Chapter 1

Introduction

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Data Communications and Networking

Network models

Protocols and standards		
Data communications		**Networking**
		Internet
		LANs and WANs
Components		Distribution processing
Data representation		Criteria
Data Flow		Structure
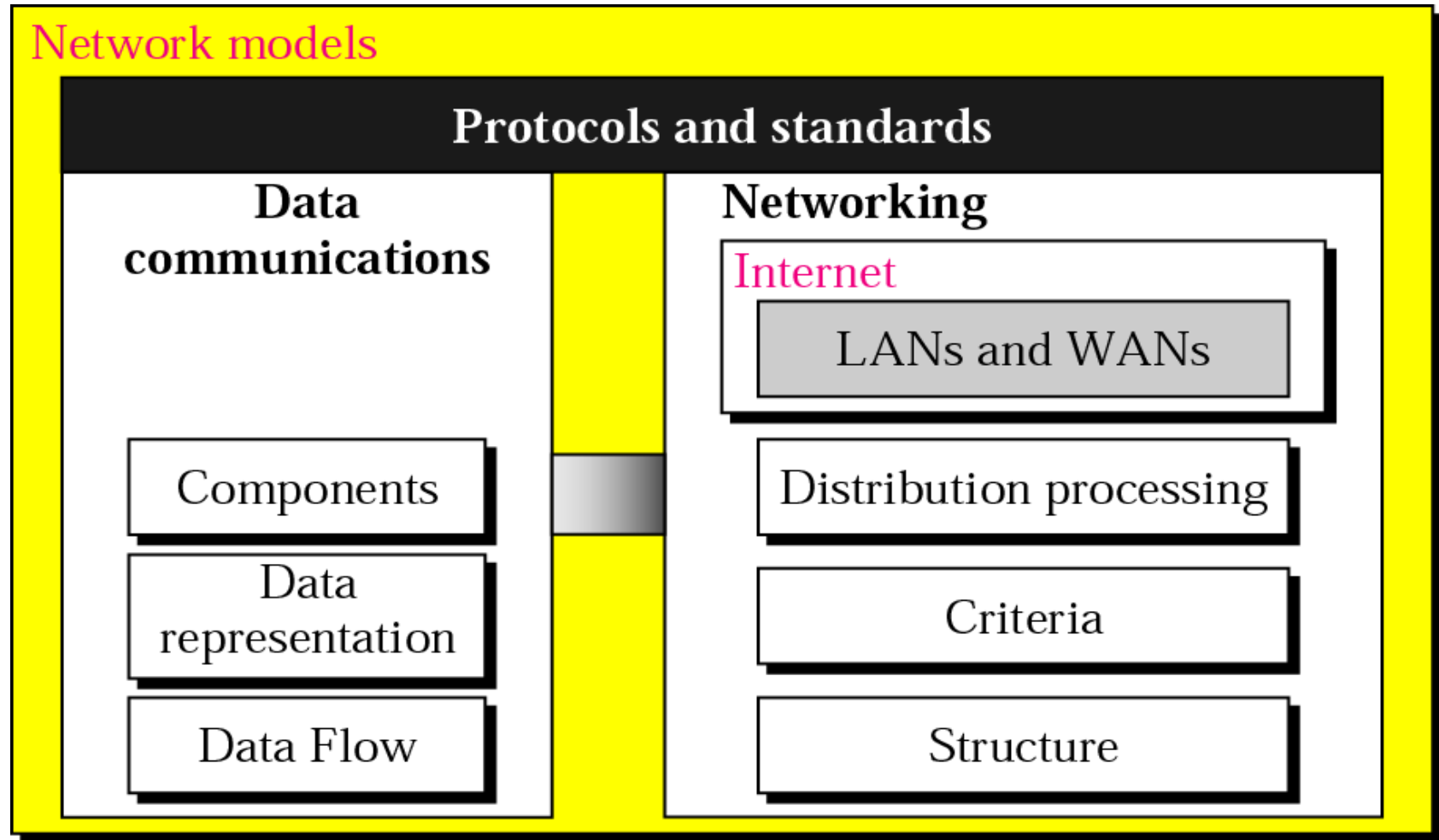
1.1 DATA COMMUNICATIONS

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**

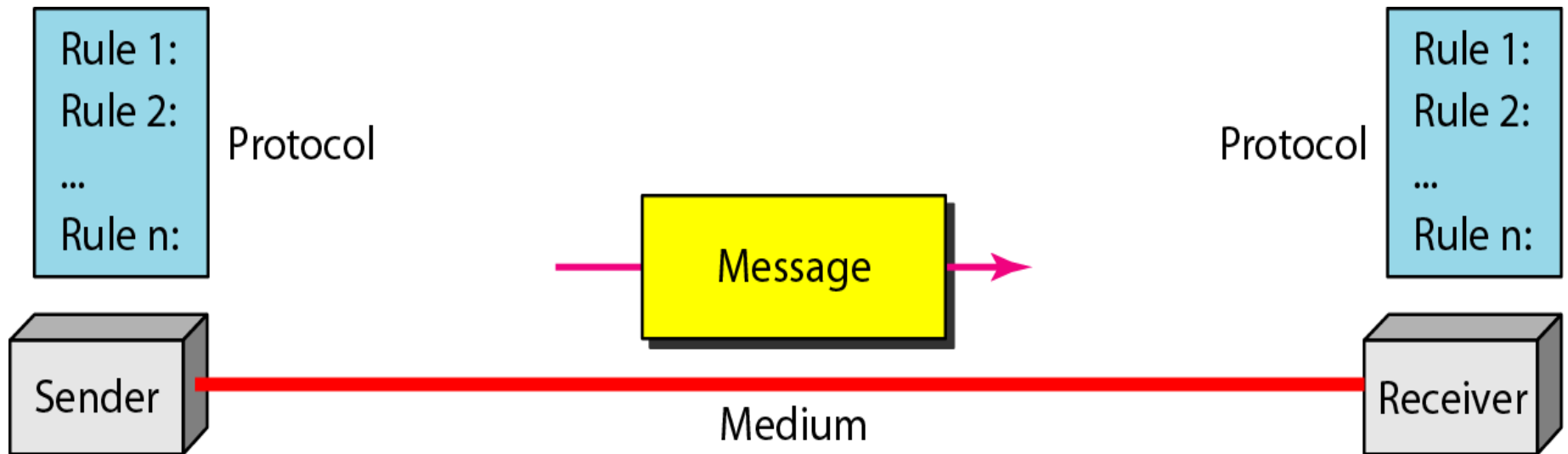 ● **must deliver data in a timely manner**

❖ **Jitter**

  ● **Refers to the variation in the packet arrival time.**

Data communication system components

Figure 1.1 *Five components of data communication*

❑ **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)

❑**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.**

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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**

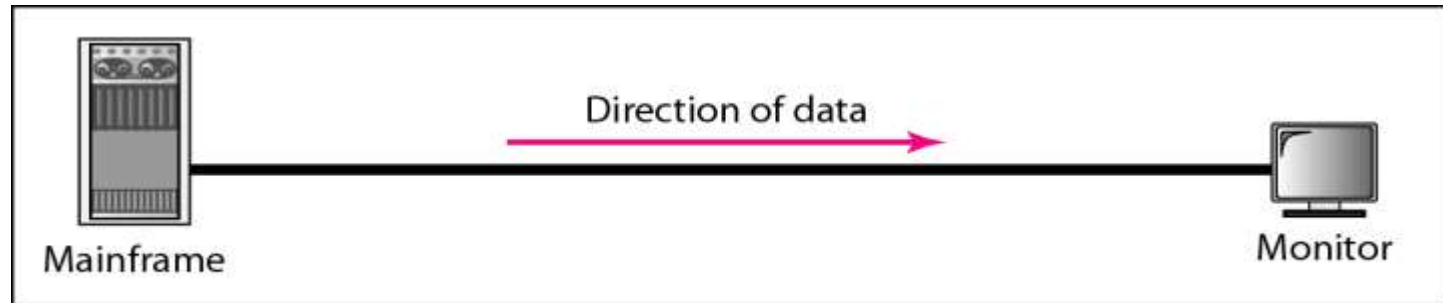◆ each station can both transmit and receive, but not at the same time

❑ **Full-Duplex**

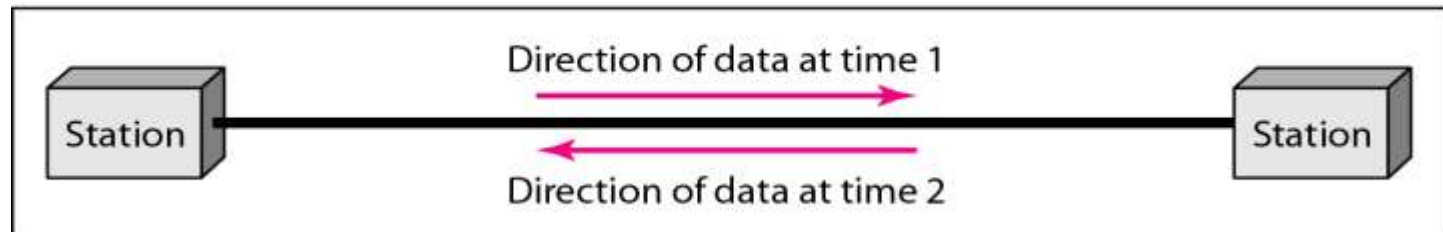◆ both stations can transmit and receive simultaneously

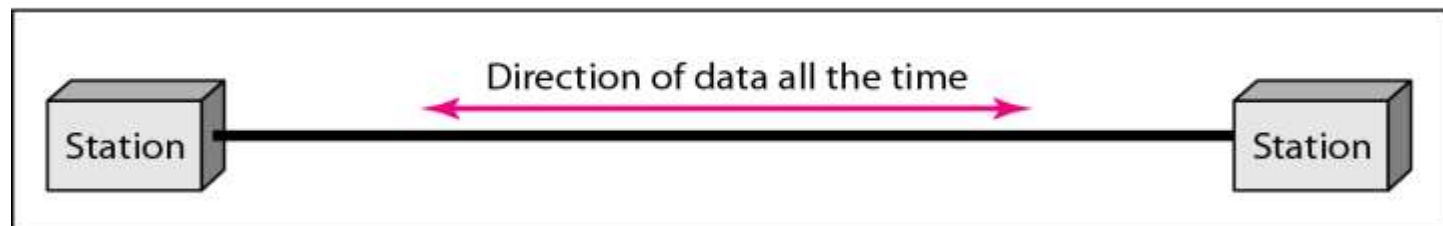**Kyung Hee University**

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
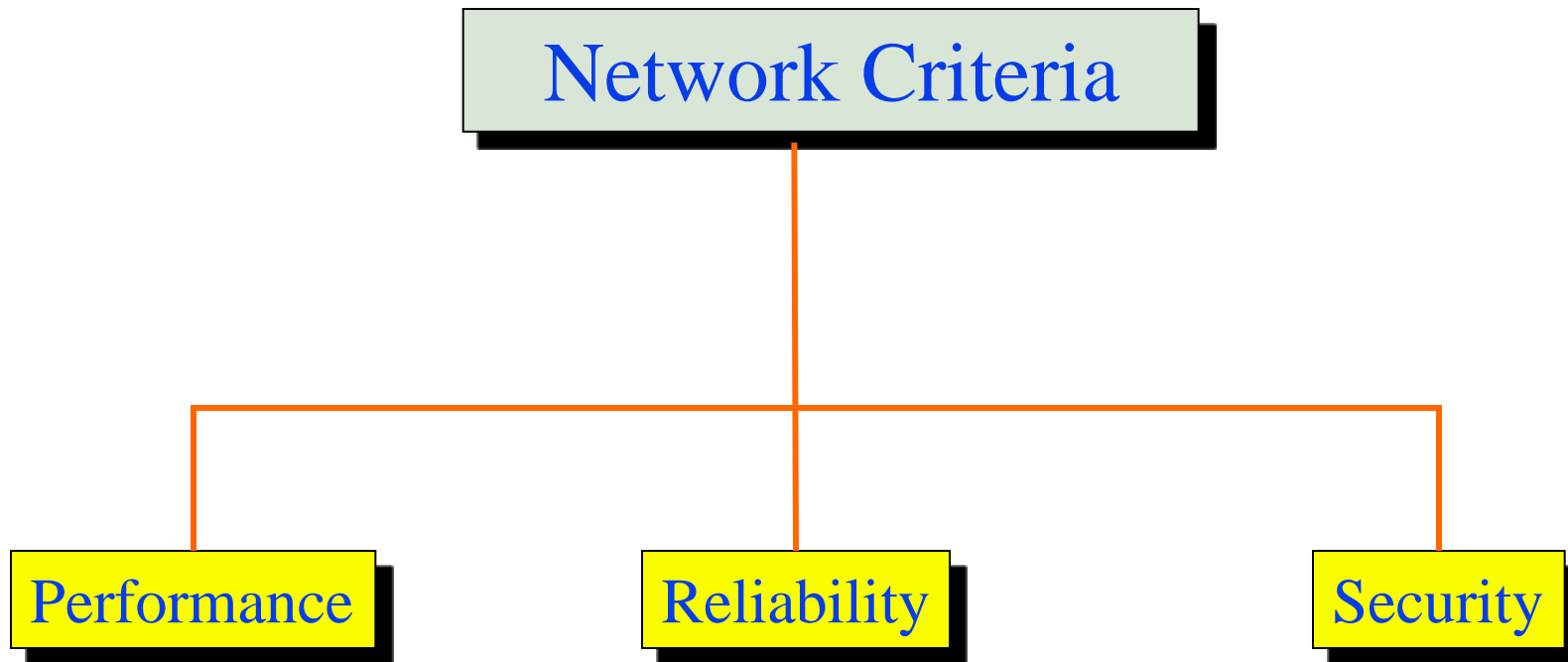
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Distributed processing

❑ **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

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            ┌──────────────────────┐
            │   Network Criteria   │
            └──────────┬───────────┘
        ┌──────────────┼──────────────┐
  ┌───────────┐  ┌────────────┐  ┌──────────┐
  │Performance│  │Reliability │  │ Security │
  └───────────┘  └────────────┘  └──────────┘
```

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**

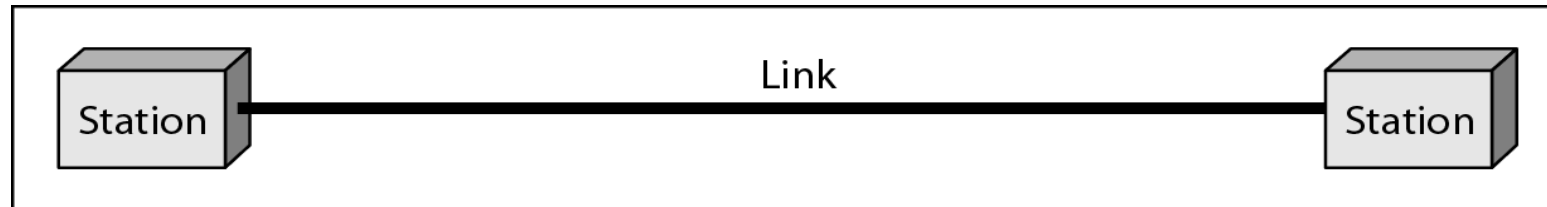❖ **Point-to-point**

- **provides a dedicated link between two devices.**

❖ **Multipoint : multi-drop**

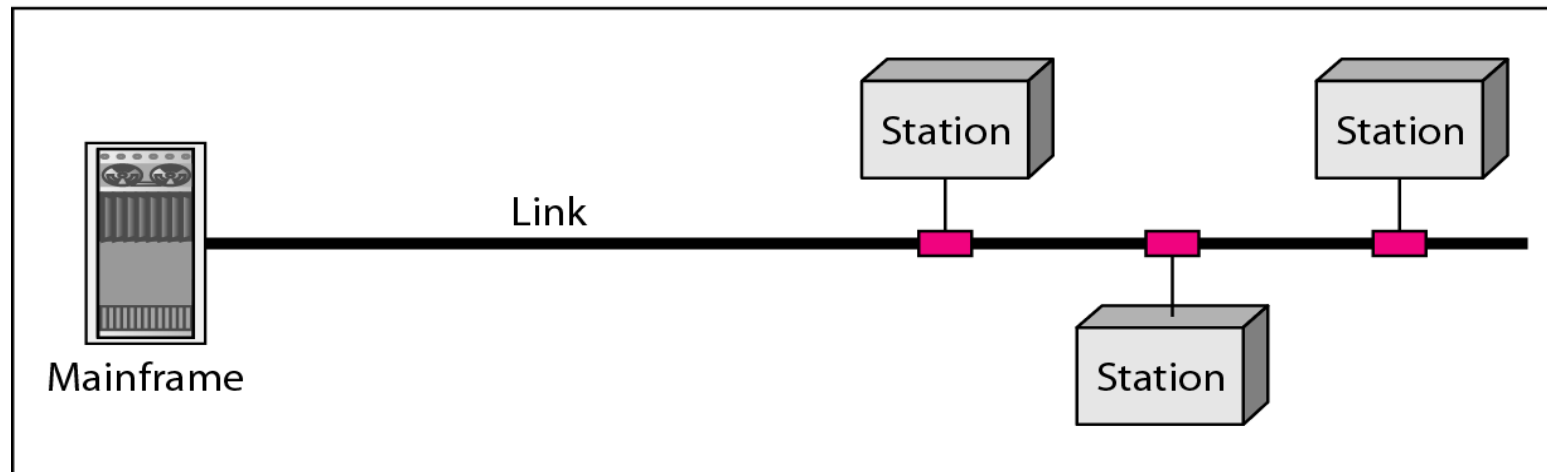- **is configuration in which more than two specific devices share a single link**

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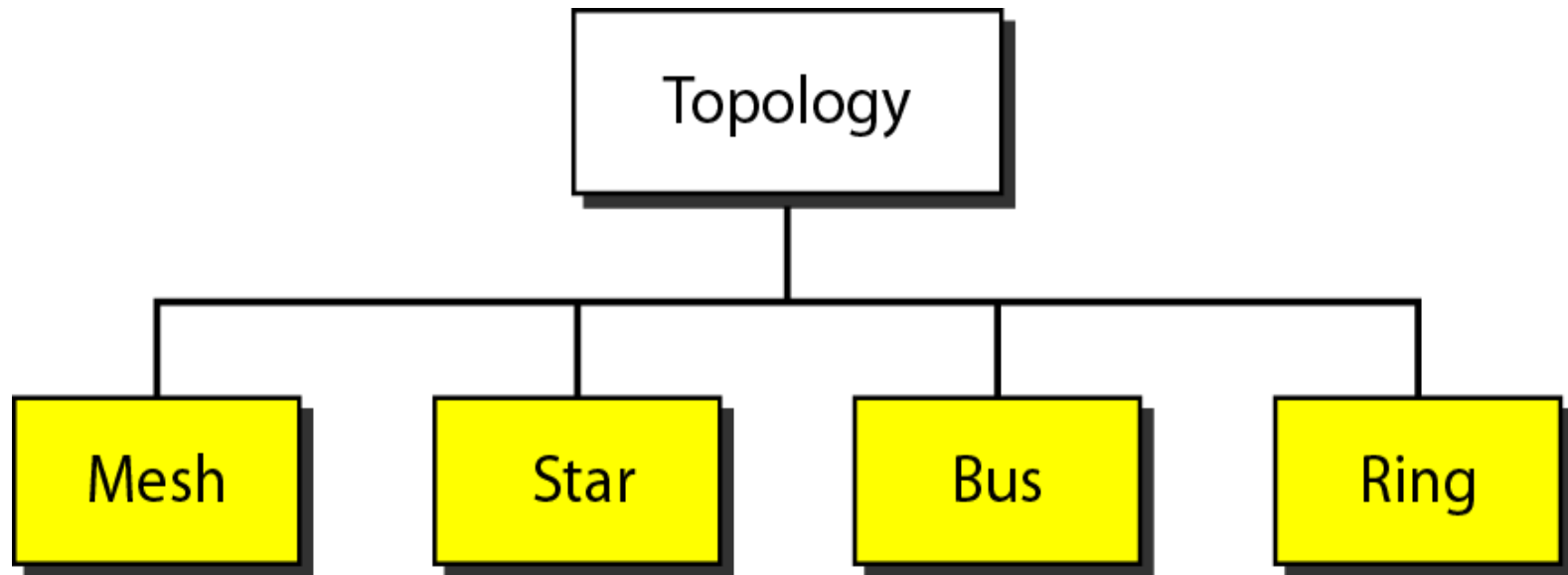

a. Point-to-point
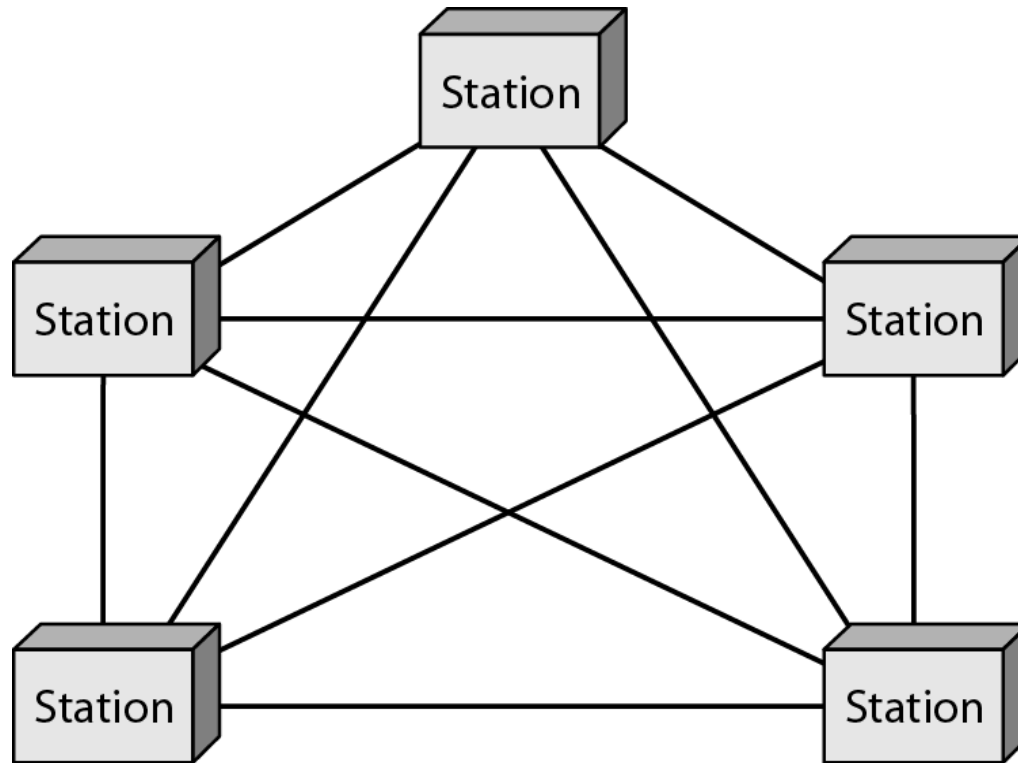
b. Multipoint

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.**   strong

- ◆ **Privacy and security.**

- ◆ **Point-to-point links make fault identification and fault isolation easy.**
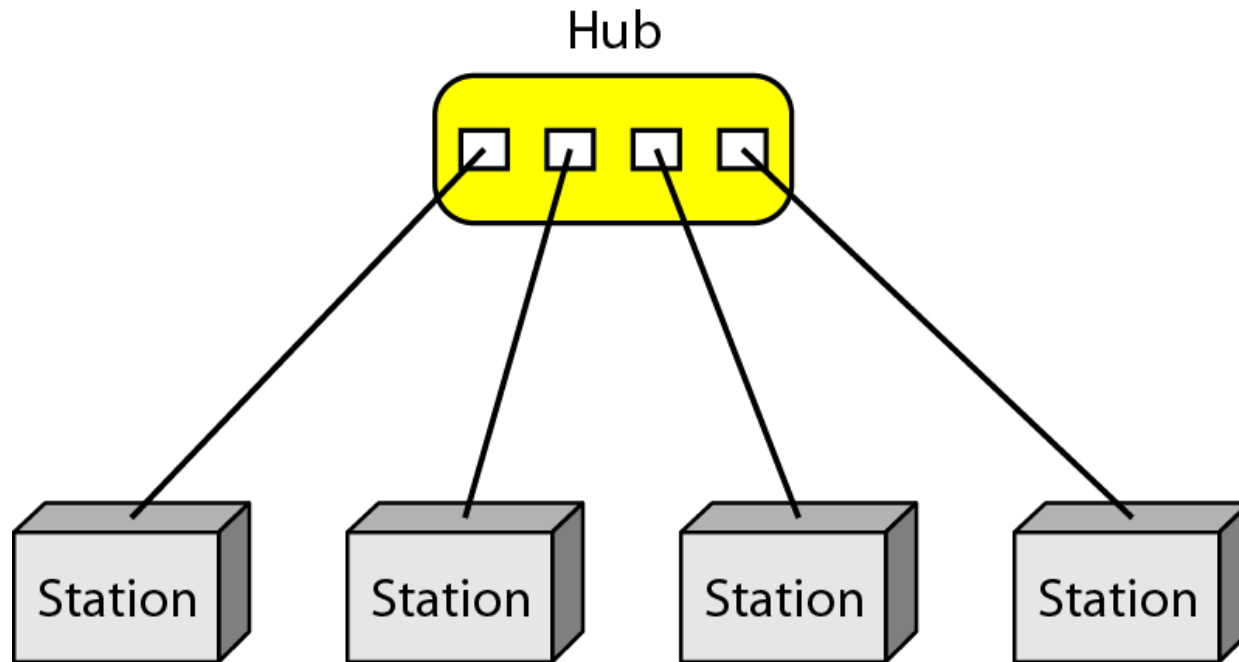
❑ Disadvantages

- ◆ **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**

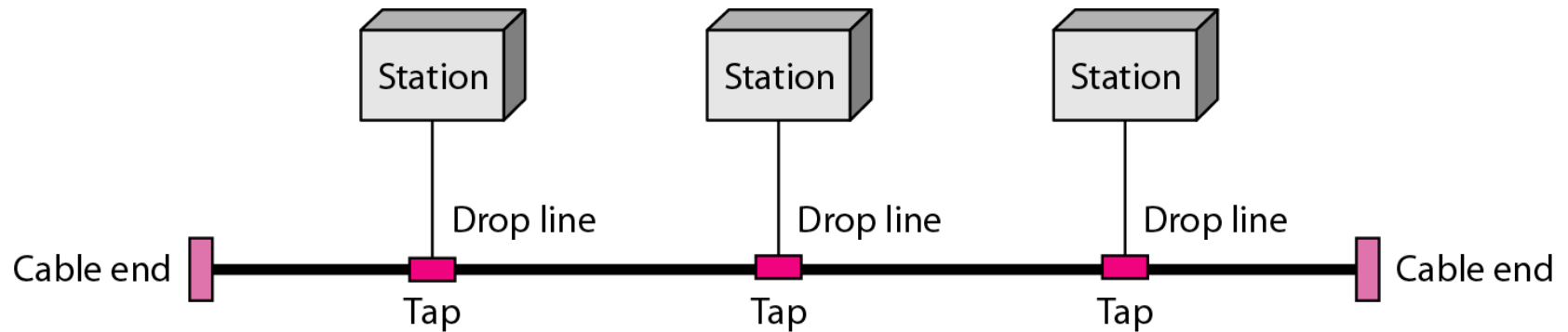❑ **Nodes are connected to the bus cable by drop lines and taps**

  ❖ **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**
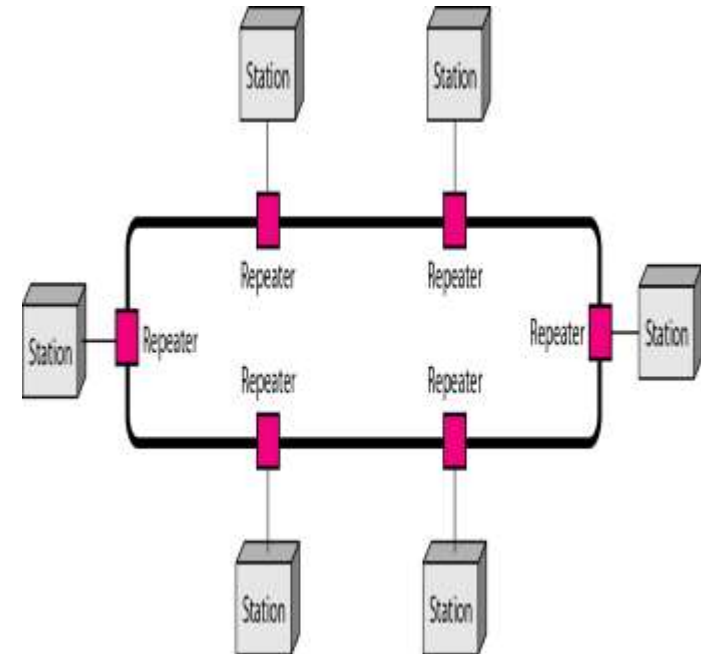
Ring Topology

❑ **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**
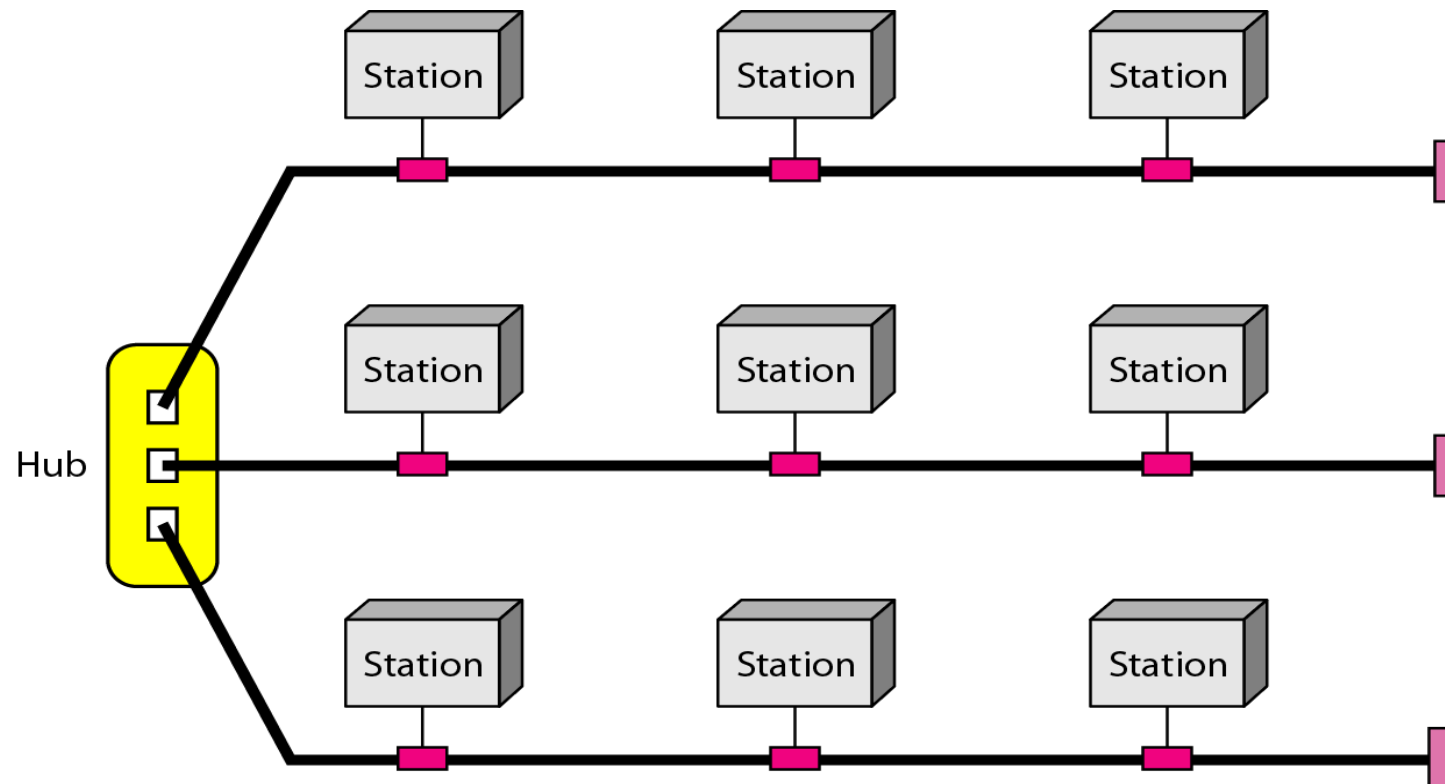
  ◆ **fault isolation is simplified**

❑ **Disadvantage**

  ❖ **unidirectional traffic**

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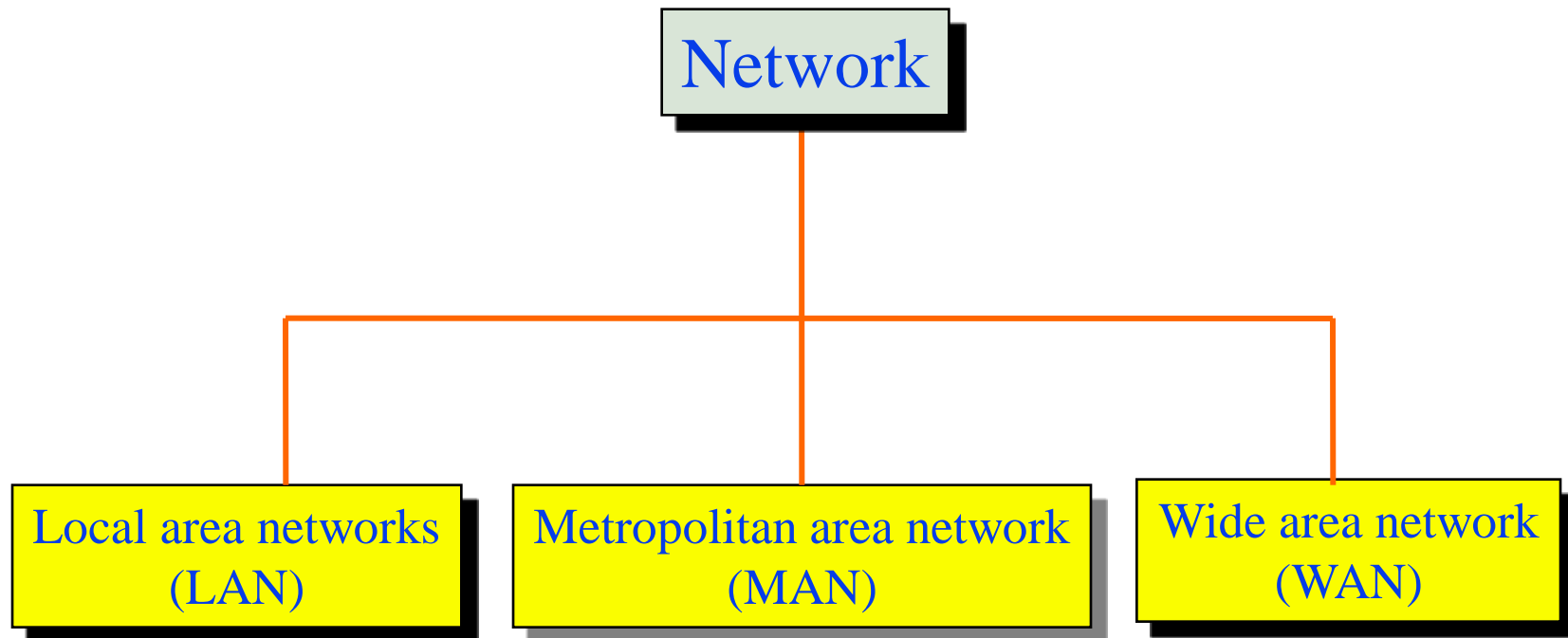
    --> needs dual ring

Hybrid Topology

❑ **A network can be hybrid.**

❑ **For example, a main star topology with each branch connecting several stations in a bus topology.**

❑ **Three primary categories**

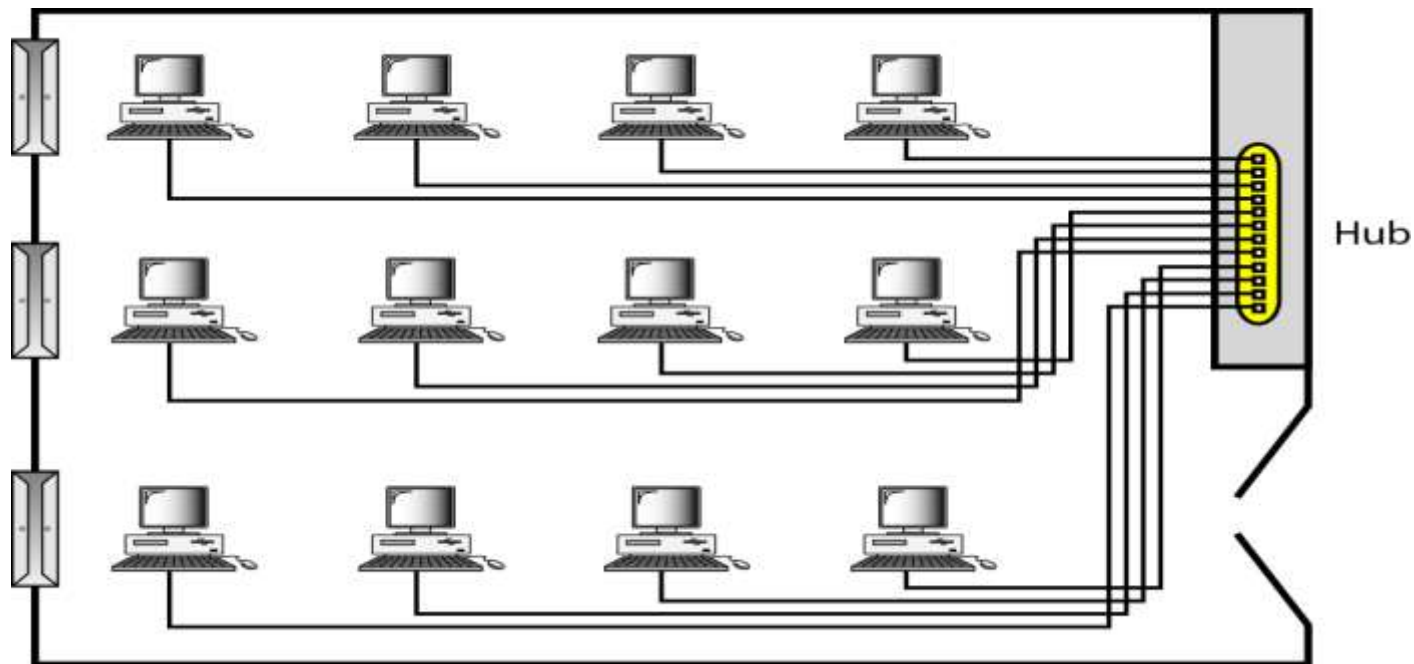❖ **size, ownership, distance it cover, physical architecture**

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                    ┌─────────────┐
                    │   Network   │
                    └──────┬──────┘
         ┌─────────────────┼─────────────────┐
┌────────────────┐ ┌────────────────────┐ ┌────────────────┐
│ Local area     │ │ Metropolitan area  │ │ Wide area      │
│ networks       │ │ network            │ │ network        │
│ (LAN)          │ │ (MAN)              │ │ (WAN)          │
└────────────────┘ └────────────────────┘ └────────────────┘
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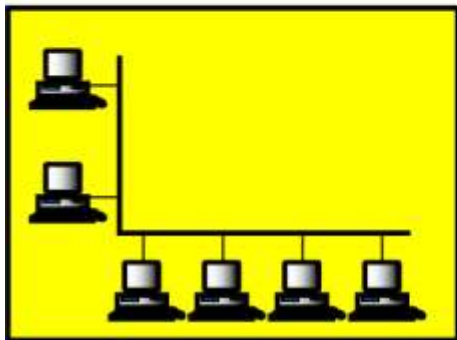
LAN (Local Area Networks)

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

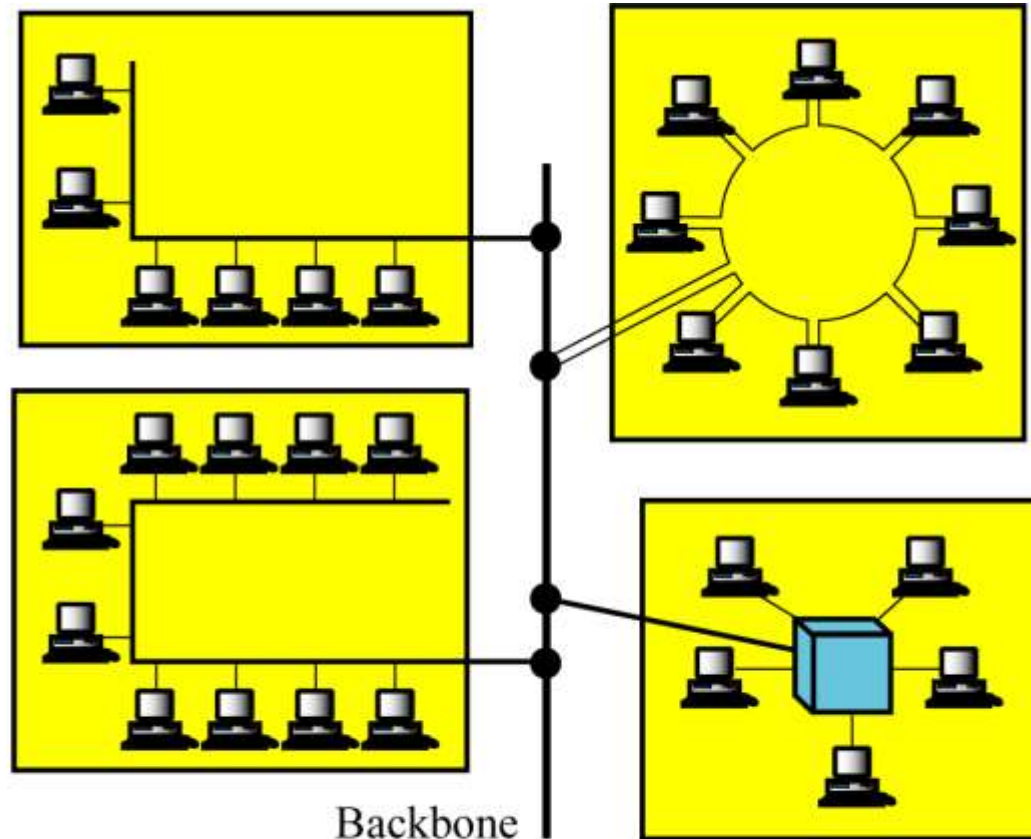**Figure 1.10** *An isolated LAN connecting 12 computers to a hub in a closet*

a. Single building LAN

Backbone

b. Multiple building LAN

❑ **MAN (Metropolitan Area Networks)**

◆ **is designed to extend over an entire city**

Public city network
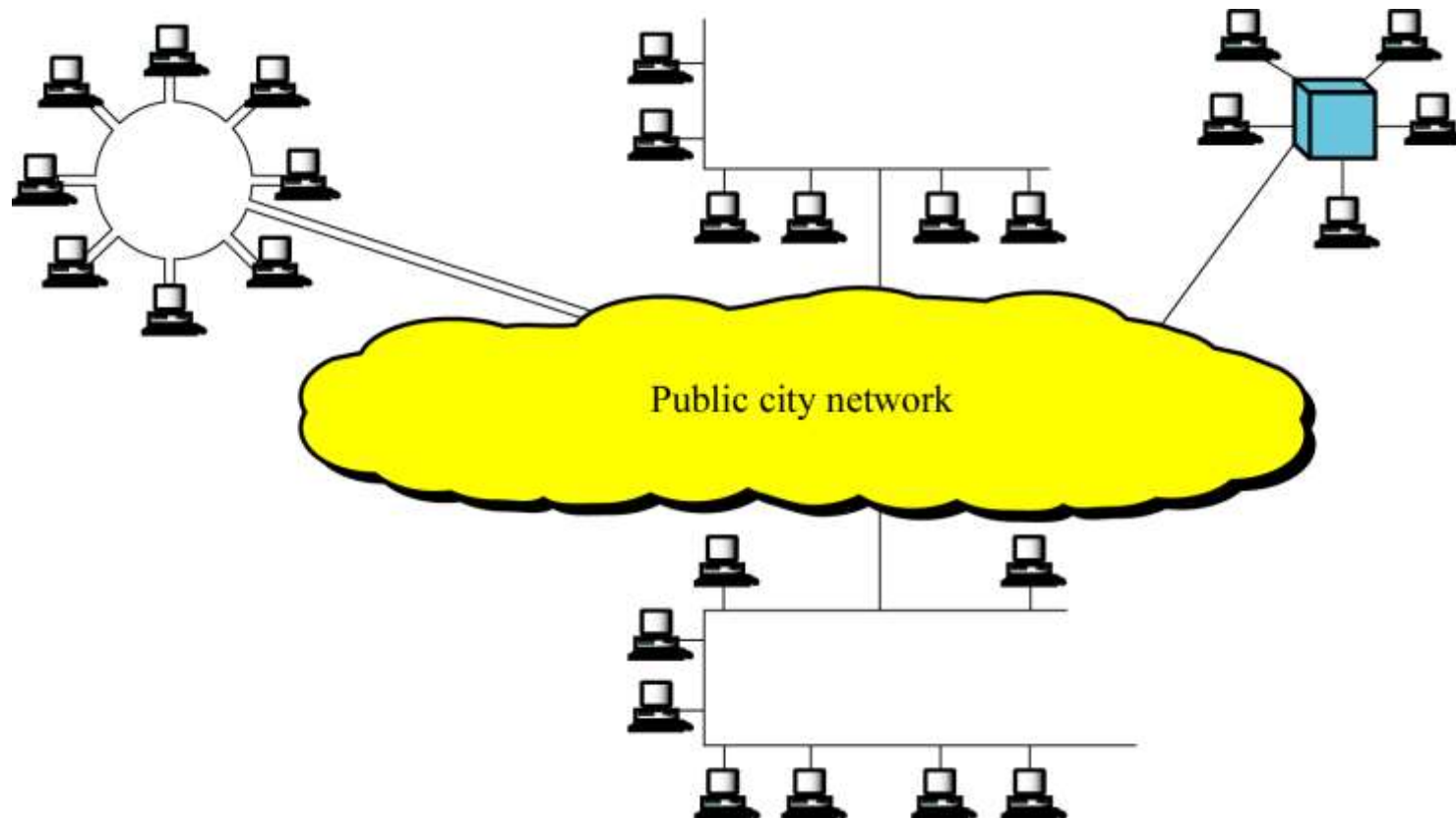
❑ **WAN(Wide Area networks)**

◆ **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**

Figure 1.11 *WANs: a switched WAN and a point-to-point WAN*
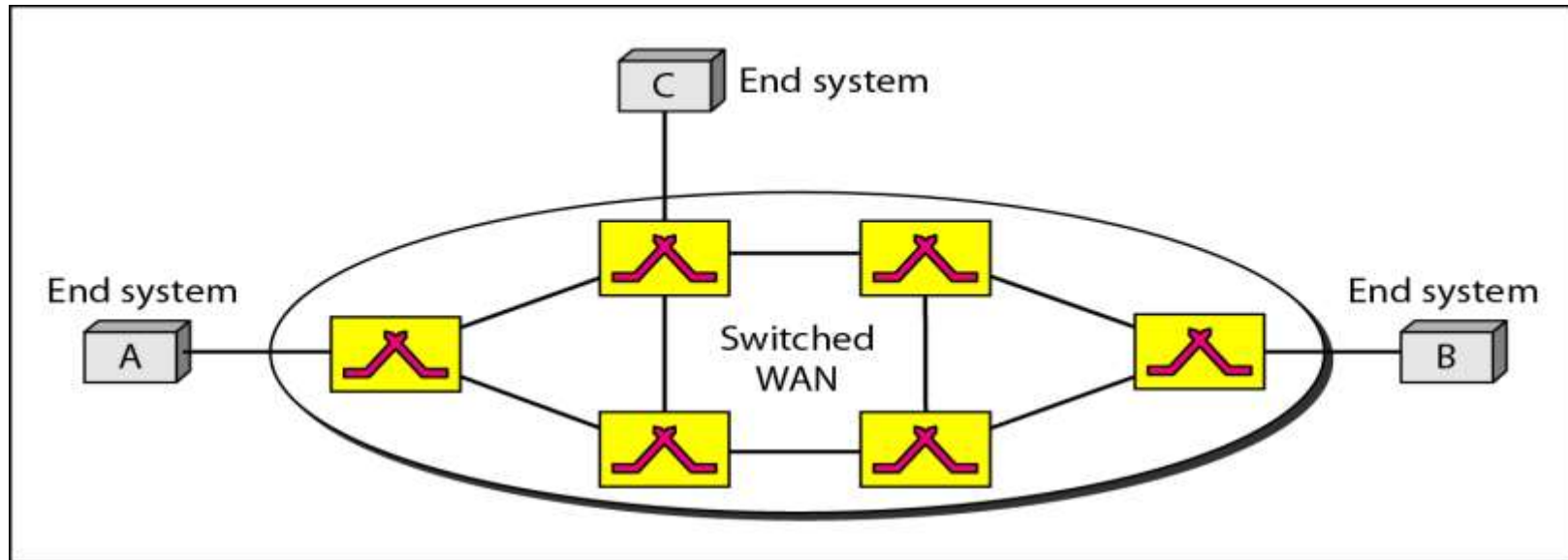
a. Switched WAN
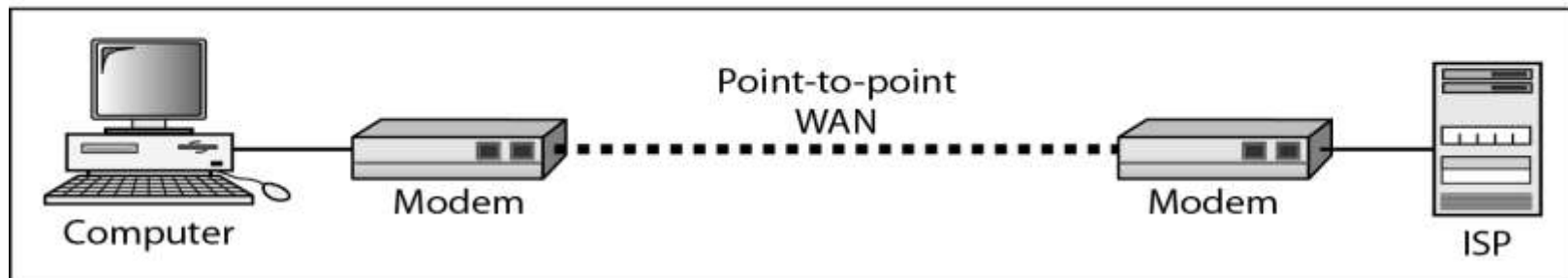
b. Point-to-point WAN

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*
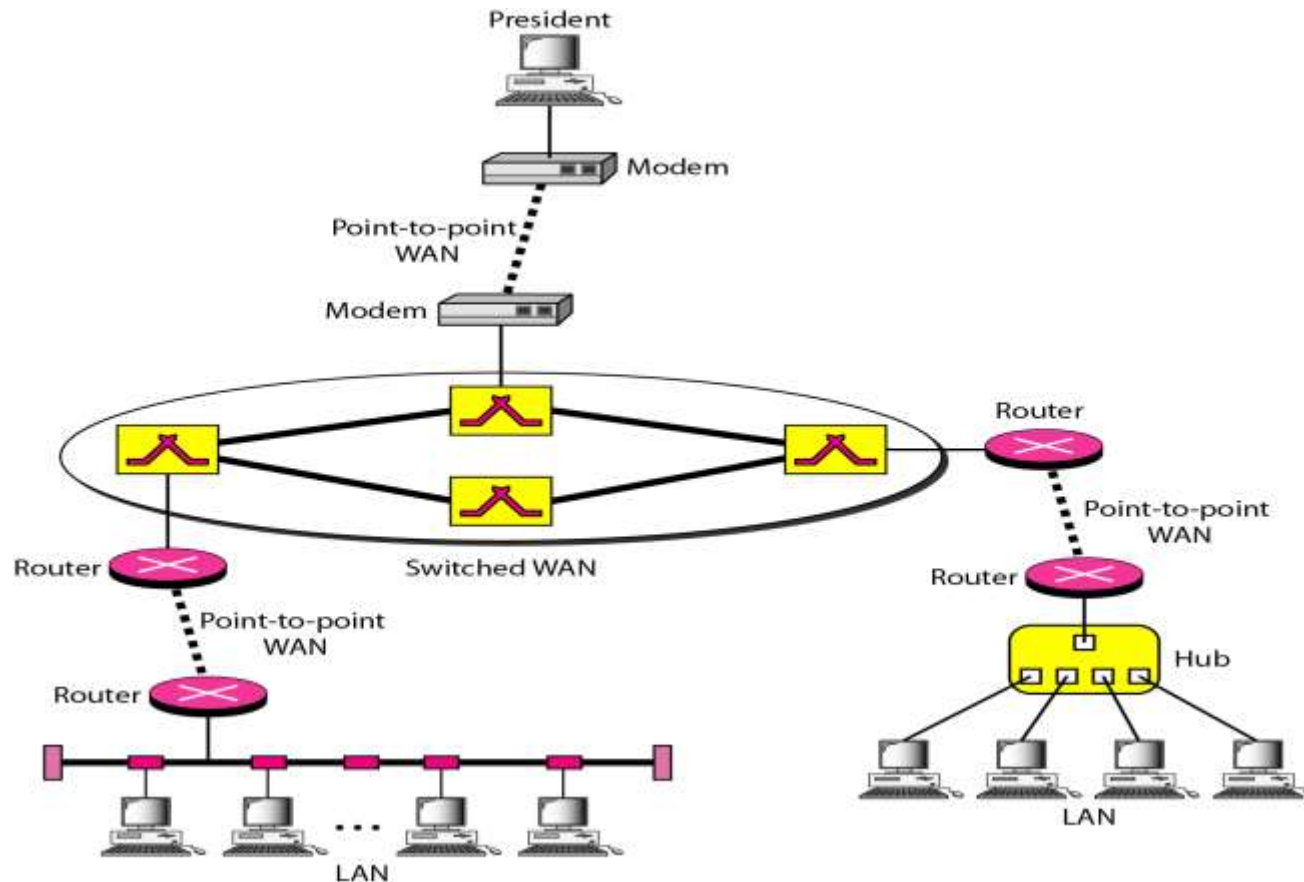
1.3   THE INTERNET

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)

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Internet

❑ **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, …**

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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

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Figure 1.13 *Hierarchical organization of the Internet*
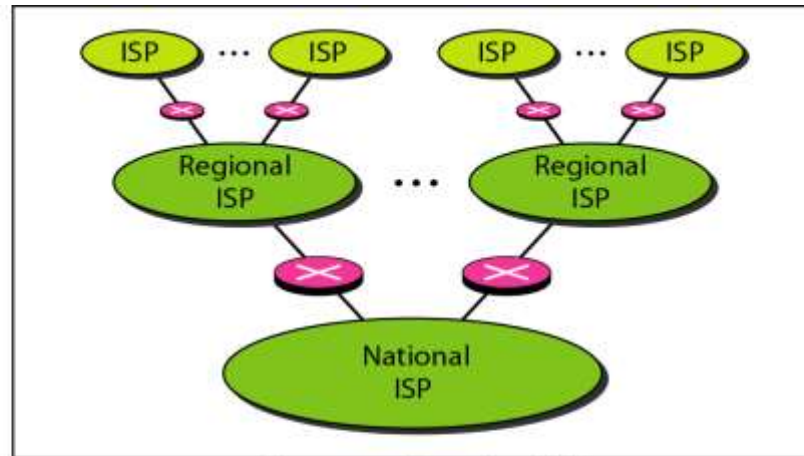
a. Structure of a national ISP
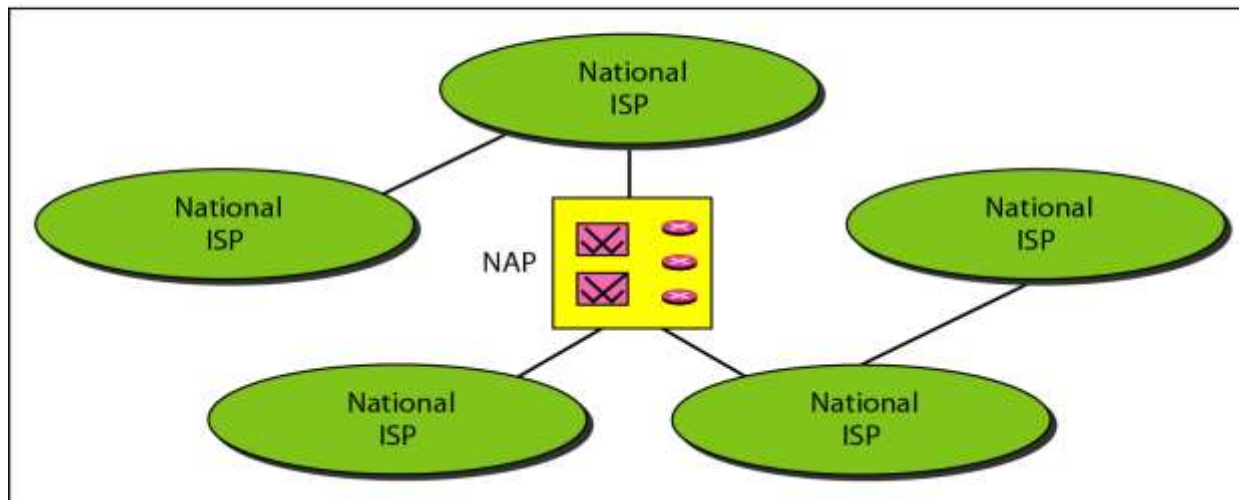
b. Interconnection of national ISPs

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

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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(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.**

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                    Standards
                        |
          ┌─────────────┴─────────────┐
     De facto                     De jure
     (by fact)                    (by law)
```
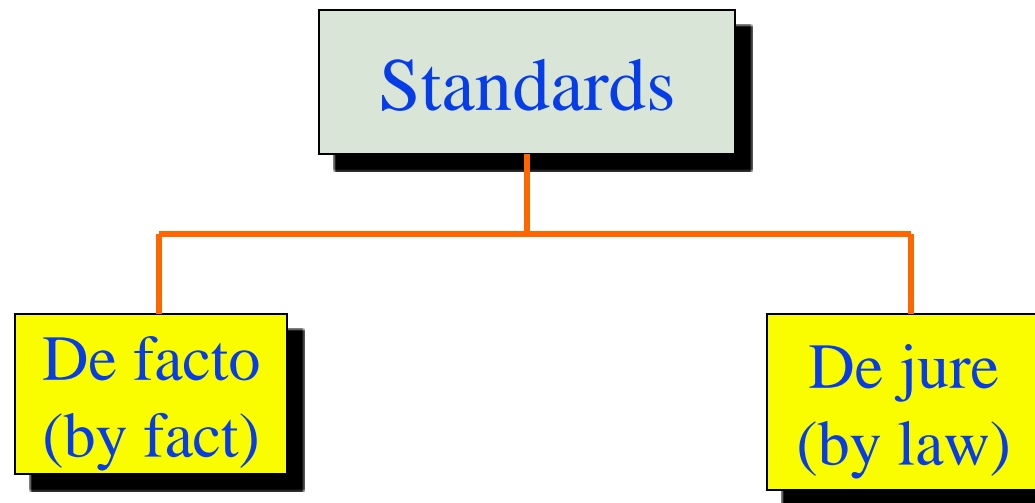
Standards Organizations (표준화 기구)

❑ **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)**

❖ **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)**

❑ **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