

Module 1

Introduction to networking

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Slide Source: B. A. Forauzan, Data Communications and Networking, McGraw-Hill
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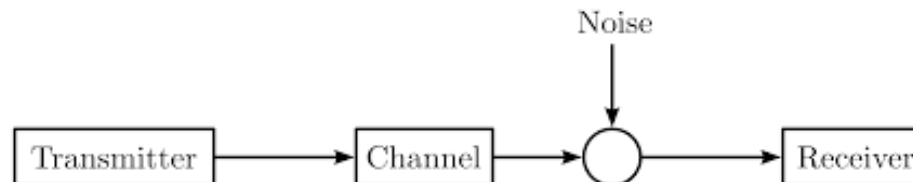
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Syllabus Contents

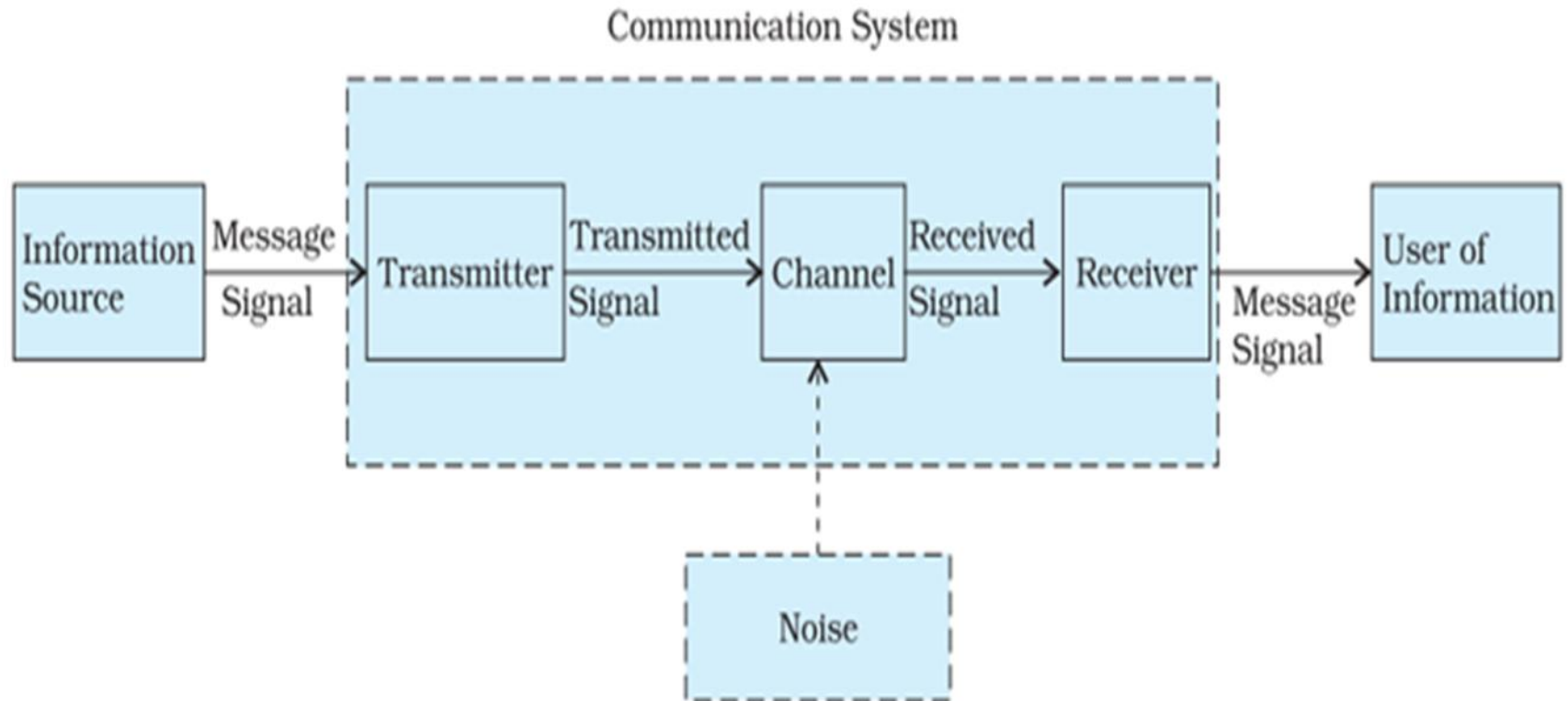
1. Data Communication basics
2. Types of Networks: LAN, WAN, MAN; Network Topology (types)
3. Network Software: Protocol hierarchy, Design Issues for layers, Connection oriented and connectionless services, Reliable and Un-reliable services
4. OSI and TCP/IP reference model, Comparison of OSI and TCP/IP reference model
5. Overview of connecting devices- NIC, Repeater, Hub, Switch, Router, Gateway
6. Self learning: Guided and unguided transmission

Communication

- Exchange of ideas/ information
 - Verbal and non-verbal
- Long distance communication historical form-
Smoke/fire, Sound (drum beats), Pigeons, Mail etc.
- Electronic Communication- Transfer of information from one place to other through electronic signal
- Types: Wired/ Wireless
- Components of Communication System
 - Sender, Receiver, Message, Channel; (noise)



Electronic Communication System



1-1 DATA COMMUNICATIONS

- Telecommunication means communication over a distance
- **Data** refers to information presented in whatever form
- *Data communication* refers to exchange of data between two devices via some form of transmission medium such as a wire cable, fiber or radio signal

Topics discussed in this section:

Components

Data Representation

Data Flow

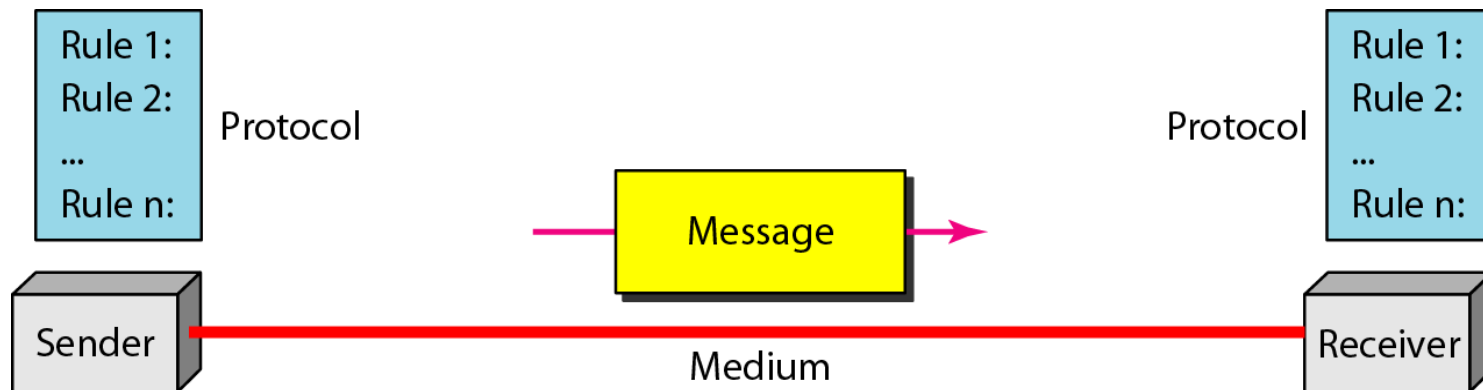
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Data Representation

- Different forms of Information/Data
 - Text- Unicode (32 bits), ASCII
 - Numbers- numbering systems
 - Images- pixels; B/W, gray scale, colour (RGB etc)
 - Audio- sound / music; continuous not discrete
 - Video- continuous or discrete
 - ...

Data Communication System *Five components of data communication system*

- Sender, Receiver, Medium, Message and Protocol

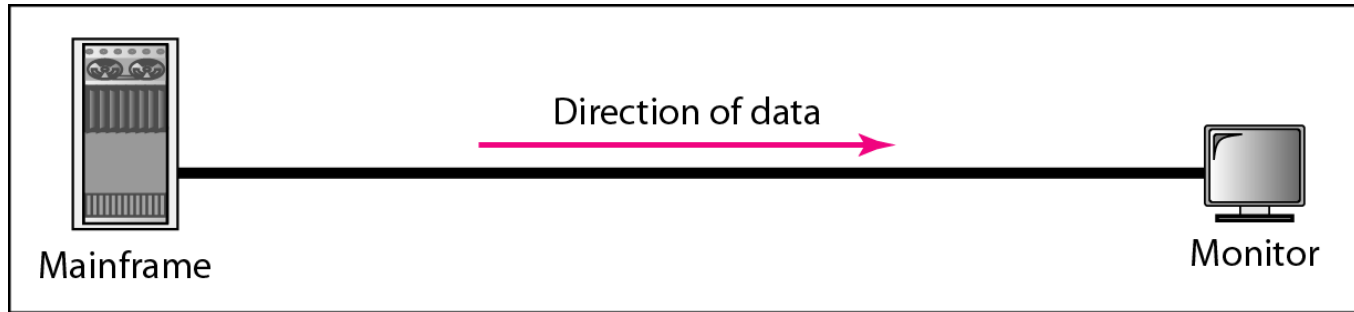


- Protocol is a set of rules that govern data communication
 - **agreement** between the communicating devices
 - without a protocol, two devices may be connected but not communicating

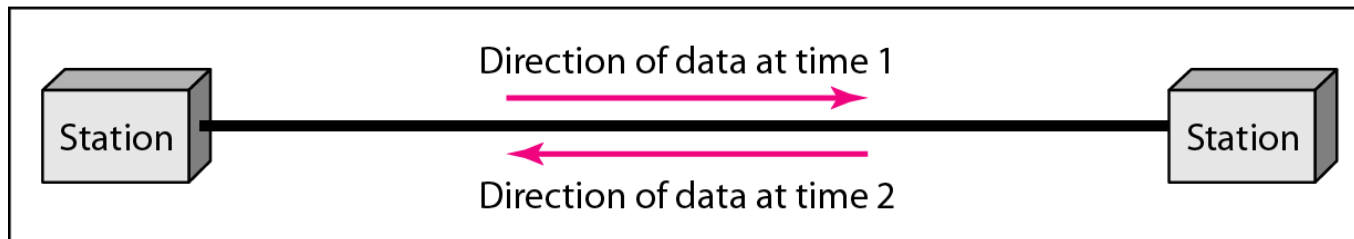
Fundamental characteristics

- The effectiveness of a data communications system depends on 4 fundamental characteristics:
- **Delivery:** The system must deliver data to the correct destination
- **Accuracy:** system must deliver the data accurately
 - Data that have been altered in transmission and left uncorrected are unusable
- **Timeliness:** system must deliver data in a timely manner; Data delivered late are useless. Eg. video and audio; real-time transmission
- **Jitter:** Variation in the packet arrival time; It is the uneven delay in the delivery of audio or video packets

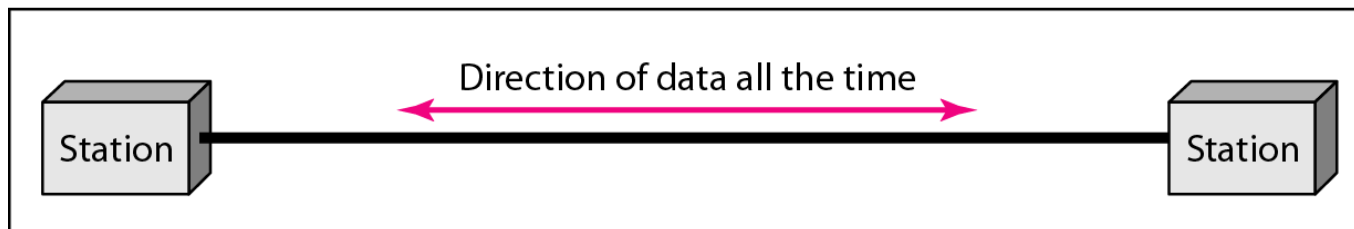
Data flow: Simplex (one way), half-duplex (two way communication but not simultaneously) and full duplex (2 way)



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***.

- *can be a Computer, Printer, Mobile, or any other device capable of sending and/or receiving data generated by other nodes on the network*
- *Distributed Processing*

Topics discussed in this section:

Physical Structures

Network Models

Categories of Networks

Interconnection of Networks: Internetwork

Network Criteria: Performance, Reliability, Security

■ Performance-

- **Transit time**- the amount of time required for a message to travel from one device to another
- **Response time**- the elapsed time between an inquiry and a response
 - depends on a number of factors: number of users, type of transmission medium, capabilities of the connected hardware, and efficiency of the software
- Networking metrics: **Throughput and Delay**
- We need more throughput and less delay
 - these two criteria are often contradictory

Network Criteria: Performance, Reliability, Security

■ Reliability-

- 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

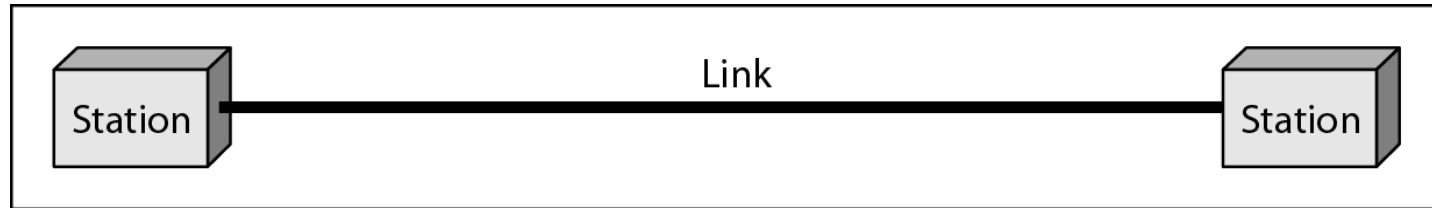
■ Security

- Security issues include protecting network resources and data from unauthorized access, protecting data from damage
- policies and procedures for recovery from breaches and data losses (development and implementation)

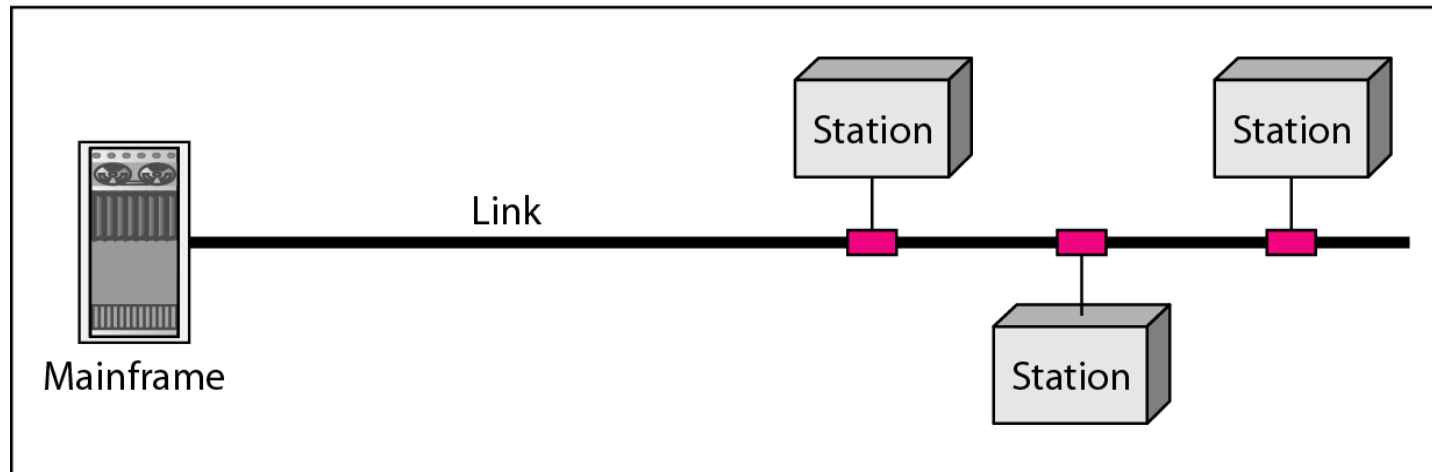
Types of connection/link (*Point-to-point and multipoint*)

- A network is two or more devices connected through links
- **Link-** communication pathway that transfers data from one device to another
- **Point-to-point-** dedicated link between two devices
 - Capacity reserved only for these devices
 - Dedicated wire cable or microwave links, IR etc.
- **Multipoint-** More than two devices share a single link
 - Capacity of the channel is shared **spatially or temporally**

Fig 1.3 Physical Structure *Types of connections: point-to-point and multipoint*



a. Point-to-point



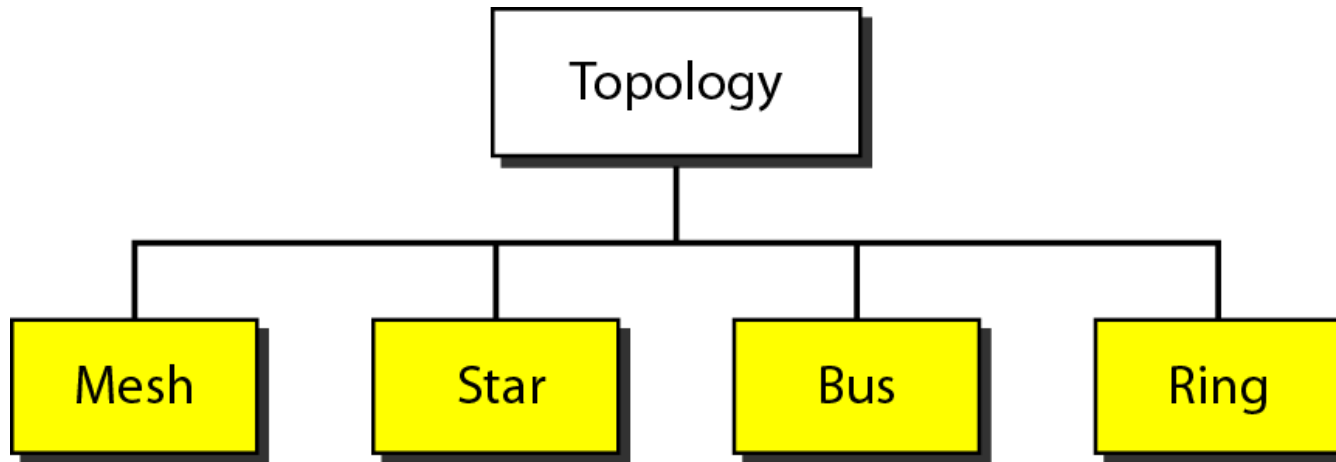
b. Multipoint

Physical Topology:

*-Refers to the **way in which a network is laid physically**;*

Geometric representation of the relationship of all the links and devices (nodes) to one another

Figure 1.4 *Categories of topology*



MESH Topology

- Every device has dedicated point-to-point link to every other device
- For network consisting of ' n ' nodes, $n(n-1)$ links are required
 - $(n-1)$ I/O ports required
 - Robust; easy fault identification and isolation
 - Privacy & Security
 - Large amount of cabling reqd → large space, expensive
 - Ex. Backbone networks; connecting Telephone regional offices

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

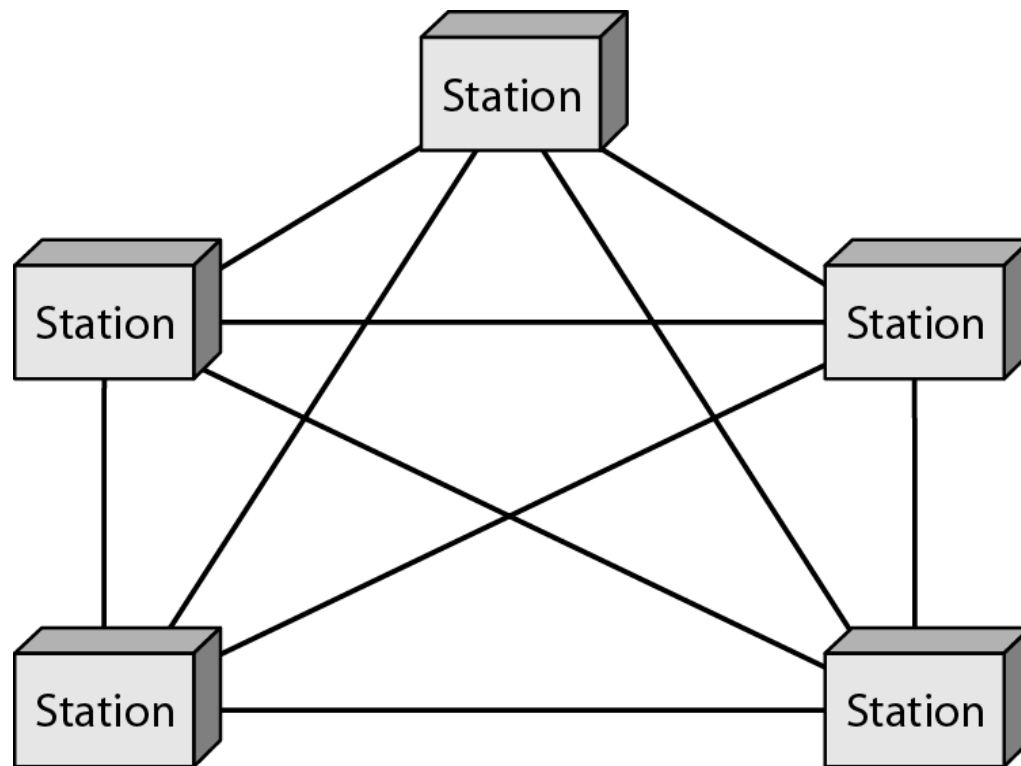
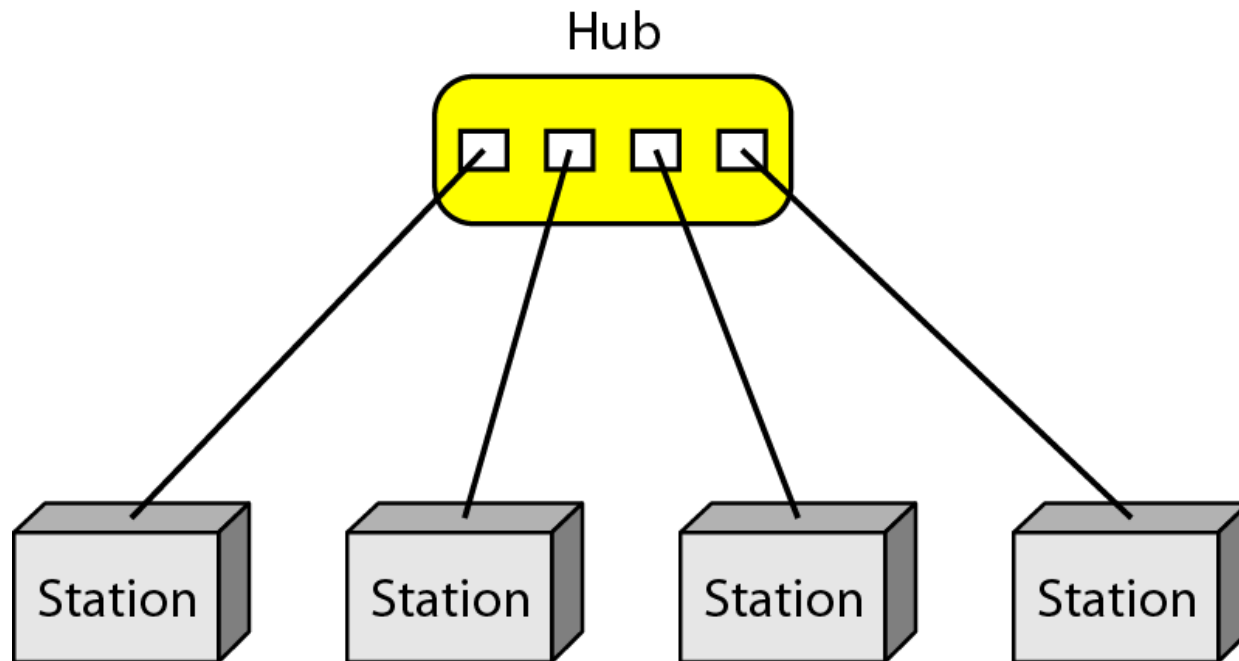


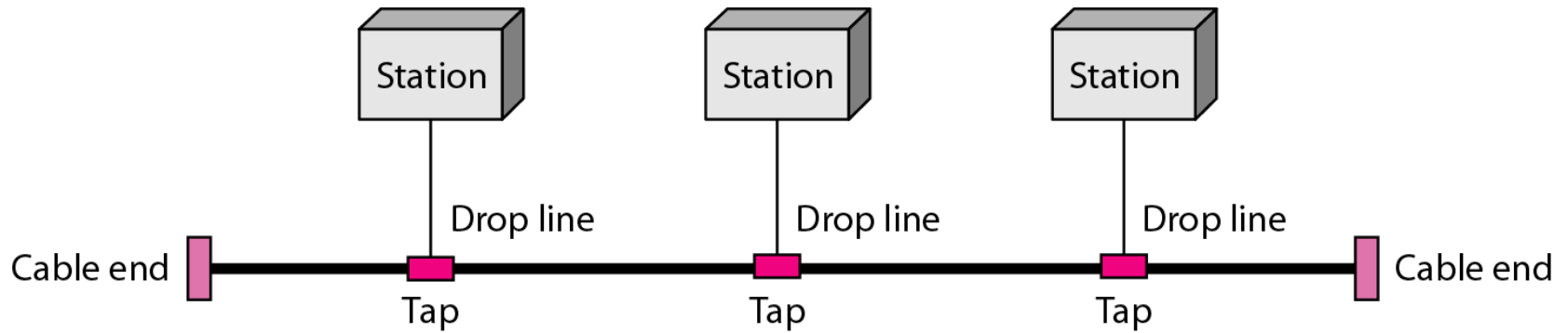
Figure 1.6 *A star topology connecting four stations*



STAR Topology

- Each device has a dedicated point-to-point link only to a central controller → Hub
 - Does not allow direct communication between devices
 - Less cabling reqd; Less expensive than Mesh
 - If one link fails only that node is affected; others can communicate
 - Not as Robust as Mesh; Hub is single point of failure
 - Ex. LAN

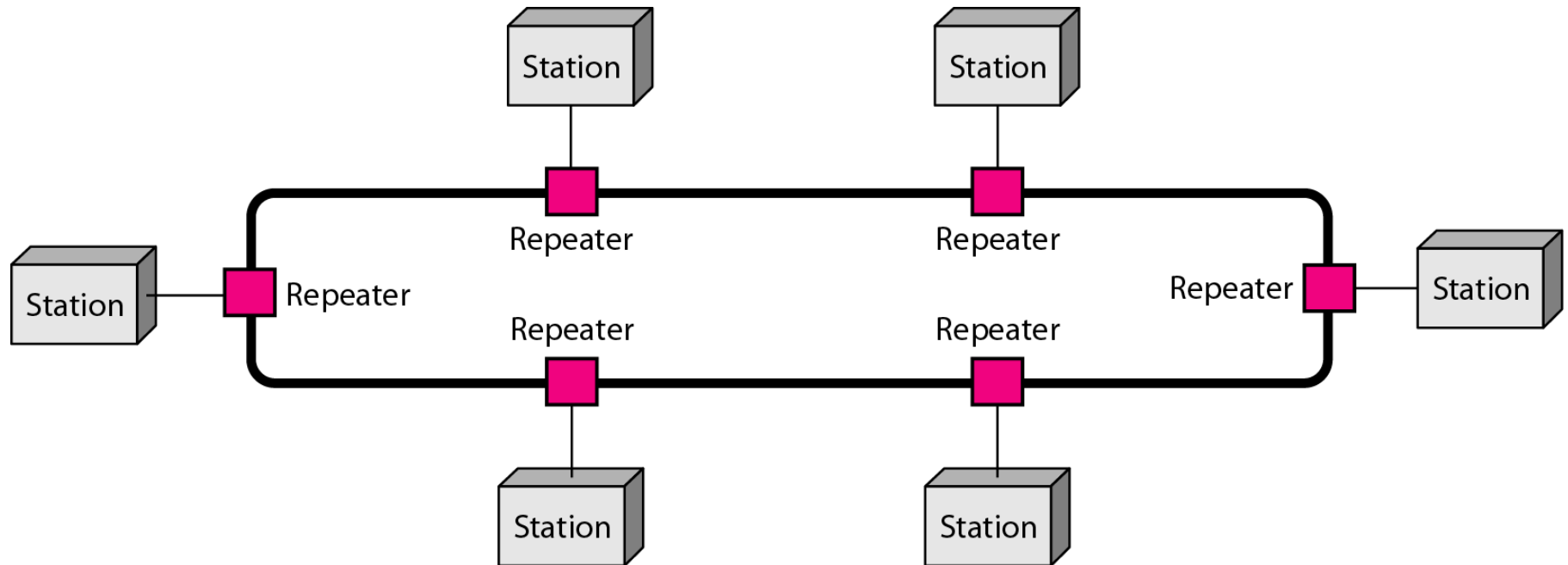
Figure 1.7 *A bus topology connecting three stations*



BUS Topology

- Multipoint topology
- one long cable acts as a **backbone** to which all devices are connected with the help of **drop lines** and **taps**
 - Least cabling hence inexpensive than other topologies
 - Signal becomes weaker as it travels farther
 - Difficult fault isolation and reconnection
 - break in cable stops communication
 - Ex. Early Ethernet LANs, now obsolete

Figure 1.8 *A ring topology connecting six stations*



Ring Topology

- Each device has a dedicated point-to-point connection to only two devices on either side of it
- Each device incorporates a **repeater**
- Signal passed along the ring in one direction
 - Easy to install and reconfigure; Less expensive than Mesh
 - Easy fault isolation
 - In simple ring (simplex links), **break in ring/disabled station can disable entire network**
 - Solved using dual ring with switching capability
 - Ex. Token Ring LAN

Figure *A dual-ring topology connecting six stations*

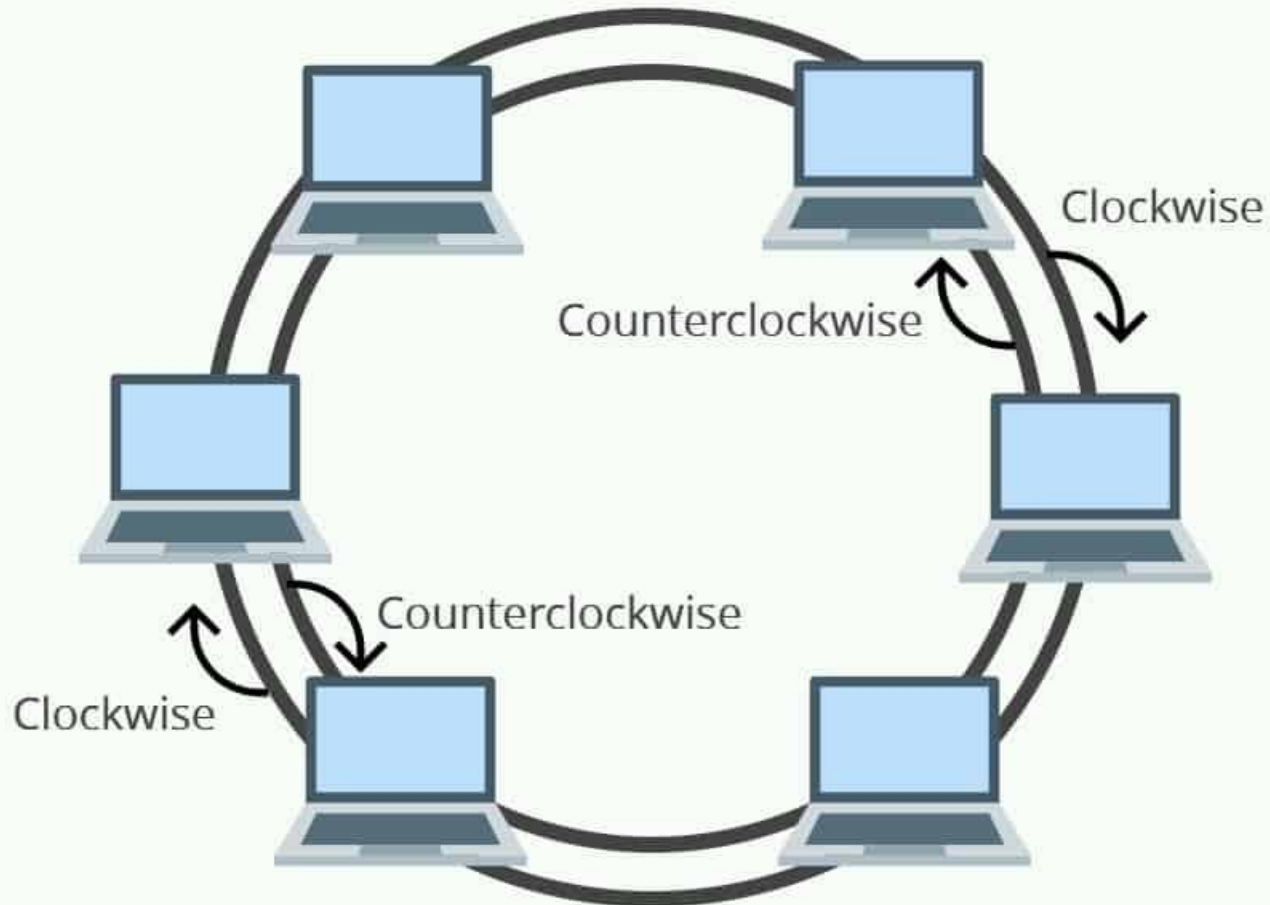
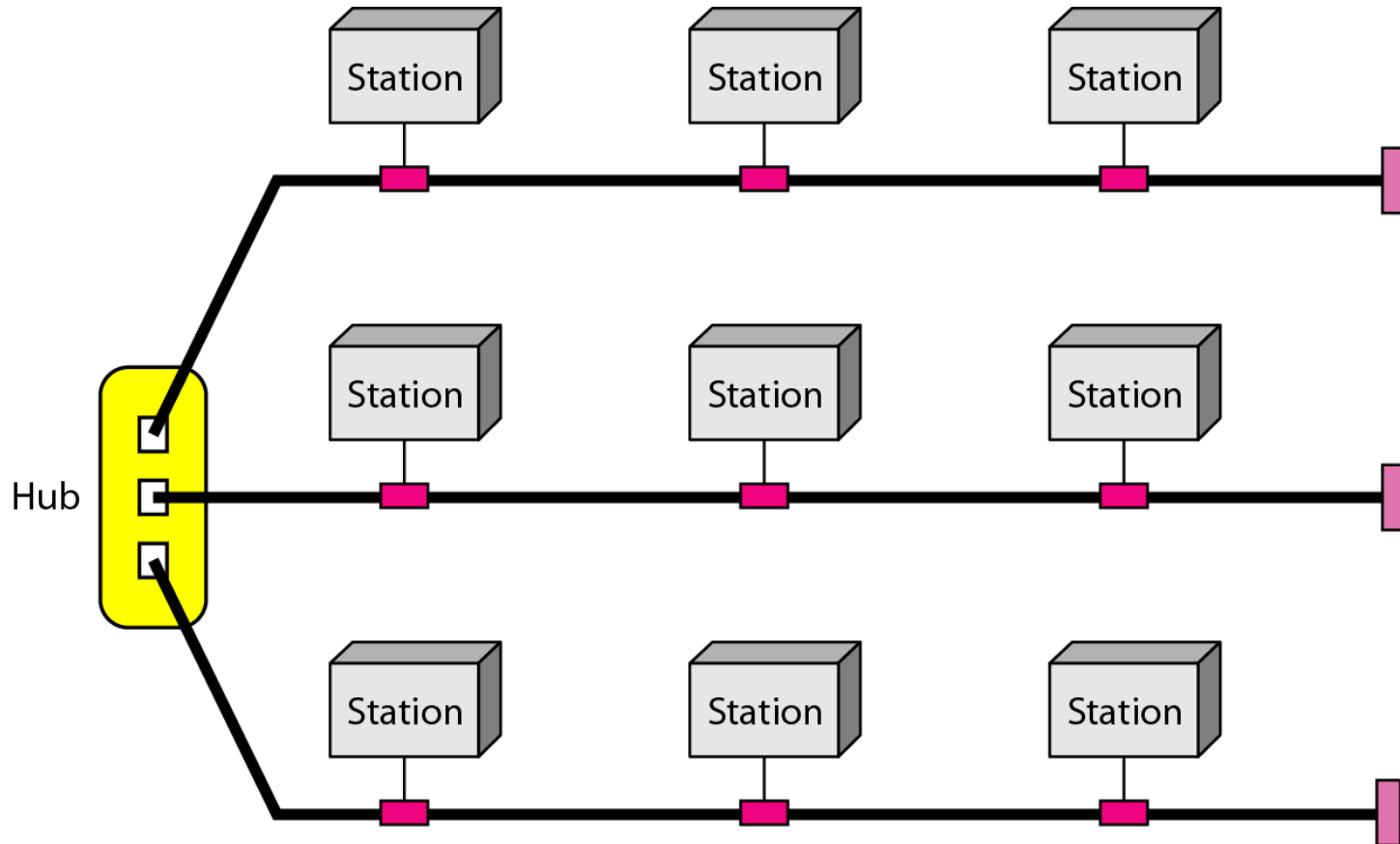


Figure 1.9 *A hybrid topology: a star backbone with three bus networks*

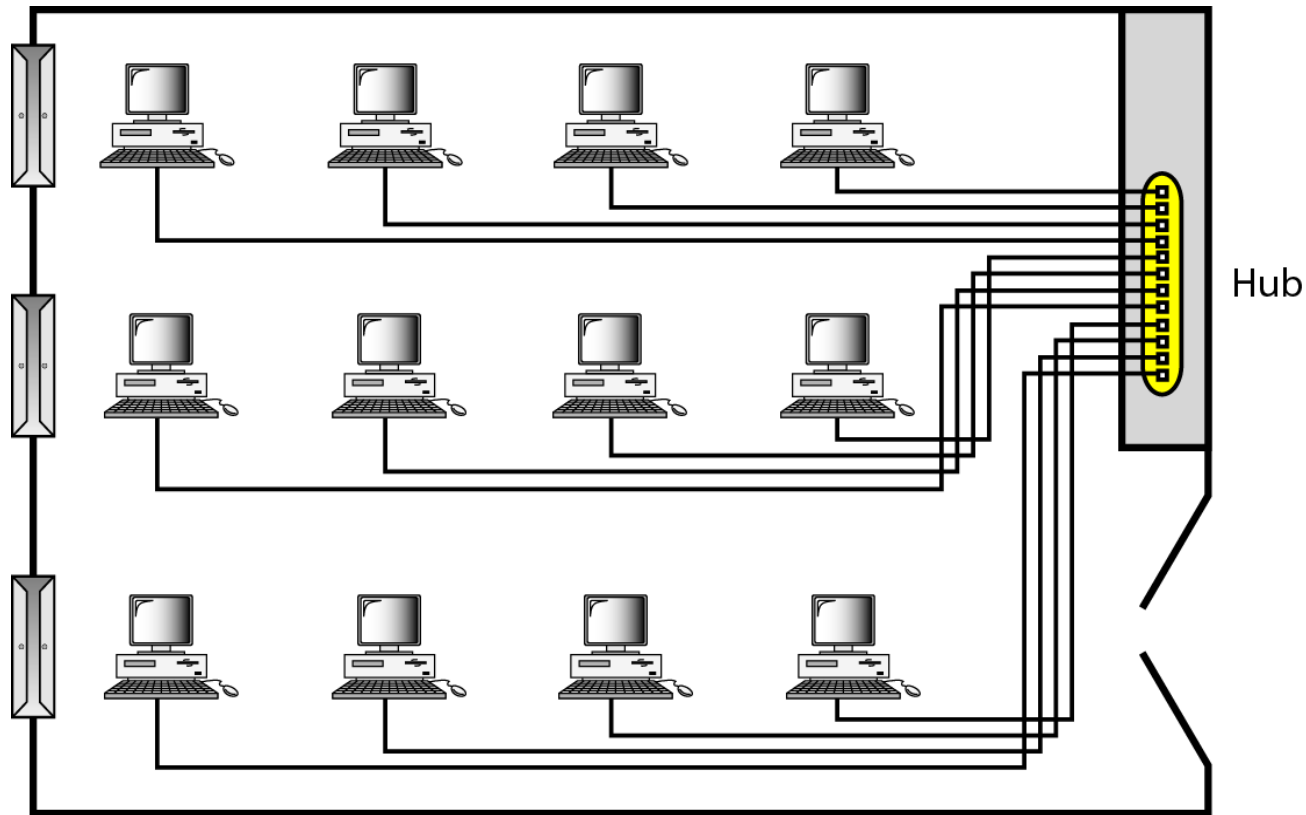


Types of Networks: LAN, MAN, WAN

■ LAN- Local Area Network

- Privately owned; Linking the devices in a single office, building or campus
- allows resources to be shared among computers
 - Resource can be HW (e.g. printer, workstation/server), SW (e.g application program) or data
 - High capacity device acts as a Server; clients use the resources (storage, files, software etc.) available on server
- Topologies: **Star, Bus and Ring**
- LAN size/Area Restricted to few kms
- Data Rate: 10 to 1000Mbps

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

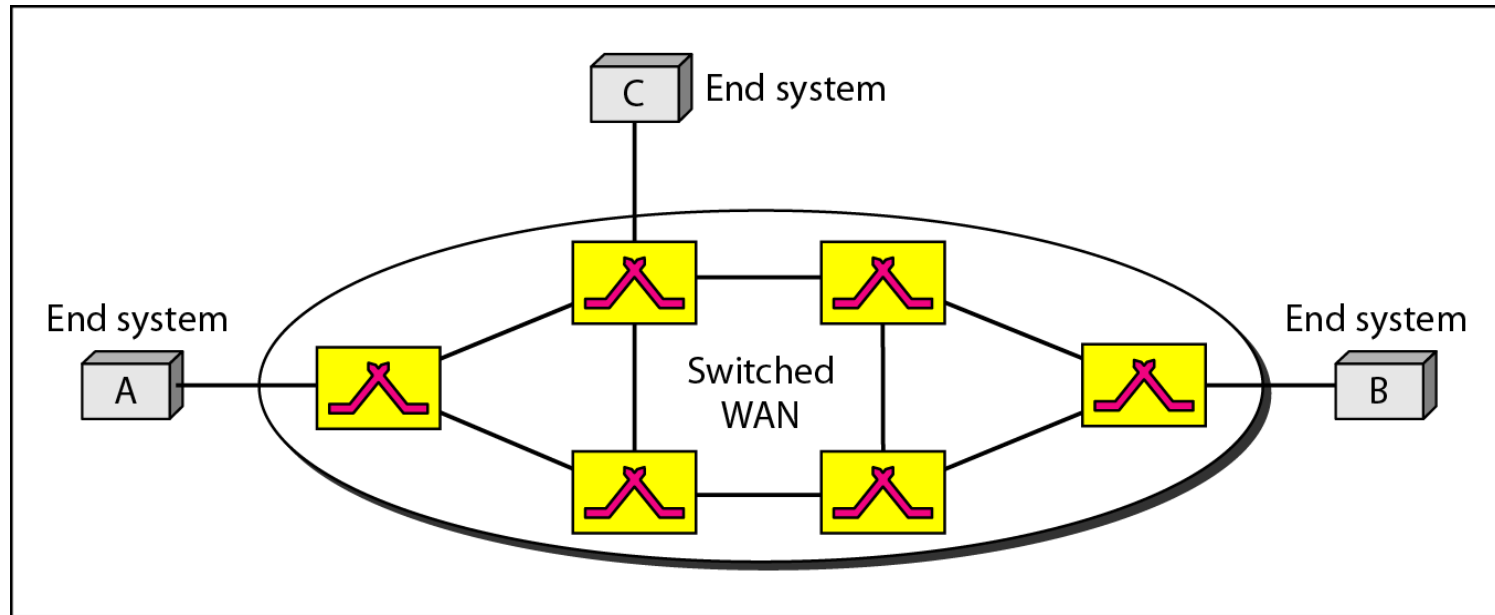


Types of Networks: LAN, MAN, WAN

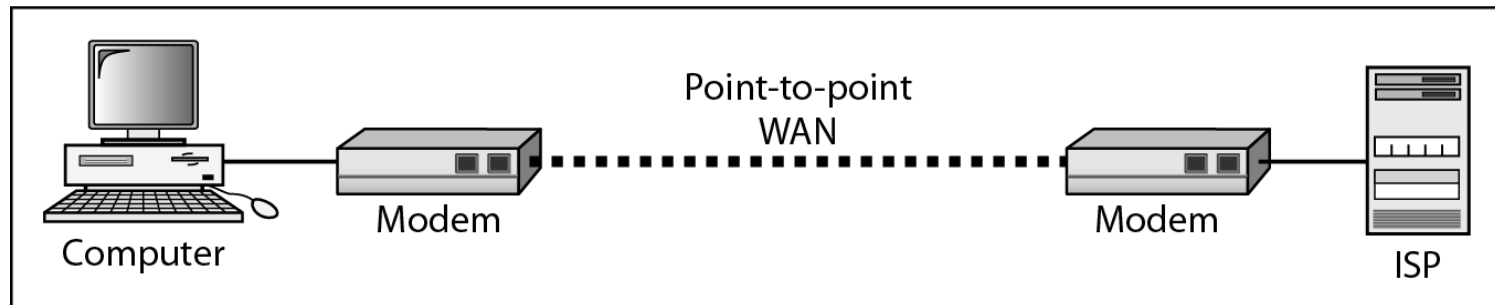
■ WAN- Wide Area Network

- Provides long distance transmission of data
- spans large geographical area that may comprise a country, a continent or entire globe
- Types- Switched, Point-to-Point
- Switched WAN- connects the end systems, that comprise a Router which connects to another LAN or WAN
 - X.25, Frame relay, ATM, wireless WAN
- Point-to-Point WAN- Home computer/LAN connected to Internet Service Provider (ISP) via Dialup/Leased line or cable TV network

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



a. Switched WAN



b. Point-to-point WAN

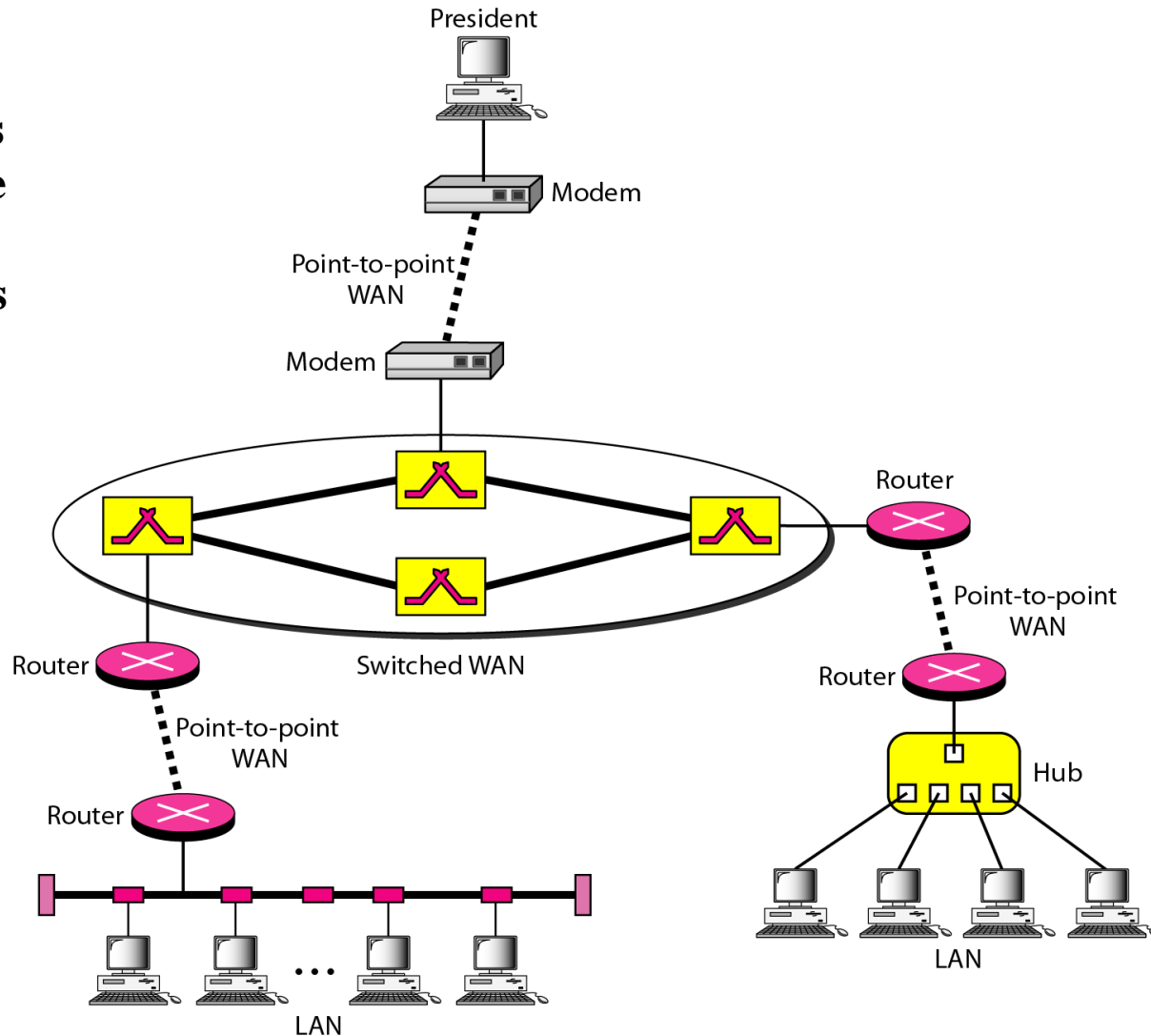
Types of Networks: LAN, MAN, WAN

■ MAN- Metropolitan Area Network

- Fits between LAN and WAN; covers region/area within a city restricted to few tens of kms
- Designed for customers who need high speed connectivity; offices spanning over the city
- E.g. Telephone company network that provides high-speed DSL line to customers

Internetwork: interconnection of networks

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



1-3 THE INTERNET

- An *internet* comprises of two or more networks that can communicate with each other
- *Internet* is a collaboration of more than hundreds of thousands of interconnected networks
- *Internet* has revolutionized many aspects of our lives
- *It is a communication system that has brought a wealth of information to our fingertips and organized it for our use*
- *Changed the way we do business as well as the way we spend our leisure time*

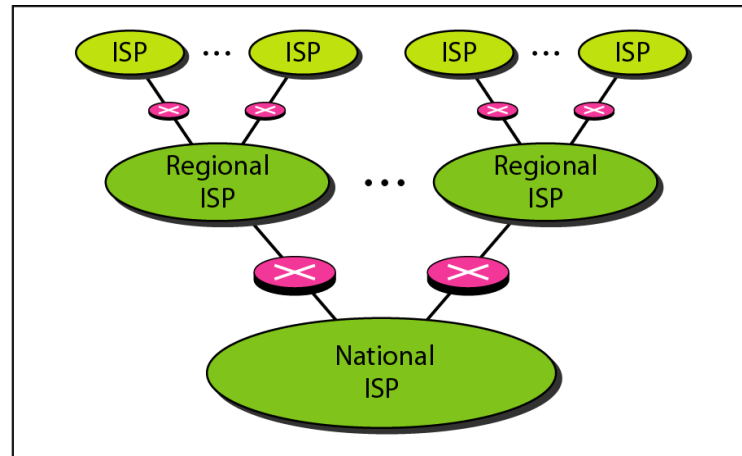
History

- First network/internet- *ARPANET*- 1969
 - Advanced Research Projects Agency (ARPA), Dept. of Defense
 - Small network of connected computers; each host computer attached through specialized computer called *IMP* (interface message processor)
 - 4 nodes at the University of California at Los Angeles (UCLA), University of California at Santa Barbara (UCSB), Stanford Research Institute (SRI) and University of Utah connected via IMP
 - *Network Control Protocol (NCP)* provided communication between the hosts
 - 1973- V. Cerf and B. Kahn-*TCP* (Transmission Control Protocol); later split into TCP and IP

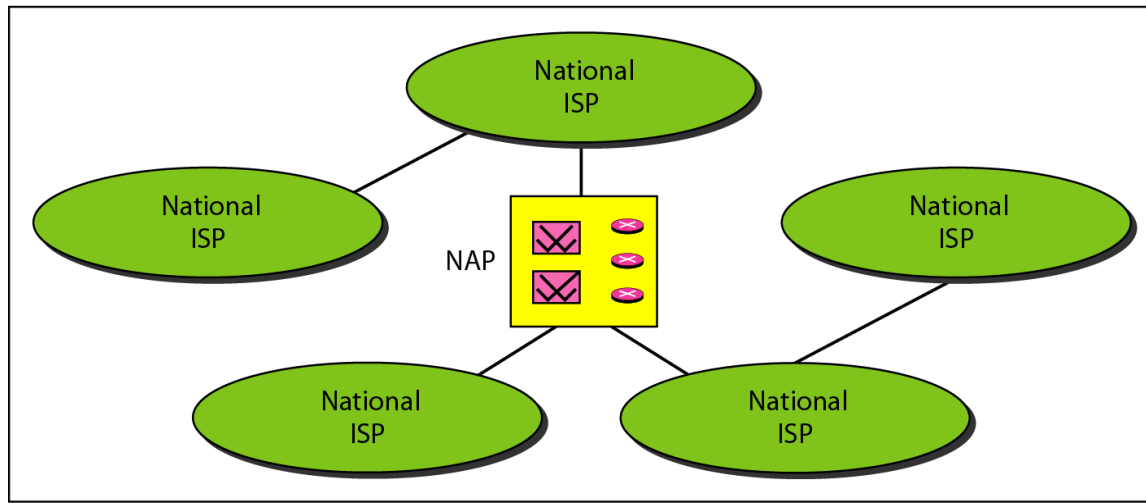
Internet Service Providers (ISPs)

- For connecting to Internet, end users use the service of **Internet Service Providers (ISPs)**
 - Types: International service providers, national service providers, regional service providers and local service providers
- **Local ISPs**- provide direct service to end users and are connected to regional ISPs or national ISPs
 - Can be a company providing Internet services, corporation or a non profit organization e.g college/University, civic body...
- **Regional ISPs** are connected to one or more national ISPs
- **National ISPs**- backbone networks created and maintained by specialized companies
 - interconnected by switching stations called **Network Access Points**
- **International ISPs**- connect National ISPs together

Figure 1.13 *Hierarchical organization of the Internet*



a. Structure of a national ISP



b. Interconnection of national ISPs

1-4 PROTOCOLS AND STANDARDS

Jargon terms: *Protocols and Standards*

- *Protocol* is synonymous with rule
- *Standards* are agreed-upon rules

Topics discussed in this section:

Protocols

Standards

Standards Organizations

Internet Standards

Connection oriented and connectionless services

Protocols

- Set of rules that govern data communication
 - Defines what is communicated, how it is communicated and when it is communicated
- Key elements- **Syntax, Semantics and Timing**
- **Syntax**- structure or format of data; order in which data is presented
 - E.g. first 48 bits sender address, next 48 bits receiver address and remaining bits the message/user data
- **Semantics**- meaning of each section of bits
 - How a bit pattern is to be interpreted and what action be taken
- **Timing**- refers to what data to be sent and how fast be sent
 - Useful for matching the sending rate of sender with the capability of receiver

Standards

- Provide **guidelines** to manufacturers, vendors, government agencies, and other service providers
- Essential for guaranteeing national and international **interoperability** (of technology and processes)
- Developed through cooperation of standards creation committees, forums and regulatory agencies
- Two categories: **De facto** and **De jure**
 - **De facto (by fact)**- standards **not been approved** by a standardisation body but have been adopted through widespread use
 - **De jure (by regulation)**- standards that have been legislated by an officially recognized body (e.g. IEEE)

Standards Organizations

- ISO: International Organization for Standardization
- ITU-T: International Telecommunication Union-
Telecommunication Standards Sector
- IEEE: Institute of Electrical and Electronics Engineers
- ANSI: American National Standards Institute
- EIA: Electronic Industries Association

- Special Interest Groups/ **Forums**- representatives from various corporations
 - work with universities and users, test and evaluate new technologies
- Regulatory Agencies - Govt. agencies to protect public interest (e.g. TRAI, FCC)
 - Regulate radio, TV, wire/cable communication

Connection Oriented and Connectionless Services

■ Connection Oriented Services

- Requires **prior session connection** between sender and receiver
- Sets up virtual links between the end systems through a network
- Reliable network service
- Suitable for Long messages
- High overhead, thus greater BW demand
- Example: Telephone call

Connection Oriented and Connectionless Services

■ Connection Less Services

- **No prior connection** between sender and receiver required
- Less overhead
- No reliability
- Suitable for Short messages, real-time traffic
- Does not maintain state information
- Example: email, SMS ...

Reliable and Unreliable Services

■ Reliable Services

- **Assured delivery** of message from sender to receiver
- Requires acknowledgement from the receiver about receipt of message
- **Large Overhead**; unsuitable for real-time applications like Voice/video i.e multimedia
- Example: TCP

Reliable and Unreliable Services

■ Unreliable Services

- Time-bound delivery of message; No guarantee
- Less Overhead; suitable for real-time applications like Voice/video i.e multimedia
- Example: UDP