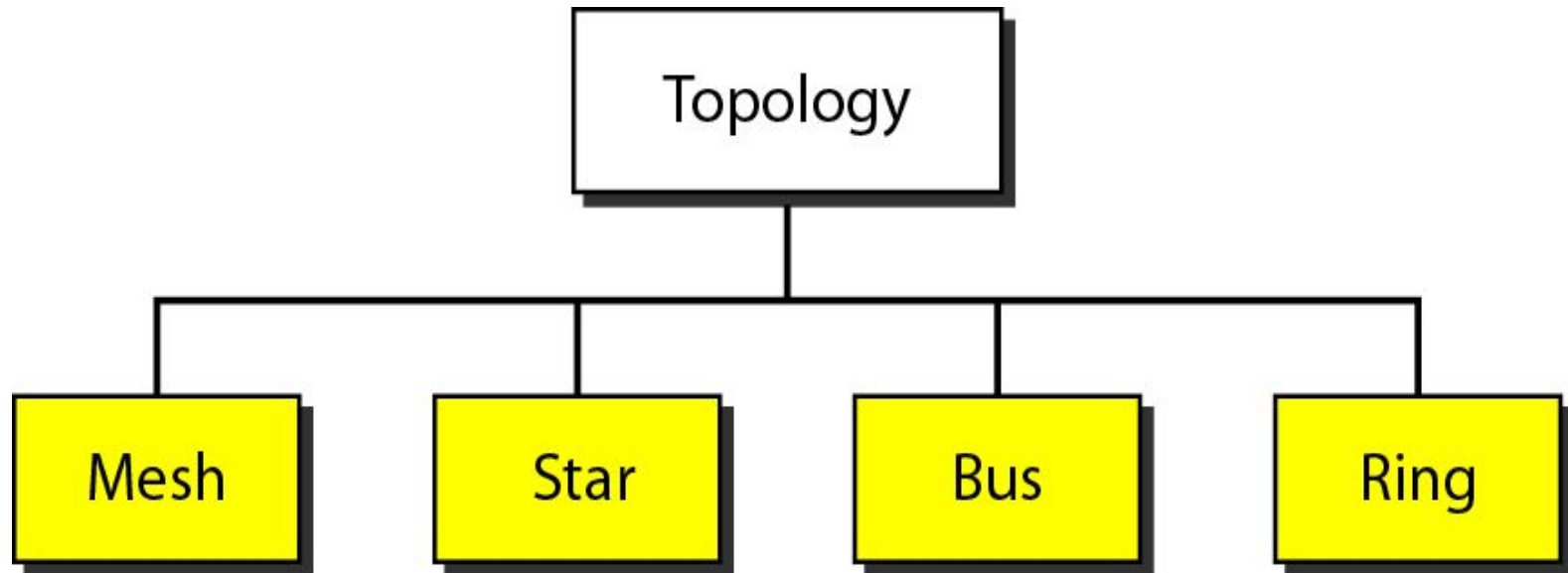


a. Point-to-point



b. Multipoint

# Physical Topology



# Physical Topology

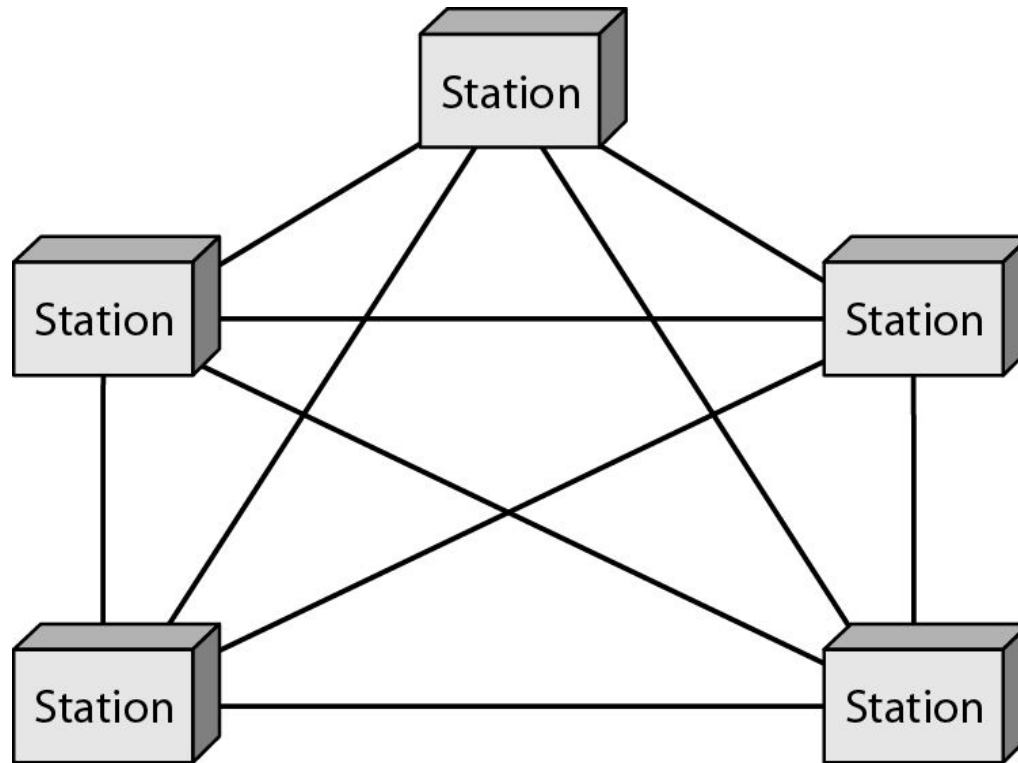
## □ Mesh

- ◆ Every device has a dedicated point-to-point link to every other device.
- ◆ A fully connected mesh network therefore has  $n(n-1)/2$  physical channels to link  $n$  devices.



# Mesh

## □ Mesh



## Mesh (cont'd)

### □ Advantages

- The use of dedicated links guarantees that each connection can carry its data load.
- Mesh topology is robust.
- Privacy and security.
- Point-to-point links make fault identification and fault isolation easy.

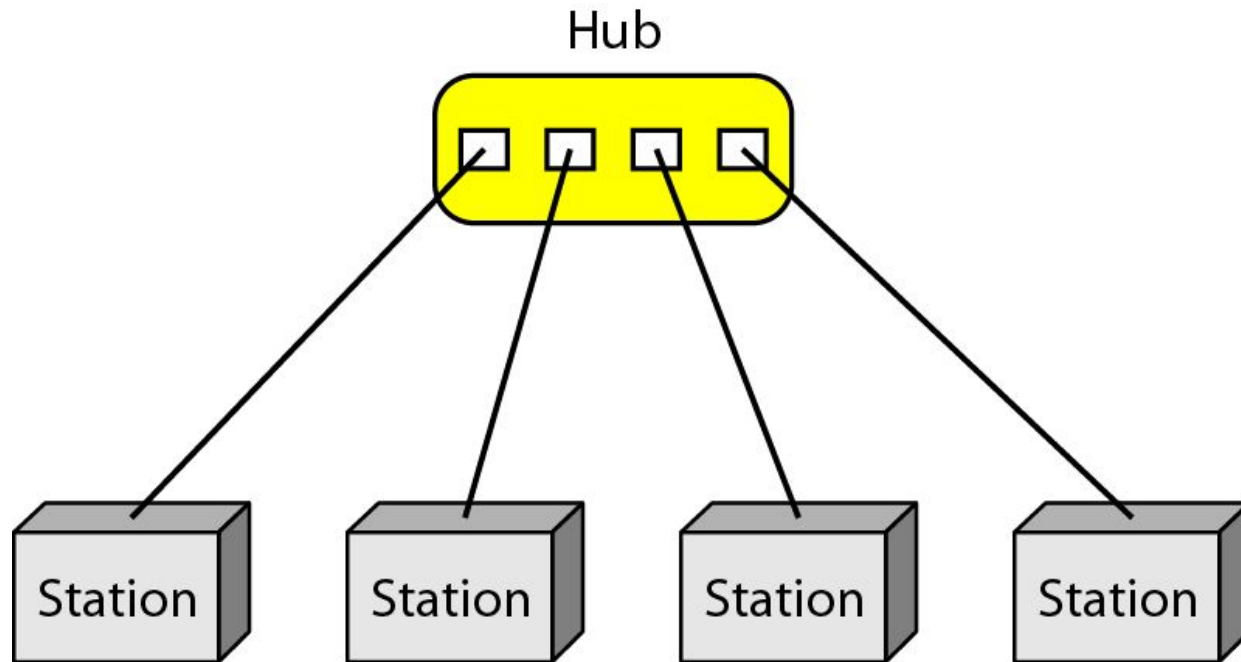


### ❏ Disadvantages

- are related to the amount of cabling and the number of I/O ports
- ❖ because every device must be connected to every other device, installation and reconfiguration are difficult
- ❖ the sheer bulk of the wiring can be greater than the available space(in walls, ceiling, or floors) can accommodate
- ❖ the hardware required to connect each link (I/O port and cable) can be prohibitively expensive

# Star Topology

- ❑ Each device has a dedicated point-to-point link only to a central controller, usually called a hub
- ❑ Star Topology





## Star (cont'd)

### □ Advantage

- ◆ Each device needs only one link and one I/O port to connect it to any number of others (easy to install and reconfigure)
- ◆ Robustness
  - if one link fails, only that link is affected

# Tree Topology

□ Tree topology is a variation of a star

◆ active hub(central hub)

- contains a repeater, which is a hardware device that generates the received bit patterns before sending them out

◆ passive hub

- provides a simple physical connection between the attached devices

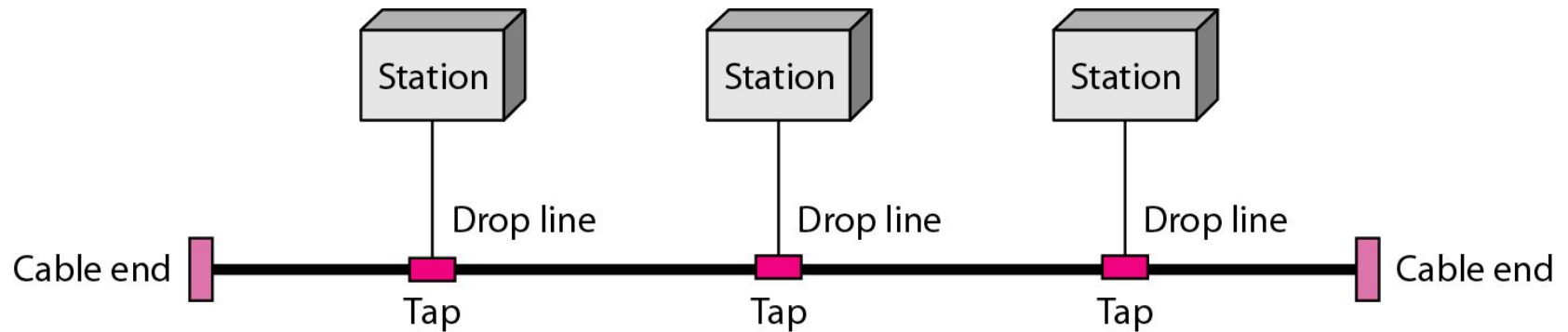


# Bus Topology

- ❑ **Bus topology is multipoint. One long cable acts as a backbone to link all the devices in the network**
- ❑ **Nodes are connected to the bus cable by drop lines and taps**
  - ◆ **Drop line**
    - **is a connection running between the device and the main cable**
  - ◆ **Tap**
    - **is a connector either splices into the main cable or punctures the sheathing of a cable to create a contact with the metallic core**



## Bus Topology (cont'd)



## Bus (cont'd)

### ❑ Advantages

- include ease of installation

### ❑ Disadvantages

- include difficult reconfiguration and fault isolation

# Ring Topology

- ❑ Each device has a dedicated point-to-point line configuration only with the two devices on either side of it

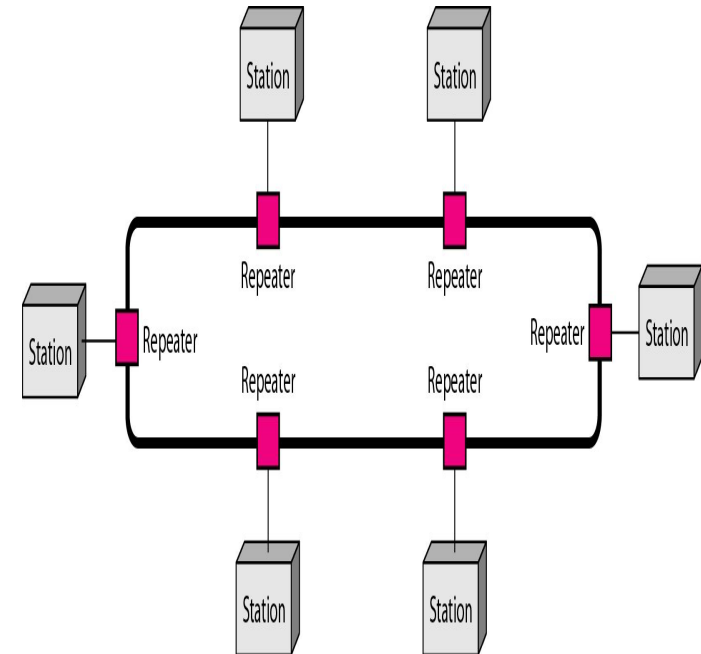
- ❑ Advantage

- is relatively easy to install and reconfigure
- fault isolation is simplified

- ❑ Disadvantage

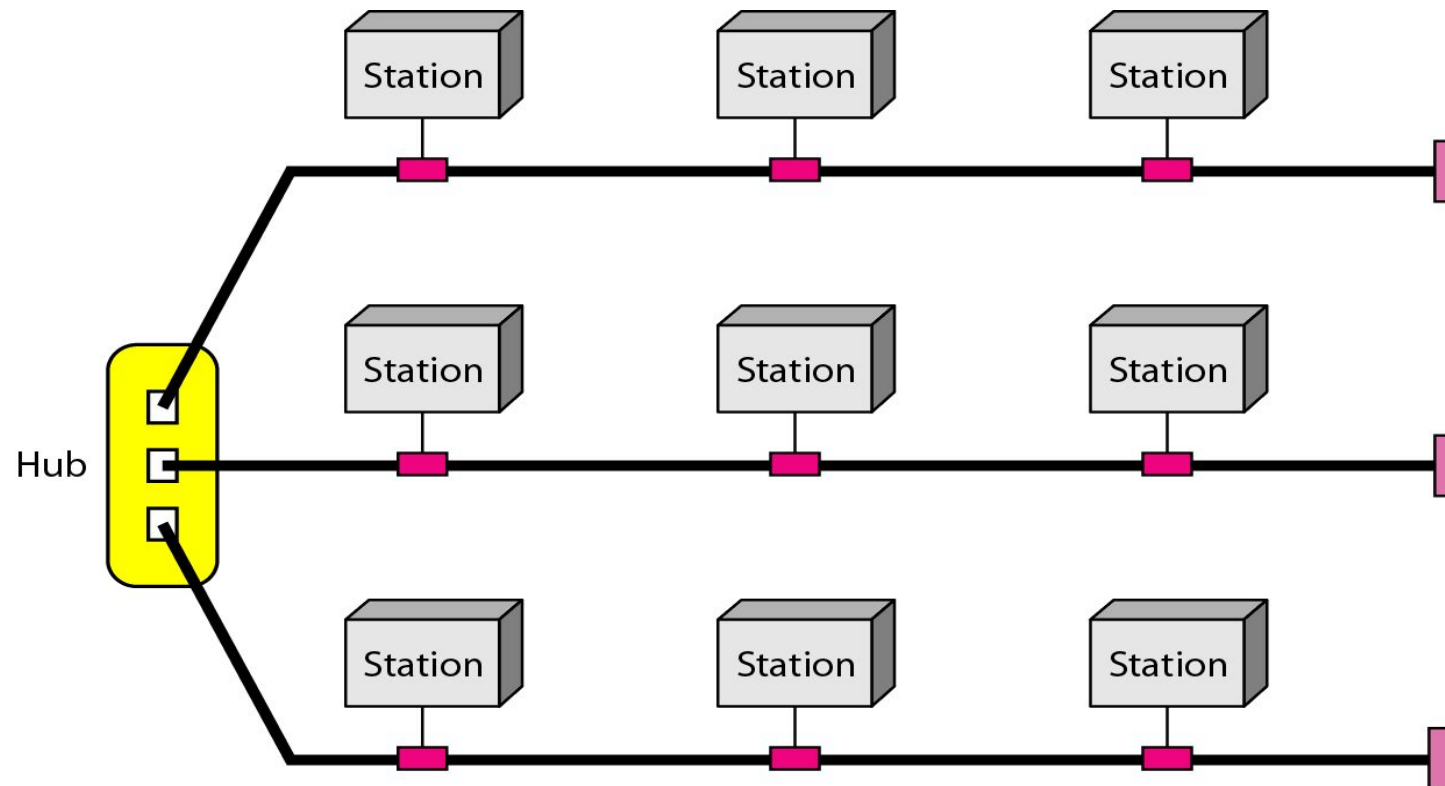
- ◆ unidirectional traffic

- break in the ring can disable the entire network  
--> needs dual ring



# Hybrid Topology

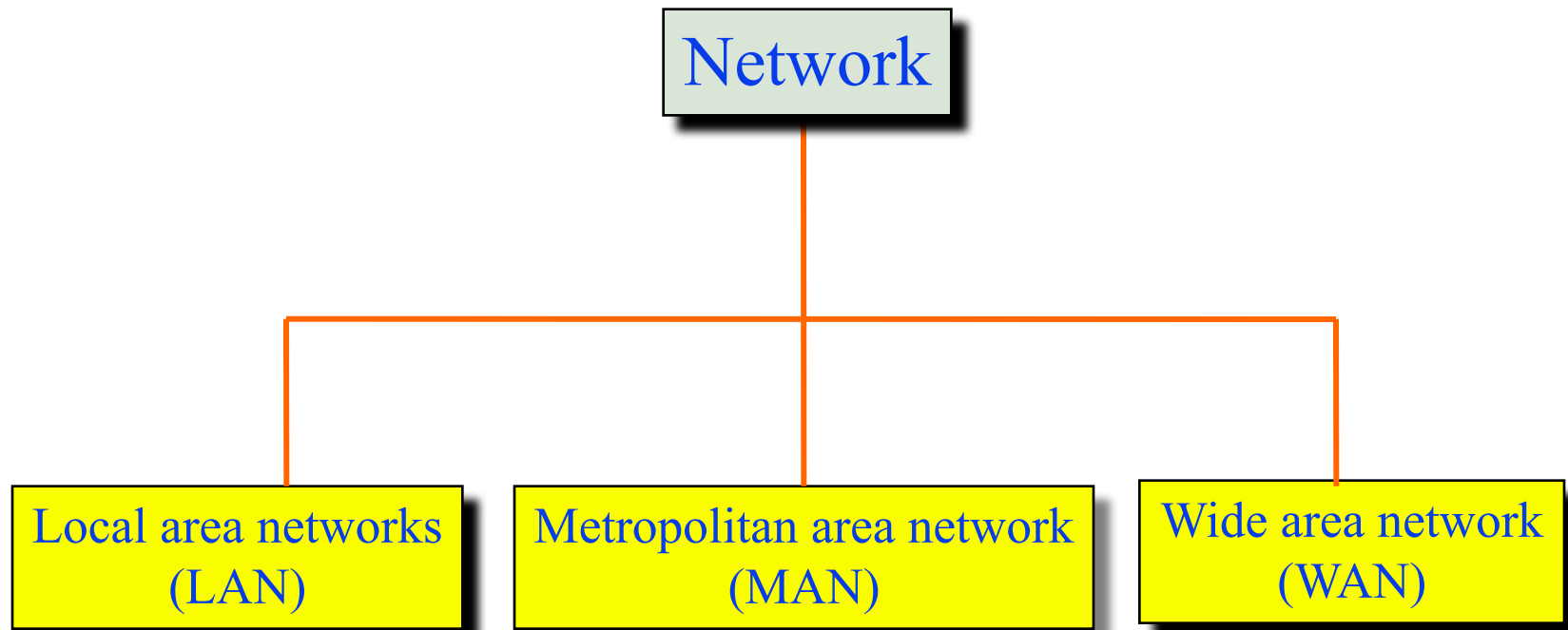
- ❑ A network can be hybrid.
- ❑ For example, a main star topology with each branch connecting several stations in a bus topology.



# Categories of Networks

## ❑ Three primary categories

◆ size, ownership, distance it cover, physical architecture

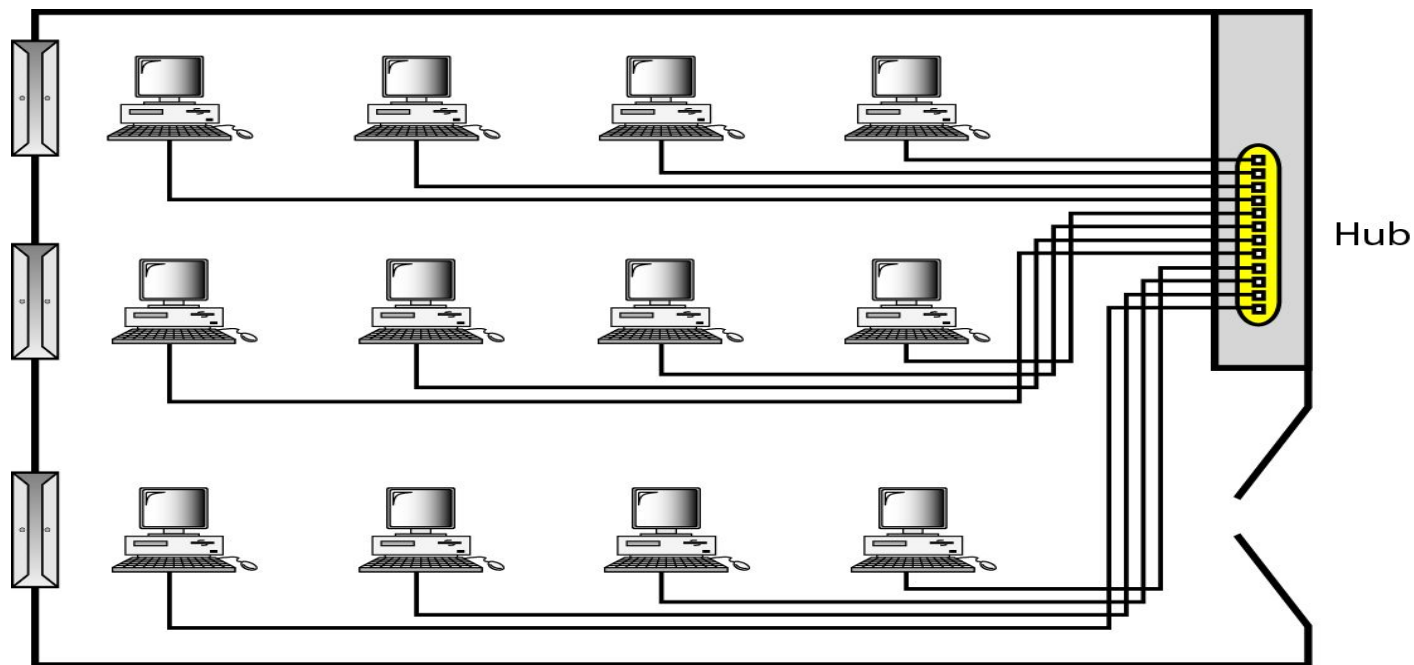




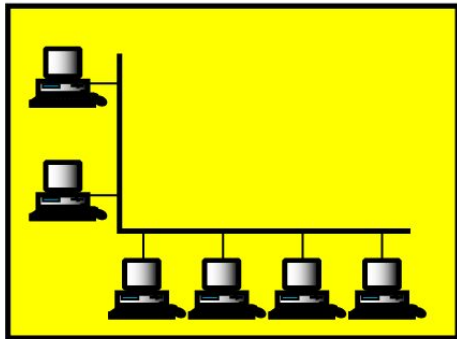
# LAN (Local Area Networks)

- ❑ LAN is usually privately owned and links the devices in a single office, building or campus

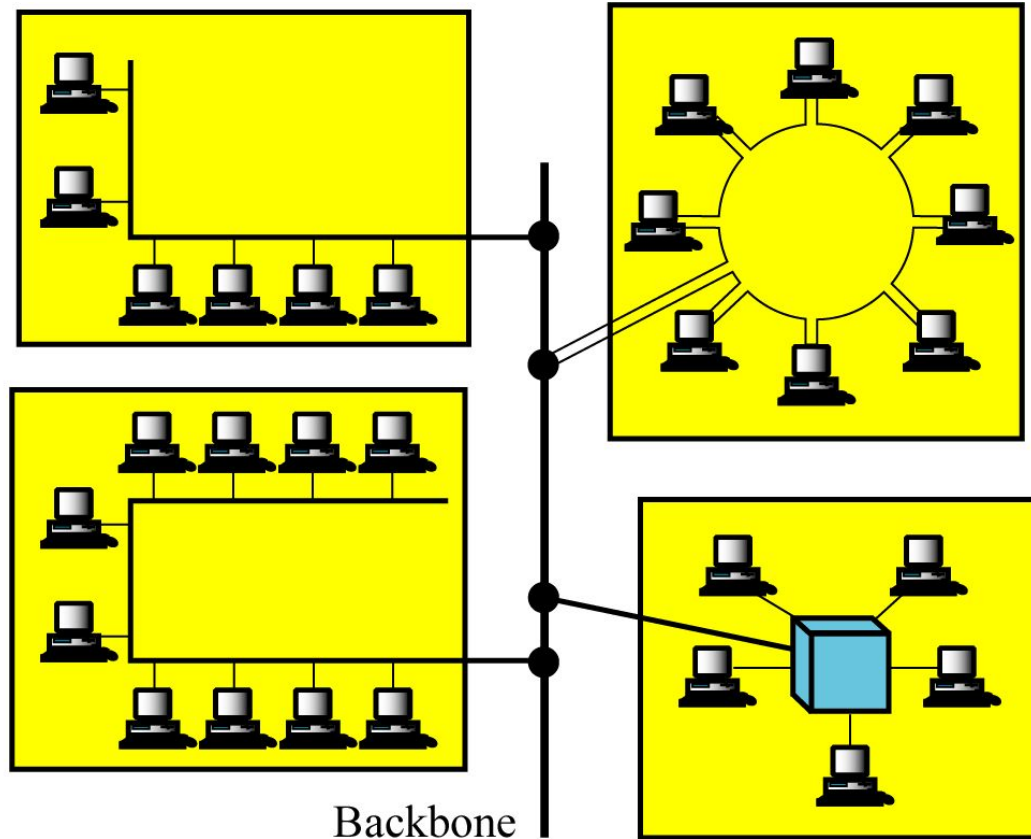
**Figure 1.10** *An isolated LAN connecting 12 computers to a hub in a closet*



# Categories of Networks (cont'd)



a. Single building LAN

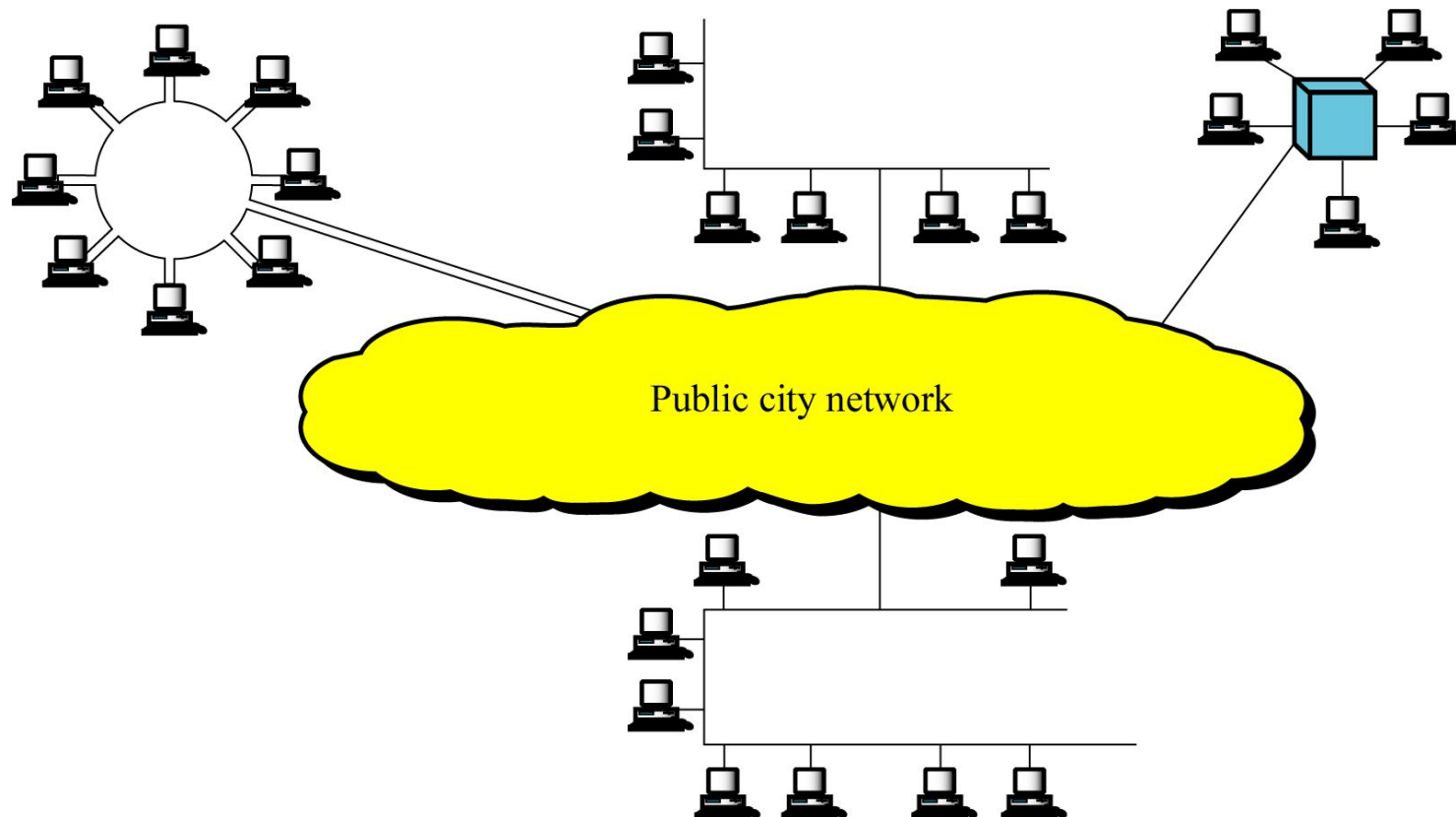


b. Multiple building LAN

# Categories of Networks (cont'd)

## ❑ MAN (Metropolitan Area Networks)

- is designed to extend over an entire city



# Categories of Networks (cont'd)

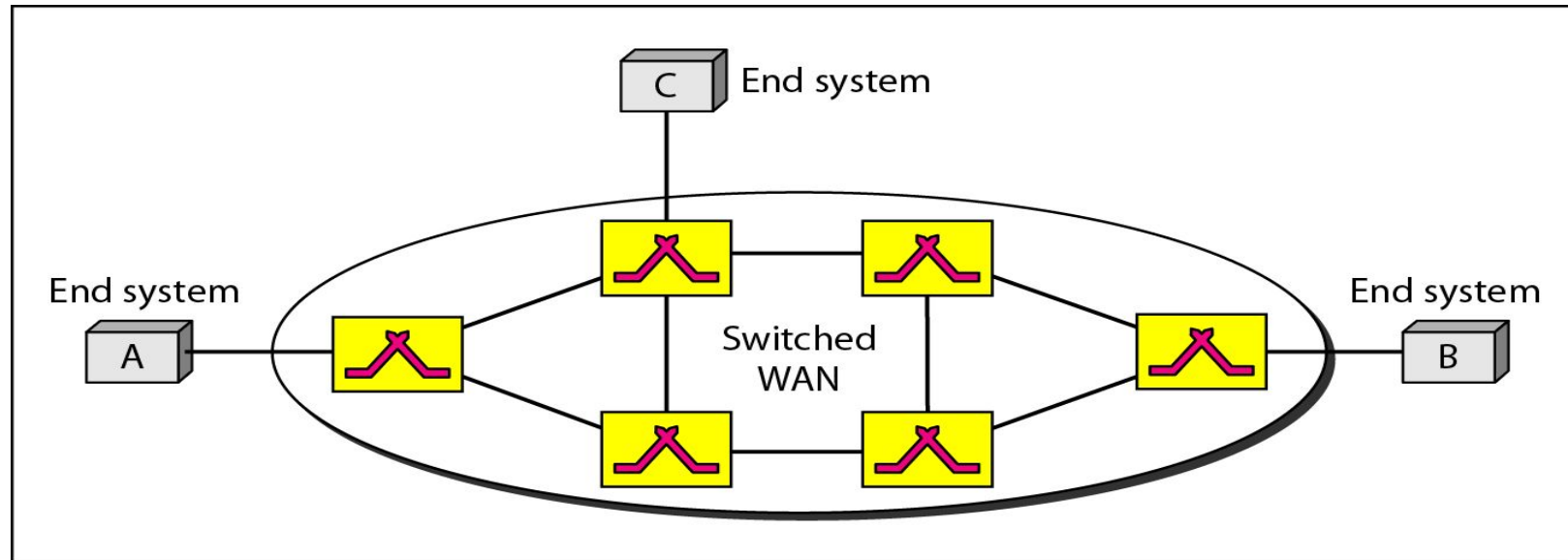
## ❑ WAN(Wide Area networks)

- provides long-distance transmission of data, voice, image, and video information over large geographical areas that may comprise a country, a continent, or even the whole world

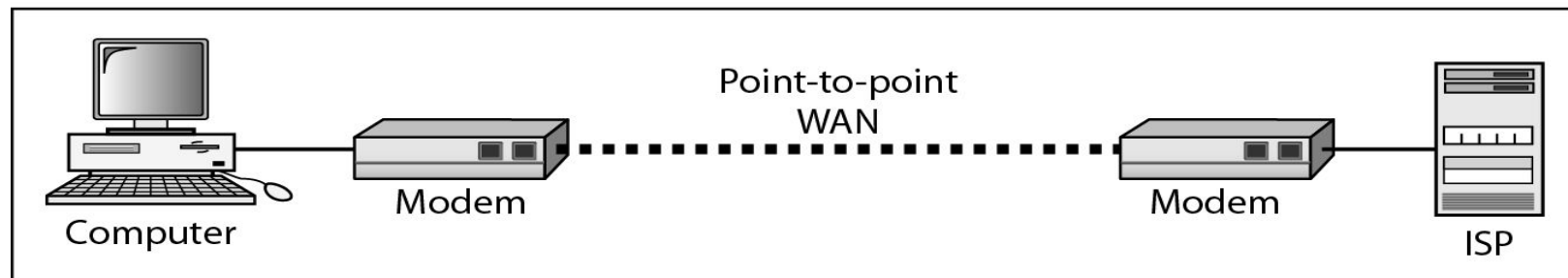


# Categories of Networks (cont'd)

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



a. Switched WAN

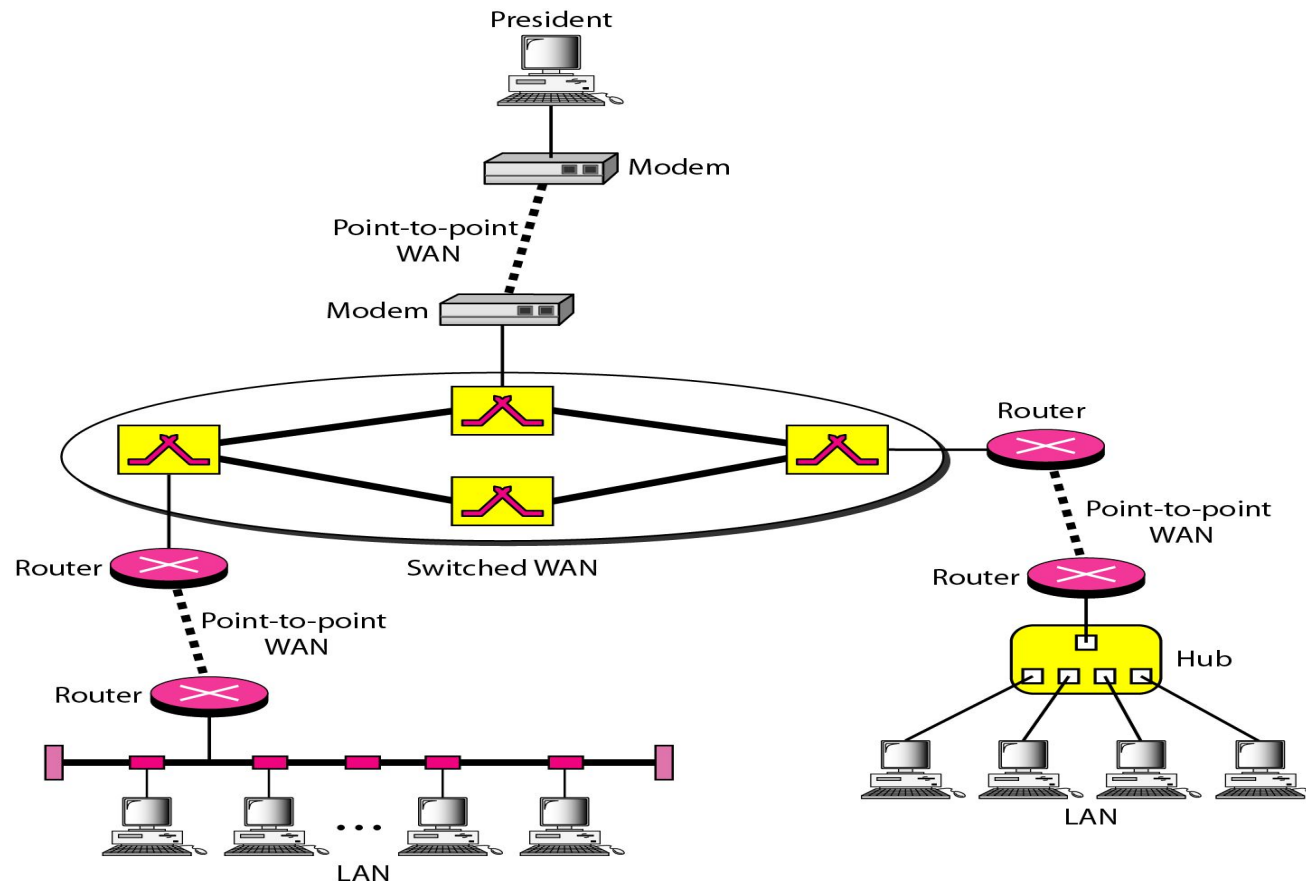


b. Point-to-point WAN

# Interconnection of Networks : Internetwork

- Two or more networks are connected, they become an internet.

**Figure 1.12** *A heterogeneous network made of four WANs and two LANs*



## 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)



## □ A Brief History

- ◆ Internet (not internet)
- ◆ ARPANET (Advanced Research Projects Agency: ARPA) – mid-1960s
  - Advanced Research Projects Agency (ARPA) in the DOD : presented ideas of ARPANET, 1967
  - Reality : 1969 (UCLA, UCSB, SRI, U of Utah)
- ◆ Birth of Internet : in 1972
  - Vint Cerf and Bob Kahn : Internetting Project
- ◆ TCP/IP : A paper by Cerf and Kahn in 1973
  - In 1983, TCP/IP became to official protocol for the ARPANET
- ◆ MILNET : in 1983
- ◆ CSNET, NSFNET, ANSNET, ...





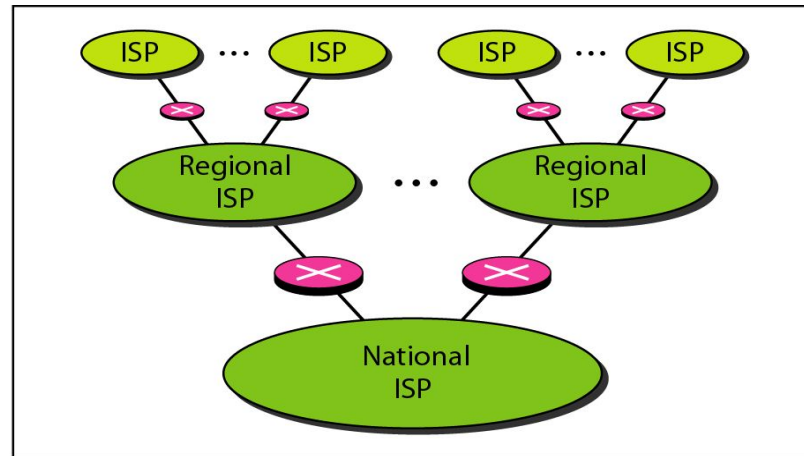
# Internet Today

- ❑ **1969.** Four-node ARPANET established.
- ❑ **1970.** ARPA hosts implement NCP.
- ❑ **1973.** Development of TCP/IP suite begins.
- ❑ **1977.** An internet tested using TCP/IP.
- ❑ **1978.** UNIX distributed to academic sites.
- ❑ **1983.** TCP/IP becomes the official protocol
- ❑ **1983.** MILNET was born.
- ❑ **1986.** NSFNET established.
- ❑ **1986,** IETF First Meeting
- ❑ **1990.** ARPANET replaced by NSFNET.
- ❑ **1991.** WWW by CERN
- ❑ **1995.** NSFNET became a research network.
- ❑ **1995.** ISPs started.
- ❑ **2006** GENI (Global Environment for Network Innovations) for Future Internet

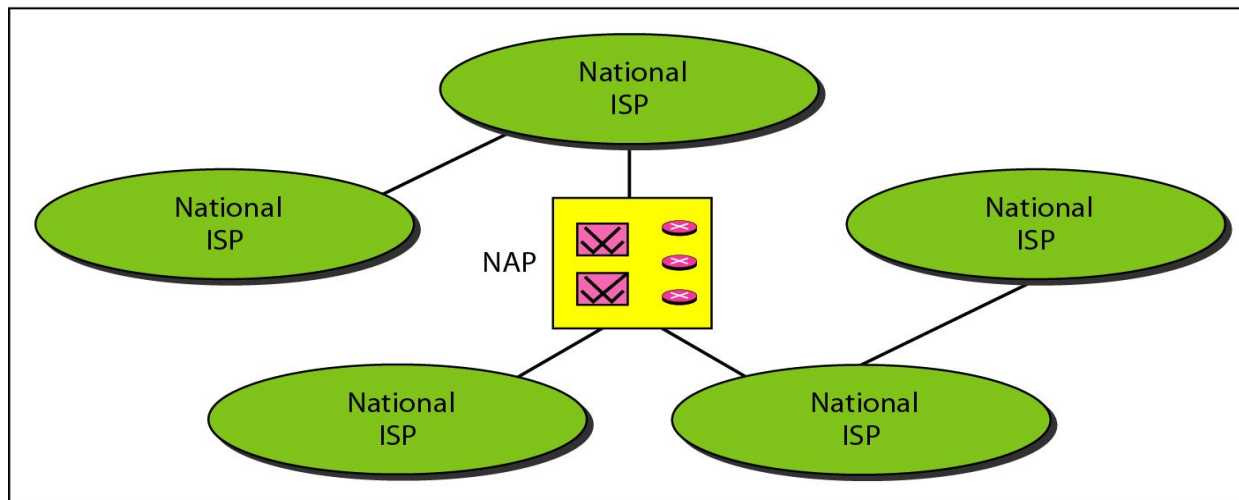


# Internet Today

**Figure 1.13** *Hierarchical organization of the Internet*



a. Structure of a national ISP



b. Interconnection of national ISPs



# 1-4 PROTOCOLS AND STANDARDS

In this section, we define two widely used terms: **protocols** and **standards**. First, we define protocol, which is synonymous with rule. Then we discuss standards, which are agreed-upon rules.

## Topics discussed in this section:

Protocols

Standards

Standards Organizations

Internet Standards



# Protocols and Standard

## ❑ Communication in computer networks

- Communication occurs between entities in different systems

## ❑ Entity

- is anything capable of sending or receiving information

## ❑ Protocol

- is a set of rules that govern data communication



### □ Key elements of a Protocol

#### ◆ Syntax (문법)

- refers to the structure or format of the data, meaning the order in which they are presented.

#### ◆ Semantics (의미론)

- refers to the meaning of each section of bits.

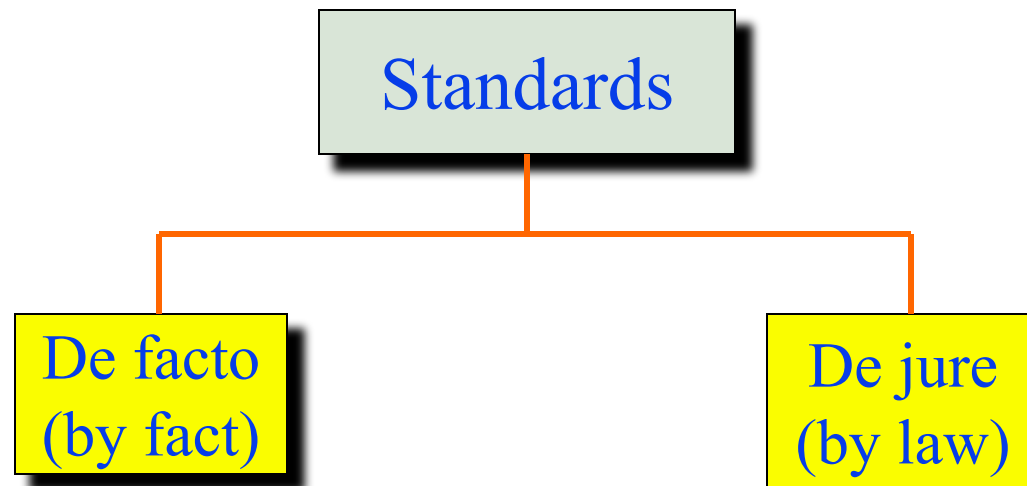
#### ◆ Timing (타이밍)

- refers to two characteristics (when data should be sent and how fast it can be sent)

# Standards

## □ Standards(표준)

- are essential in creating and maintaining an open and competitive market for equipment manufactures and in guaranteeing national and international interoperability of data and communications technology and processes.



# Standards Organizations (표준화 기구)

## □ Standard Creation Committees

### ◆ ISO (The International Standard Organization)

- created in 1947
- Multi national body
- is an organization dedicated to worldwide agreement on international standards in a variety of fields (scientific, technological, economic activity)



# Standards Organizations (cont'd)

## ❖ **ITU-T(International Telecommunications Union - Telecommunications Standards Sector)**

- **is an international standards organization related to the United Nations that develops standards for telecommunications.**
- **Two popular standards developed by ITU-T are the V series (data transmission over phone lines) and the X series (transmission over public digital networks)**





# Standards Organizations (cont'd)

## ◆ ANSI (American National Standard Institute)

- is a nonprofit organization and is the U.S. voting representative to be both the ISO and the ITU-T

## ◆ IEEE (Institute of Electrical and Electronic Engineers)

- is the largest national professional group involved in developing standards for computing, communication, electrical engineering, and electronics)

## ◆ EIA (Electronic Industries Association)

- is an association of electronics manufactures in the United States. (EIA-232-D, EIA-530 standards)



# Standards Organizations (cont'd)

## □ Forums

- ◆ consist of representatives from corporation that test, evaluate and standardize new technologies.
- ◆ Frame Relay Forum
- ◆ ATM Forum and ATM consortium

## □ Regulatory agencies

- ◆ FCC (Federal Communications Commission)



방송통신위원회

Broadcasting and Communications Commission



# Internet Standards

- ❑ **Internet standard by IETF (Internet Engineering Task Force)**
  - ◆ is a thoroughly tested specification that is useful to and adhered by those who work with the Internet
- ❑ **A specification begins as an Internet draft**
  - ◆ Working document with no official status and six-month life-time
- ❑ **RFC (Request for Comment) Recommendation from Internet authorities**

## Standards (cont'd)

### □ by law standard

~ are those that have been legislated by an officially recognized body.

### □ by fact standard

~ are often established originally by manufactures seeking to define the functionality of a new product or technology.

#### ◆ proprietary (closed)

~ are those originally invented by a commercial organization as a basis for the operation of its products.

#### ◆ nonproprietary (open)

~ are those originally developed by group or committees that have passed them into the public domain.

## Standards Organizations (cont'd)

- ❑ **Telecommunications Technology Association**  
한국정보통신기술협회(TTA) : <http://www.tta.or.kr>
  - ITU related standardization
- ❑ **Korean Agency for Technology and Standards**  
한국기술표준원[KATS] : <http://www.kats.go.kr>
  - ISO related standardization



# Summary (1)

- ❑ **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.

## Summary (2)

- ❑ **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 state, 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.



## Summary (3)

- ❑ 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.
- ❑ The ISO, ITU-T, ANSI, IEEE, and EIA are some of the organizations involved in standards creation.
- ❑ Forums are special-interest groups that quickly evaluate and standardize new technologies.
- ❑ A Request for Comment (RFC) is an idea or concept that is a precursor to an Internet standard.



# Q & A

