# Module-I

# Introduction

# Outline

- Data Communications
- Type of Connection
- Physical Topology
- Categories of Networks
- Protocols and Standards
- Layered Tasks
- OSI Model
- TCP/IP Protocol Suite
- TCP/IP Addressing

# 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 of a data communications system**
- **Data Flow**

- Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable.
- For data communications to occur, the communicating devices must be part of a communication system made up of a combination of hardware (physical equipment) and software (programs).
- The effectiveness of a data communications system depends on four fundamental characteristics:

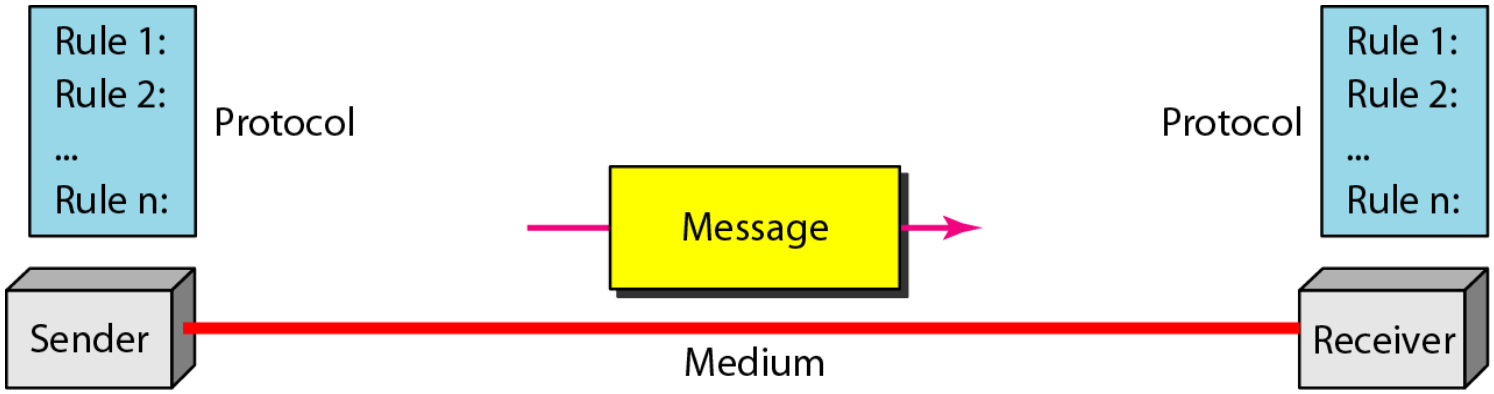
❖ Delivery

❖ Accuracy

❖ Timeliness

❖ Jitter

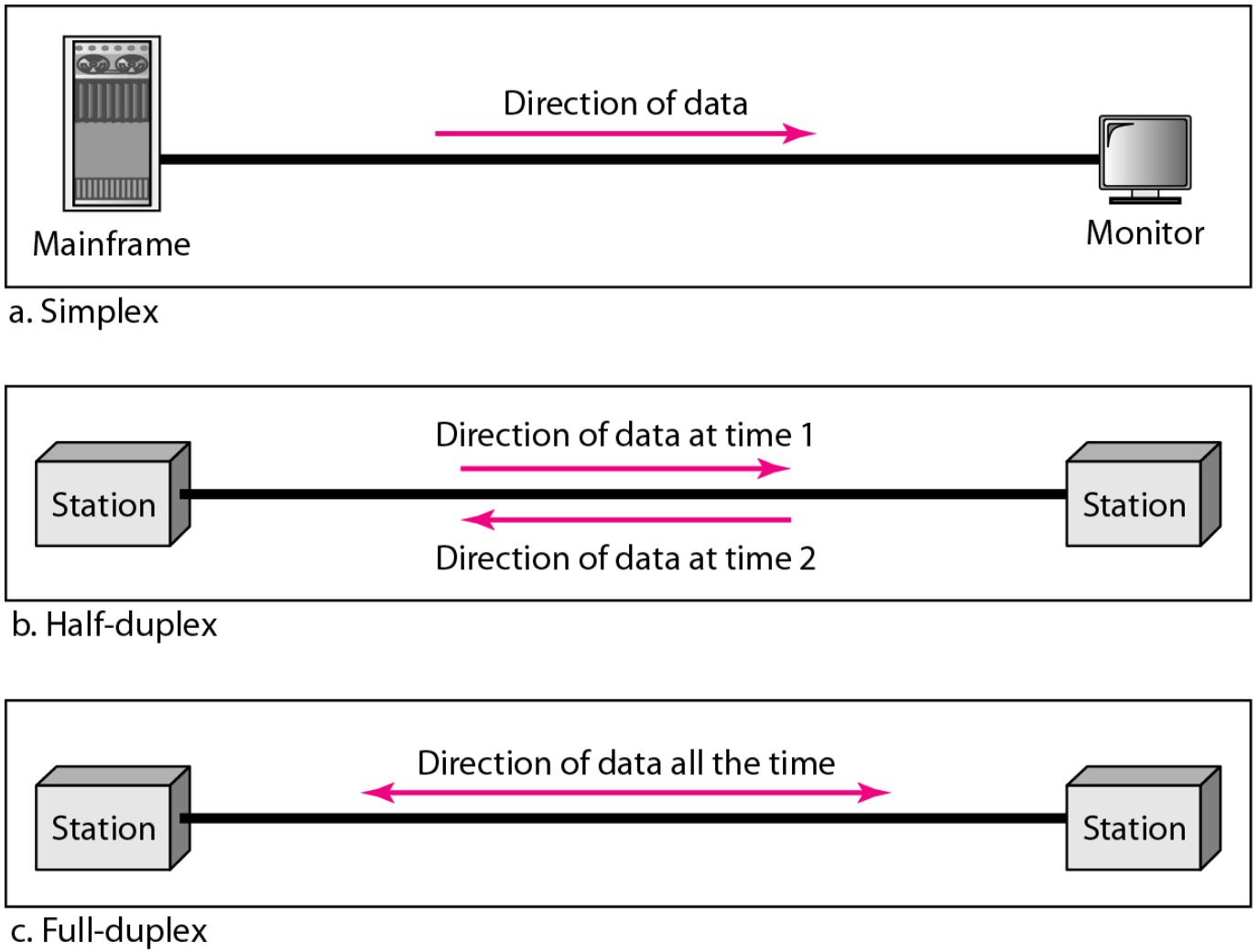
## Figure 1.1 *Components of a data communication system*




**Data Representation:**

- Text
- Numbers
- Images
- Audio
- Video

## 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. A link can be a cable, air, optical fiber, or any medium which can transport a signal carrying information.***

***Topics discussed in this section:***

- **Network Criteria**
- **Physical Structures**
- **Categories of Networks**

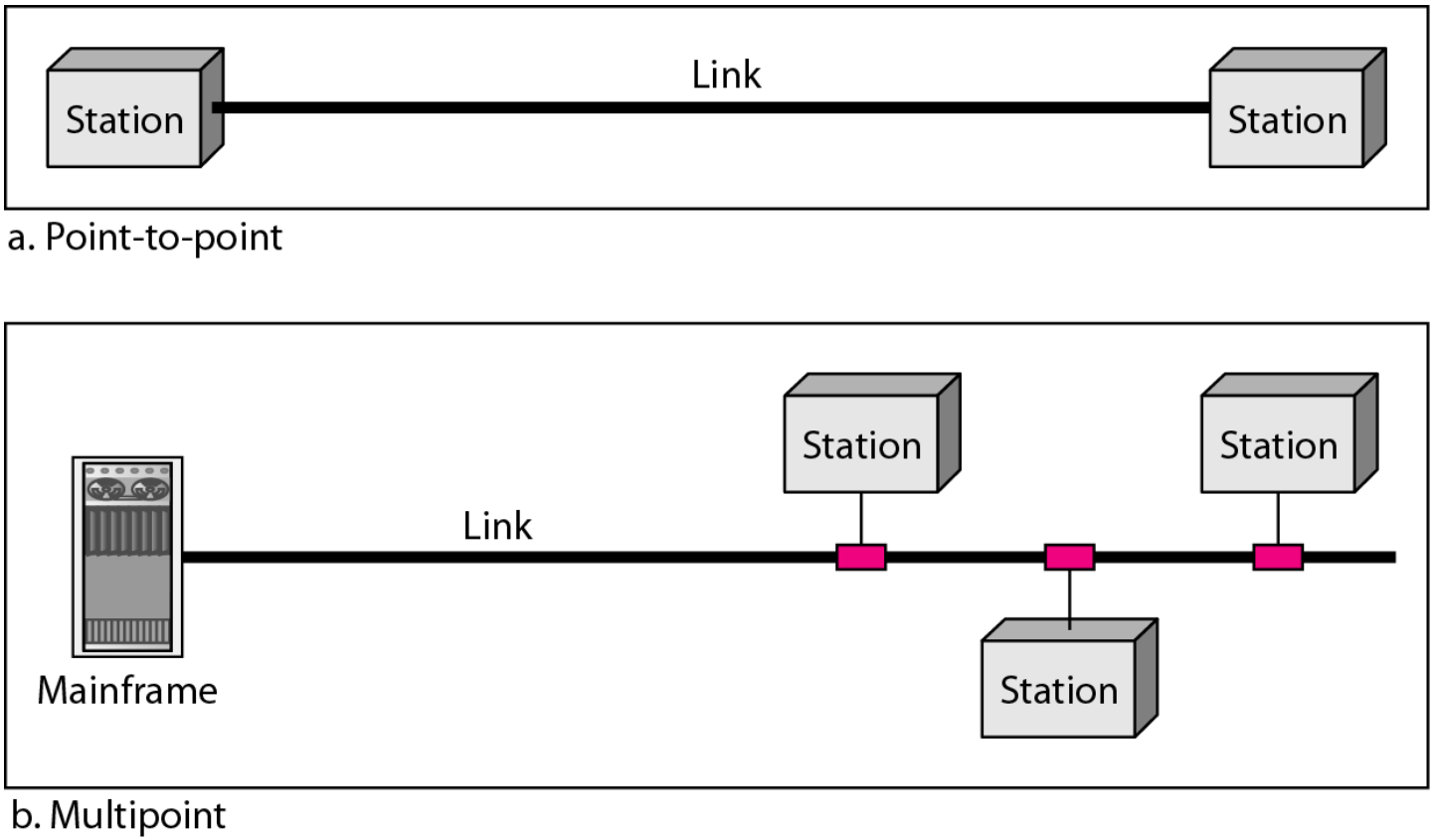
# Network Criteria

- **Performance :** Performance can be measured in many ways, including transit time and response time
  - **Depends on Network Elements: the number of users, the type of transmission medium, the capabilities of the connected hardware, and the efficiency of the software.**
  - **Measured in terms of Delay and Throughput**
- **Reliability : accuracy of delivery, network reliability is measured by the frequency of failure, the time it takes a link to recover from a failure, and the network's robustness in a catastrophe.**
  - **Failure rate of network components**
  - **Measured in terms of availability/robustness**
- **Security: protecting data from unauthorized access, protecting data from damage and development, and implementing policies and procedures for recovery from breaches and data losses.**
  - **Data protection against corruption/loss of data due to:**
    - **Errors**
    - **Malicious users**

# ☐Physical Structures

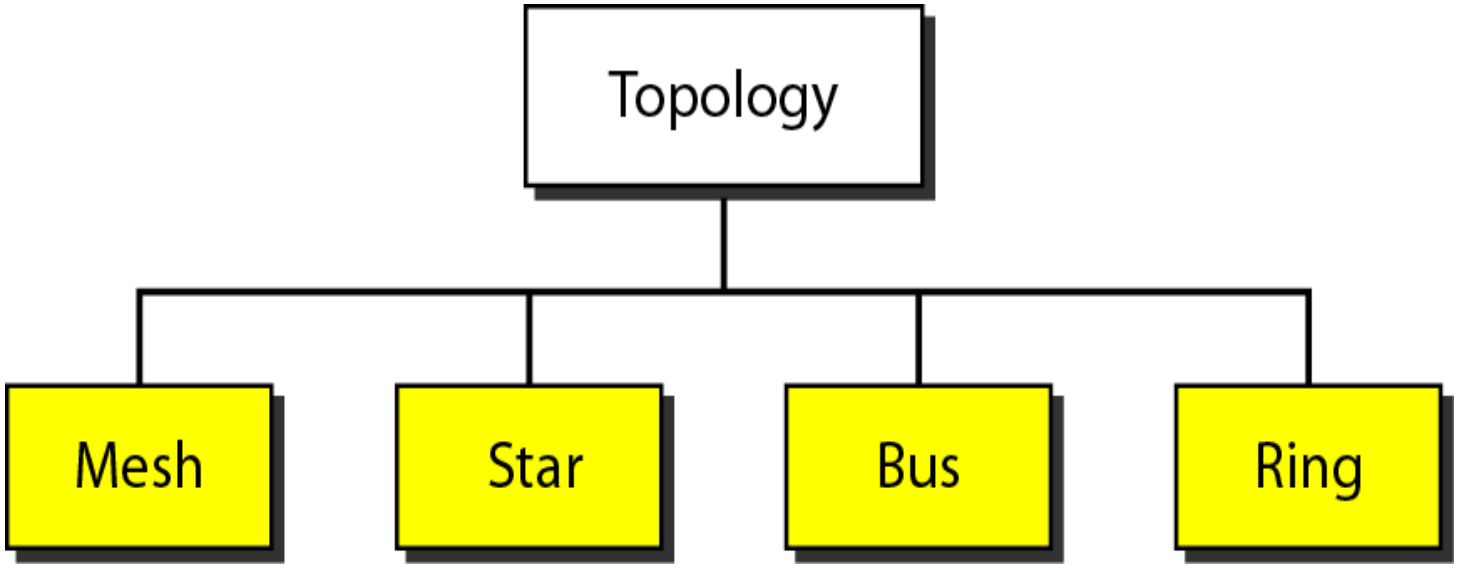
- **Type of Connection**
  - **Point to Point - single transmitter and receiver :** microwave or satellite links
  - **Multipoint - multiple recipients of single transmission**
- **Physical Topology**
  - **Connection of devices**
  - **Type of transmission - unicast, mulitcast, broadcast**

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

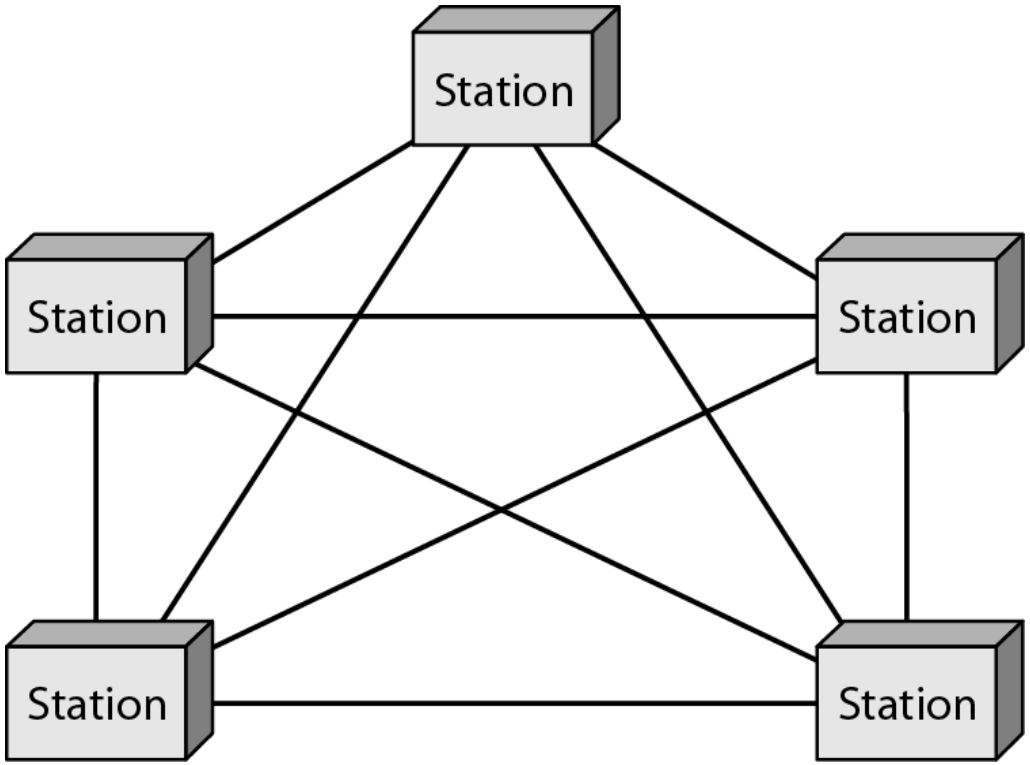


## Figure 1.4 *Categories of topology*

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.



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




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

## Advantage:

- 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.
- Robust. If one link becomes unusable, it does not incapacitate the entire system.
- 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.

**Disadvantages**: 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.

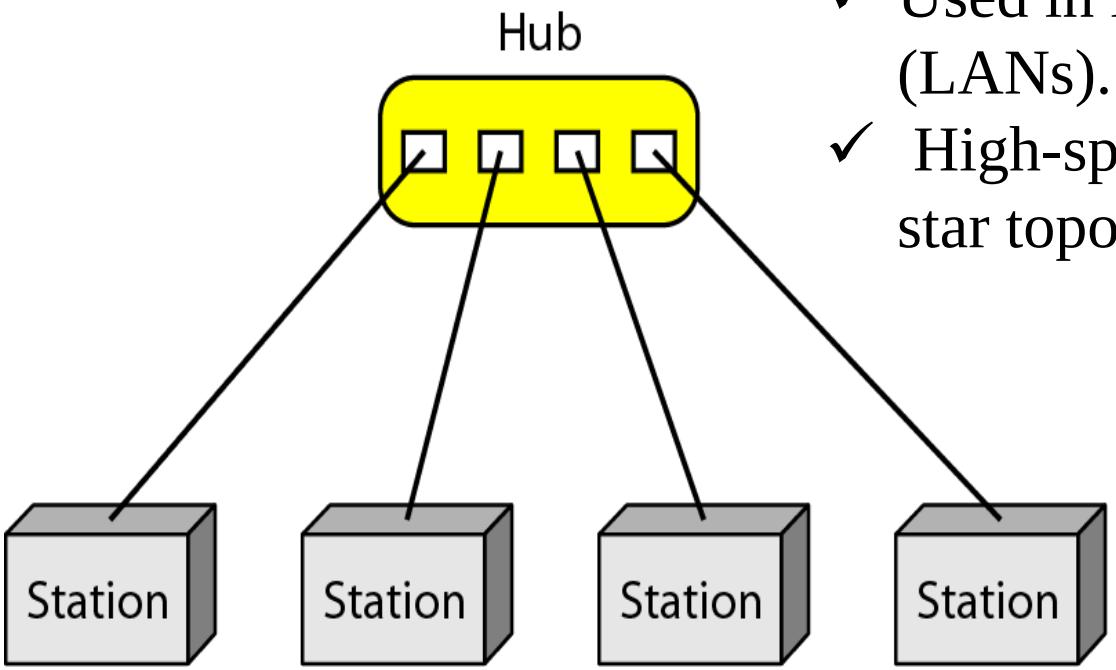
- Second, the sheer bulk of the wiring can be greater than the available space (in walls, ceilings, or floors) can accommodate.

- 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.

## Figure 1.6 *A star topology connecting four stations*

In a star topology, each device has a dedicated point-to-point link only to a central controller, usually called a hub. The devices are not directly linked to one another




- ✓ Used in local-area networks (LANs).
- ✓ High-speed LANs often use a star topology with a central hub.

- 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.

- 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.

**Advantages:** Robustness

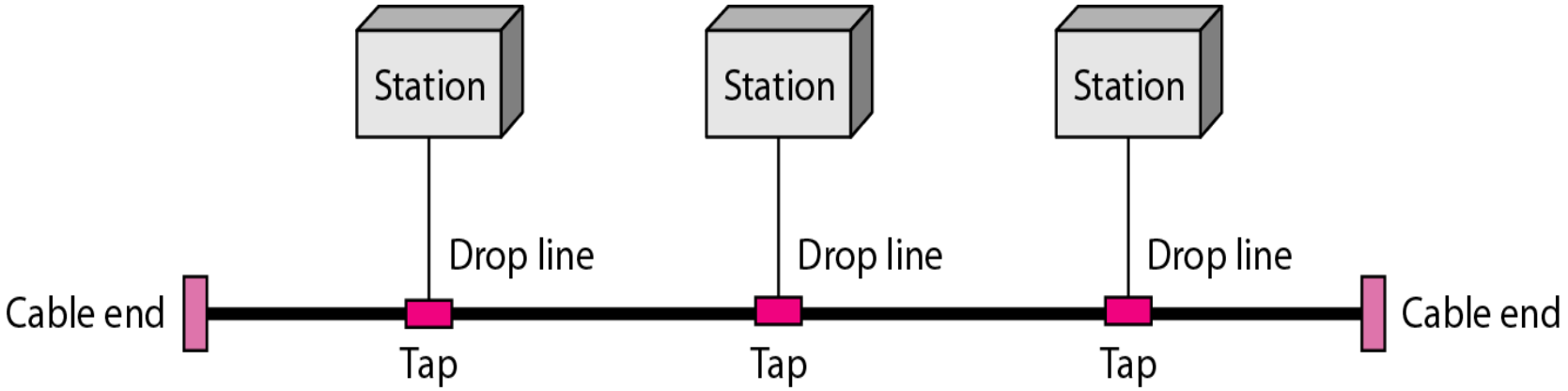
- If one link fails, only that link is affected.
- All other links remain active. This factor also lends itself to easy fault identification and fault isolation.
- As long as the hub is working, it can be used to monitor link problems and bypass defective link**s.**

**Disadvantage:** Dependency

- ✓ 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).

## Figure 1.7 *A bus topology connecting three stations*

- ✓ point-to-point connection
- ✓ Multipoint connection
- ✓ One long cable acts as a backbone to link all the devices in a network




- ✓ Local area networks.
- ✓ Ethernet LANs

- 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.

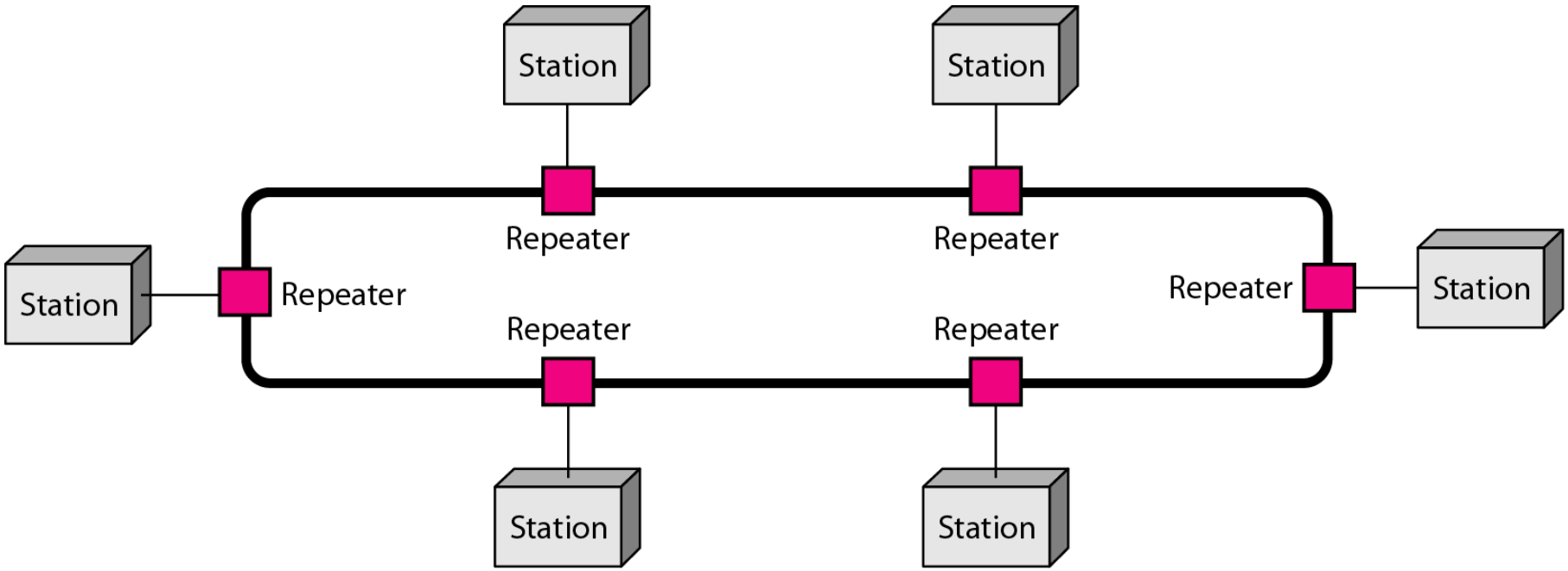
## **Advantages:** Easy Installation

- 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:** 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.
- 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.

## Figure 1.8 *A ring topology connecting six stations*



## *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.

**Advantages:** Easy to install and reconfigure.

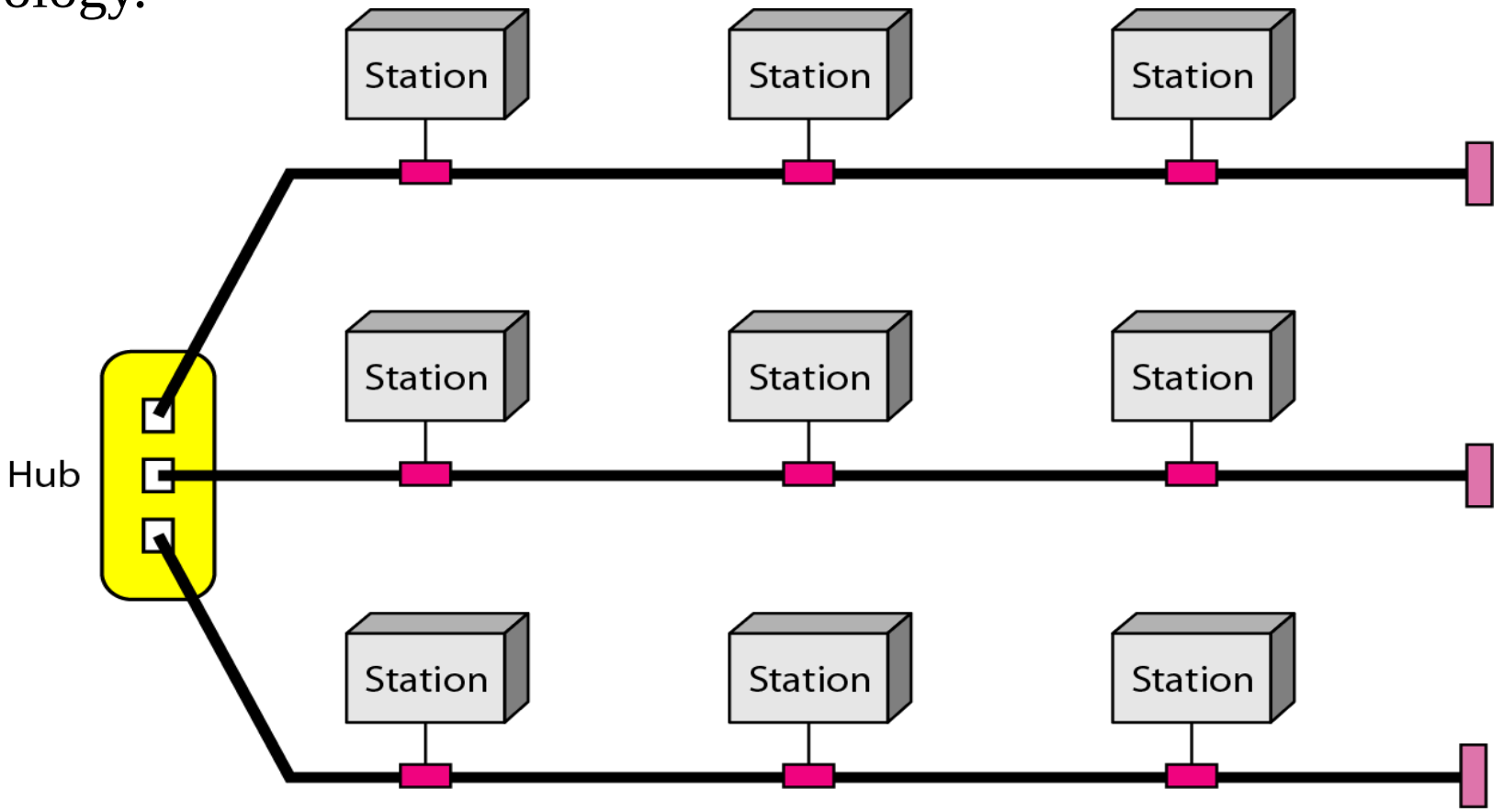
- ✓ Each device is linked to only its immediate neighbors (either physically or logically).
- ✓ To add or delete a device requires changing only two connections.
- ✓ The only constraints are media and traffic considerations (maximum ring length and number of devices). In addition, fault isolation is simplified.
- ✓ Generally in a ring, a signal is circulating at all times.
- ✓ If one device does not receive a signal within a specified period, it can issue an alarm.
- ✓ The alarm alerts the network operator to the problem and its location

**Disadvantages:** Unidirectional traffic

- ✓ 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

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

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



# Categories of Networks

- Local Area Networks (LANs)
  - Short distances-Covers area < 2miles
  - Designed to provide local interconnectivity
- Wide Area Networks (WANs)
  - Long distances-Can be worldwide
  - Provide connectivity over large areas
- Metropolitan Area Networks (MANs)
  - Provide connectivity over areas such as a city, a campus
  - Between LAN & WAN, span 10s of miles

# Local Area Networks (LANs)

- 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.
- 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.

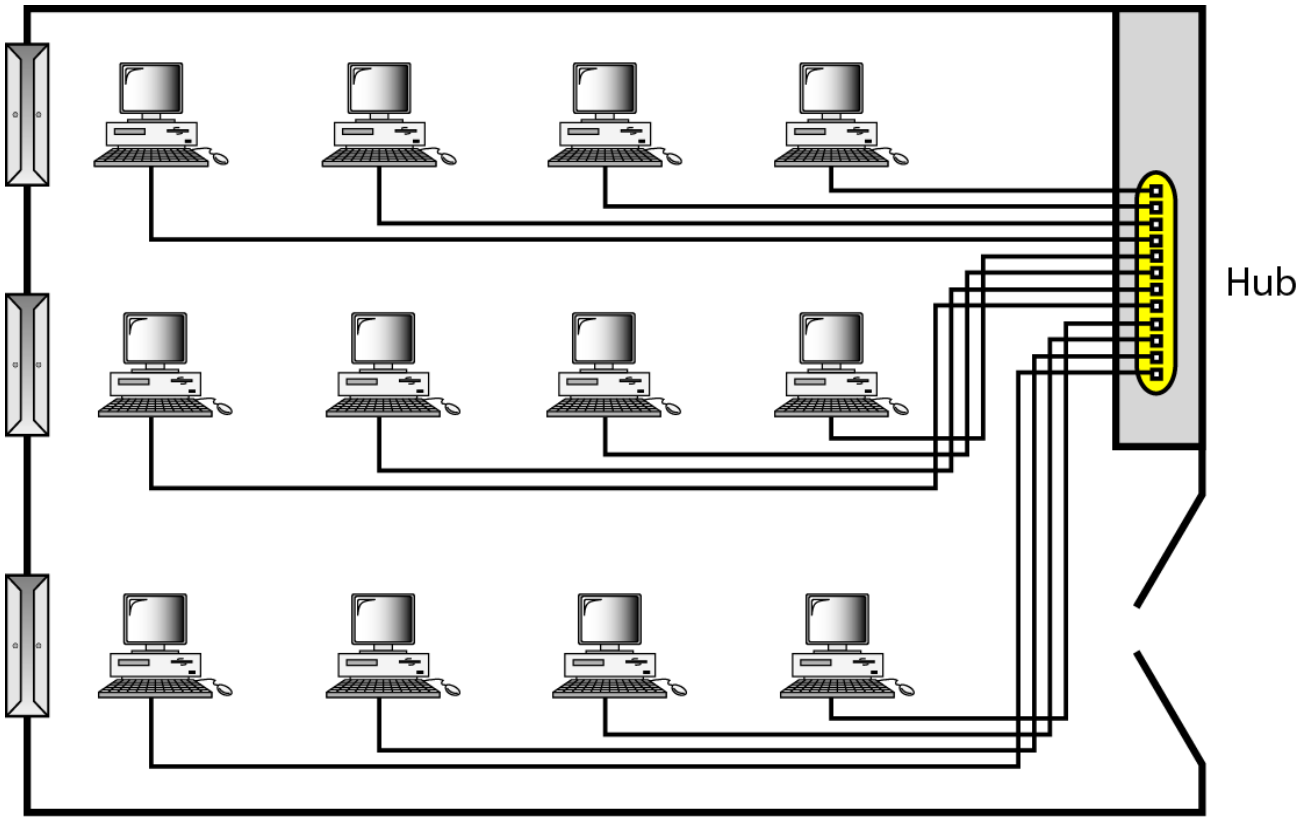
# Local Area Networks (LANs)

- A common example of a LAN, found in many business environments, links a workgroup of task-related computers, for example, engineering workstations or accounting PCs.
- One of the computers may be given a large capacity disk drive and may become a server to clients.
- Software can be stored on this central server and used as needed by the whole group.
- In this example, the size of the LAN may be determined by licensing restrictions on the number of users per copy of software, or by restrictions on the number of users licensed to access the operating system.

# Local Area Networks (LANs)

- 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.

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



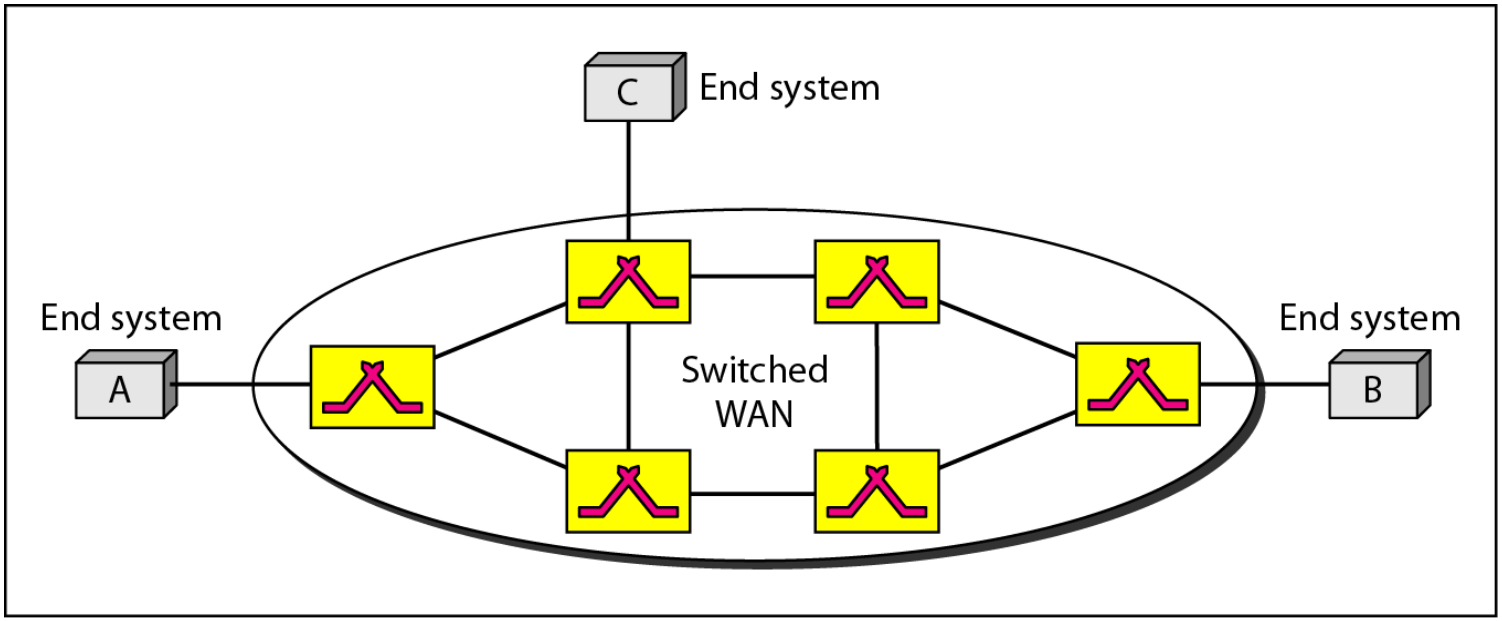
# Wide Area Networks (WANs)

- 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.

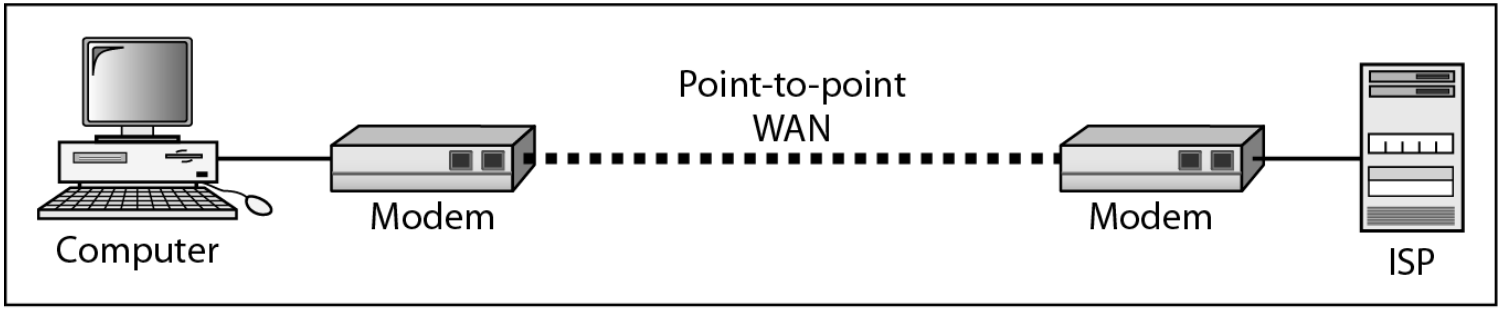
# Wide Area Networks (WANs)

- 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 (lSP). This type of WAN is often used to provide Internet access.
- An early example of a switched WAN is X.25, a network designed to provide connectivity between end users.
- X.25 is being gradually replaced by a high-speed, more efficient network called Frame Relay.
- A good example of a switched WAN is the asynchronous transfer mode (ATM) network, which is a network with fixed-size data unit packets called cells.
- Another example of WANs is the wireless WAN that is becoming more and more popular.

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




a. Switched WAN




b. Point-to-point WAN

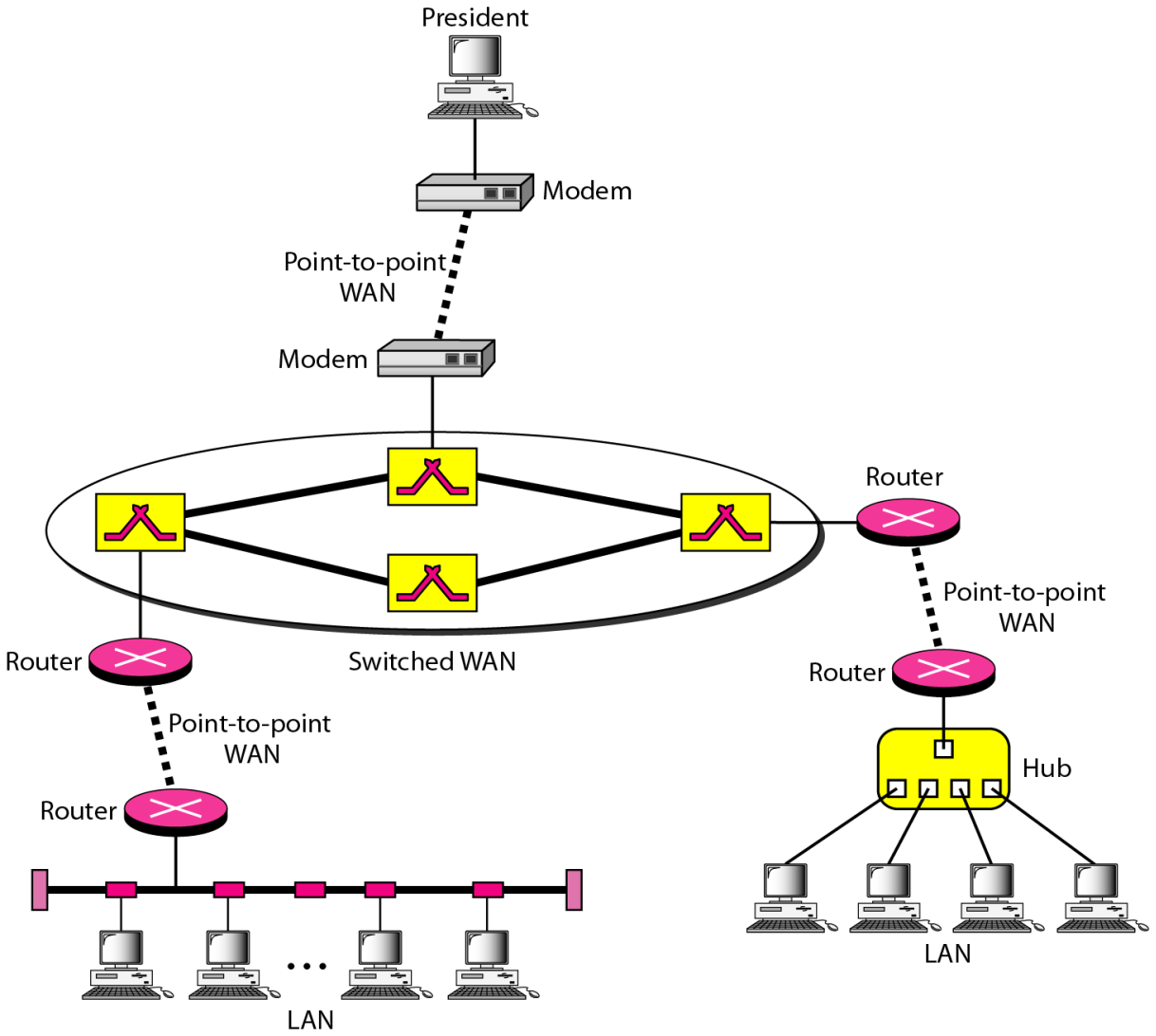
# Metropolitan Area Networks (MANs)

- 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.

Example: The telephone company network that can provide a high-speed DSL line to the customer.

Another example: 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

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



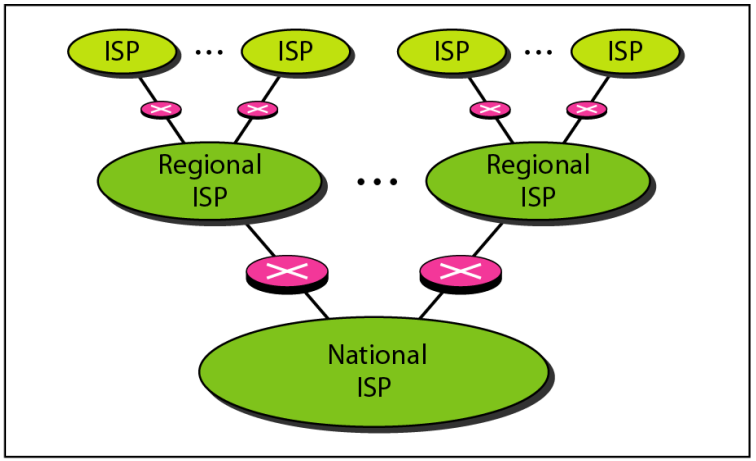
# 1-3 THE INTERNET

***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.***

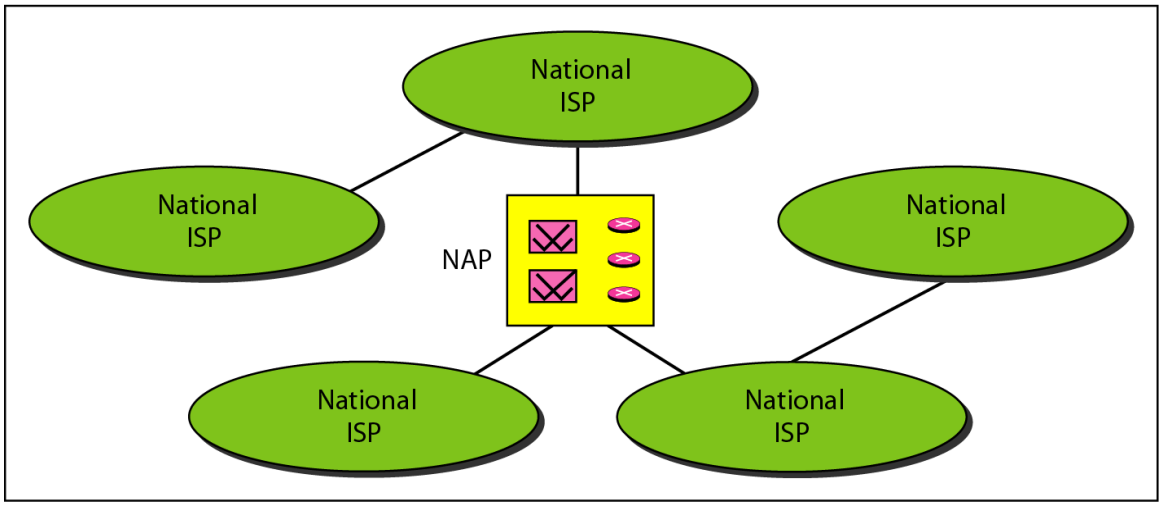
***Topics discussed in this section:***

**Organization of the Internet**
**Internet Service Providers (ISPs)**

# Figure 1.13 *Hierarchical organization of the Internet*




a. Structure of a national ISP




b. Interconnection of national ISPs

# 1-4 PROTOCOLS

***A protocol is synonymous with rule. It consists of a set of rules that govern data communications. It determines what is communicated, how it is communicated and when it is communicated. The key elements of a protocol are syntax, semantics and timing***

***Topics discussed in this section:***

- **Syntax**
- **Semantics**
- **Timing**

# ❑Elements of a Protocol

- **Syntax**
  - **Structure or format of the data**
  - **Indicates how to read the bits - field delineation**
  - Example: 8-bits address of sender, 8-bits address of receiver
- **Semantics**
  - **Interprets the meaning of the bits**
  - **Knows which fields define what action**
  - Example: Does the address is a route to be taken or the final destination of the message
- **Timing**
  - **When data should be sent and what**
  - **Speed at which data should be sent or speed at which it is being received.**
  - Example: sender produces data at 100 Mbps but the receiver can process data at only 1 Mbps ⇒ overload and data loose

# Standards

- Essential in creating and maintaining an open and competitive market for equipment manufactures.
- Guaranteeing national and international interoperability of data and telecommunication technology and processes.
- Providing guidelines to manufacturers, vendors, government agencies, and other service providers to ensure the kind of interconnectivity necessary in today's marketplace and in international communications

# Standards

- Two categories
  - De facto: not approved by an organized body but adopted as standards through widespread use
  - De jure: Legislated by an officially recognized body

# Standards

- Standards are developed through the cooperation of:
  - Standards Creation Committees
    - ISO, ITU-T, CCITT, ANSI, IEEE, EIA
  - Forums
    - Created by special-interest groups
    - Present their conclusions to the standards bodies
  - Regulatory Agencies
    - Ministry of Telecommunication and Information Technology (KSA)
    - Purpose: Protecting the public by regulating radio, television, and communication

# Standards

- Internet standards
  - Tested thoroughly tested specification that is useful to be adhered to by those who work with the Internet
  - Formalized regulation that must be followed
  - Specification become Internet standard
    - Begins as Internet draft for 6 months
    - Upon recommendation from the Internet authorities draft published as Request for Comment (RFC)
    - RFC is edited, assigned a number, and made available to all interested parties