

# **Module 1**

## **Introduction to networking**

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Slide Source: B. A. Forauzan, Data Communications and Networking, McGraw-Hill  
Online Learning Centre

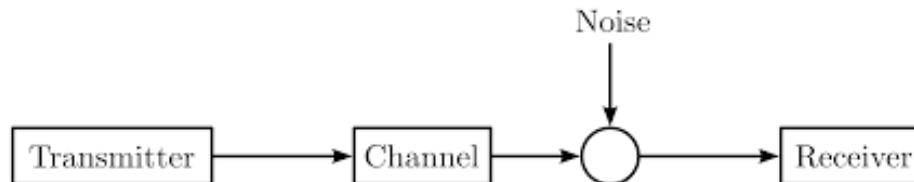
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# Syllabus Contents

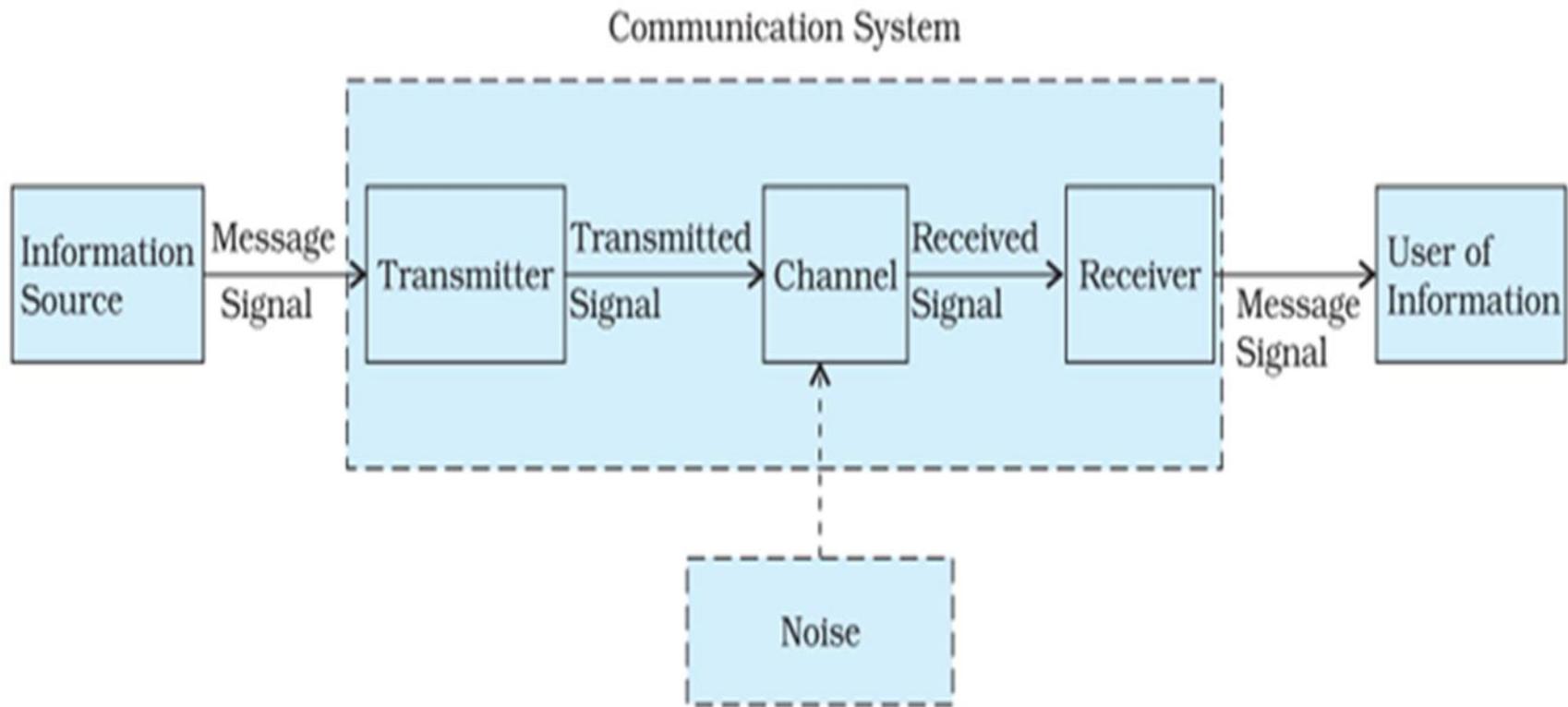
1. Data Communication basics
2. Types of Networks: LAN, WAN, MAN; Network Topology (types)
3. Network Software: Protocol hierarchy, Design Issues for layers, Connection oriented and connectionless services, Reliable and Un-reliable services
4. OSI and TCP/IP reference model, Comparison of OSI and TCP/IP 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 forms-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

# Data Representation

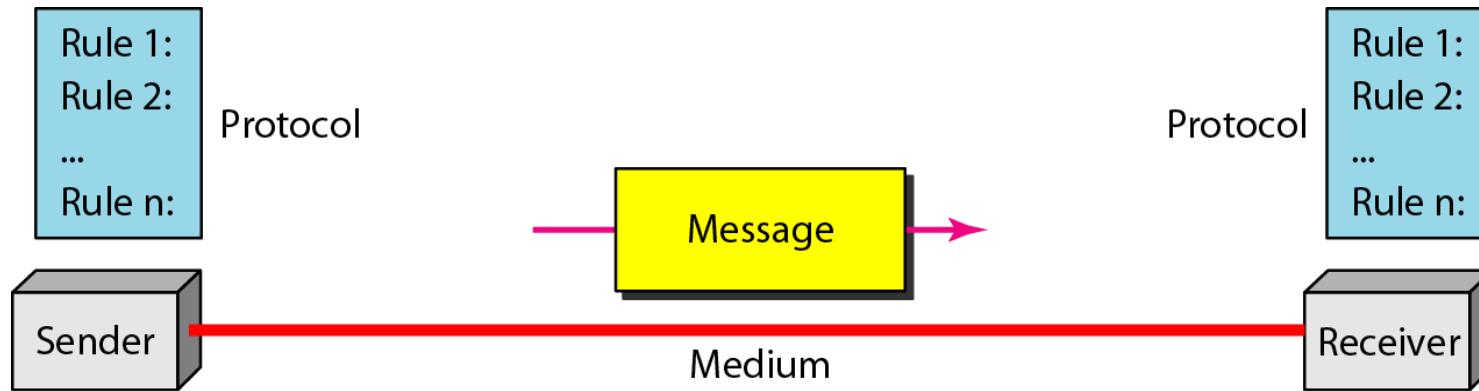
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- Different forms of Information/Data
  - Text- Unicode (32 bits ), ASCII
  - Numbers- numbering systems
  - Images- pixels; B/W, gray scale, colour (RGB etc)
  - Audio- sound / music; continuous not discrete
  - Video- continuous or discrete
  - ...

# Data Communication System *Five components of data communication system*

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- → Sender, Receiver, Medium, Message and Protocol



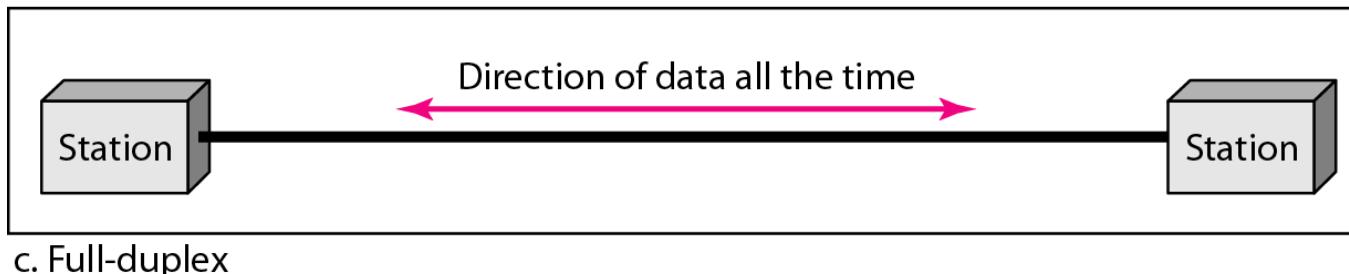
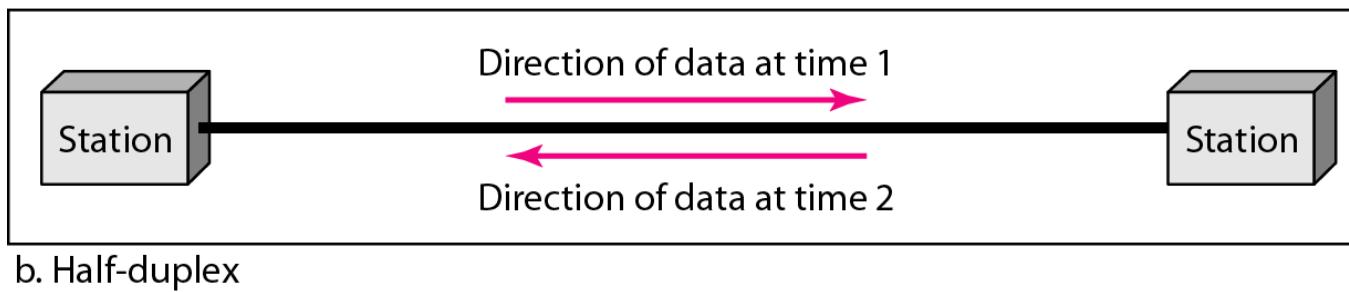
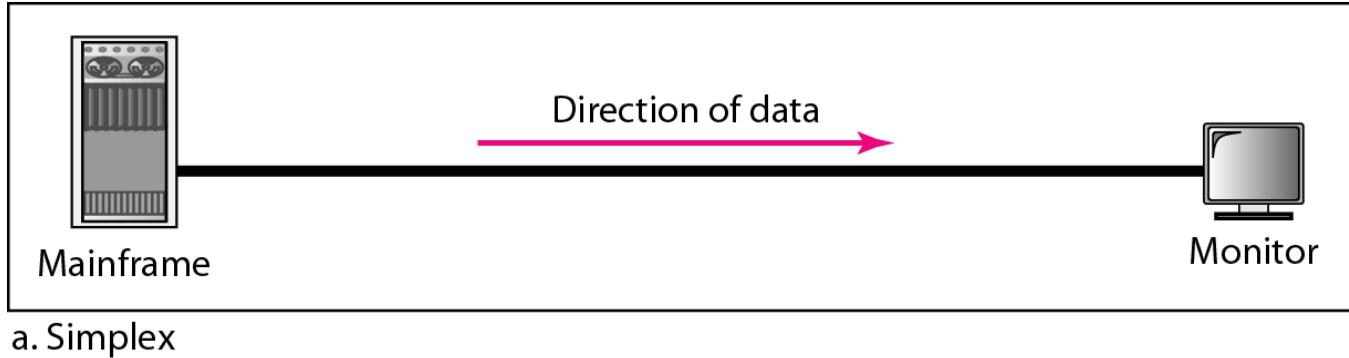
- → Protocol is a set of rules that govern data communication
  - **agreement** between the communicating devices
  - without a protocol, two devices may be connected but not communicating

# Fundamental characteristics

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- 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)



## 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

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## ■ 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

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## ■ 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

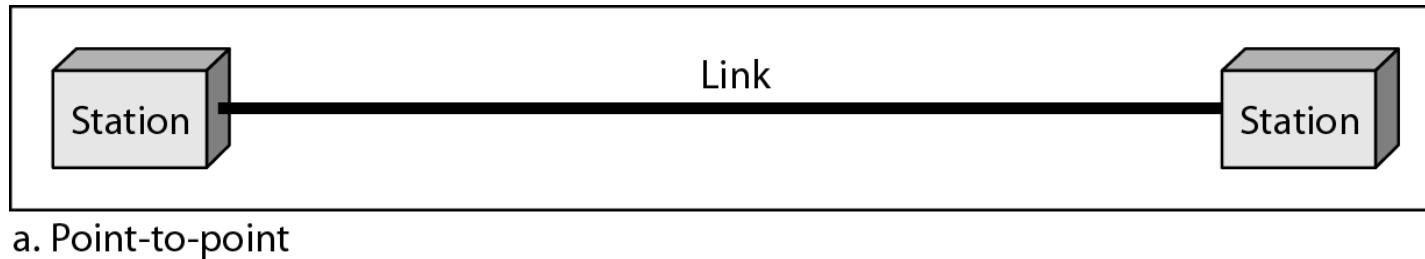
- Security issues include protecting network resources and data from unauthorized access, protecting data from damage
- policies and procedures for recovery from breaches and data losses (development and implementation)

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

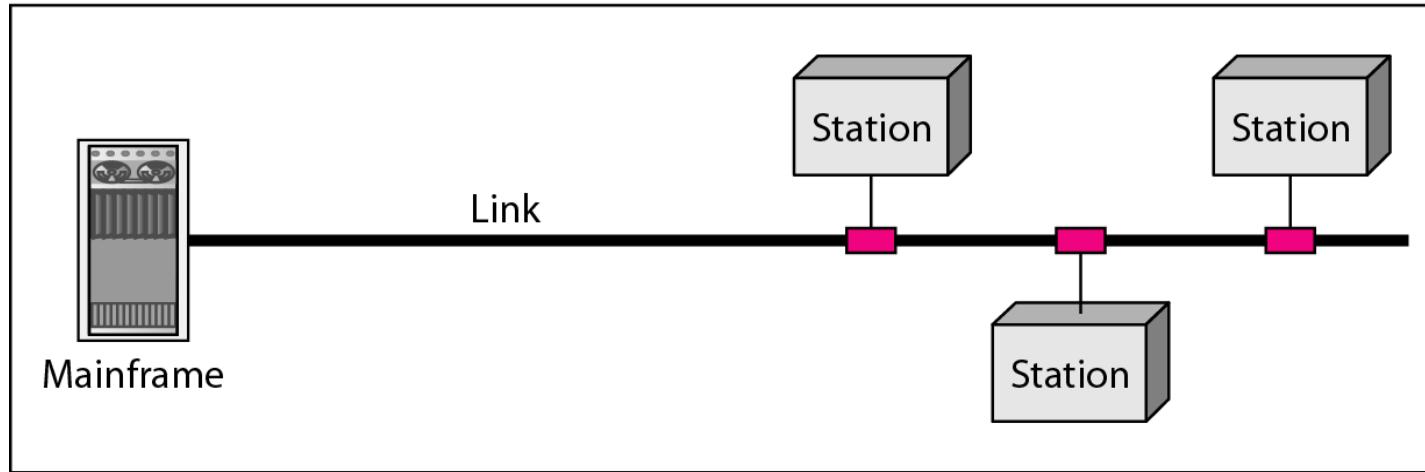
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- A network is two or more devices connected through links
- **Link-** communication pathway that transfers data from one device to another
- **Point-to-point-** dedicated link between two devices
  - Capacity reserved only for these devices
  - Dedicated 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

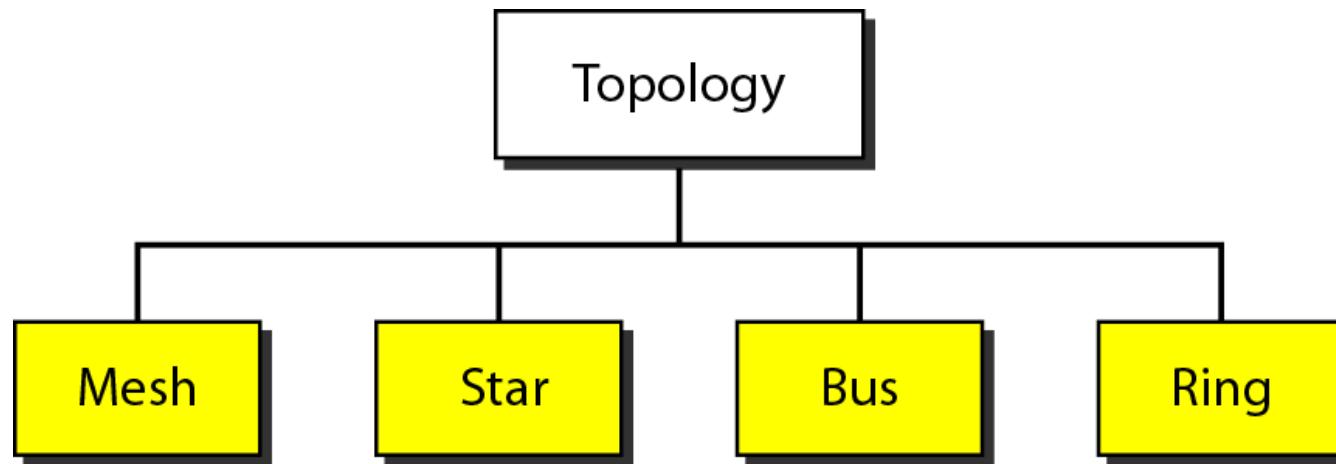
# Physical Topology:

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*-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**



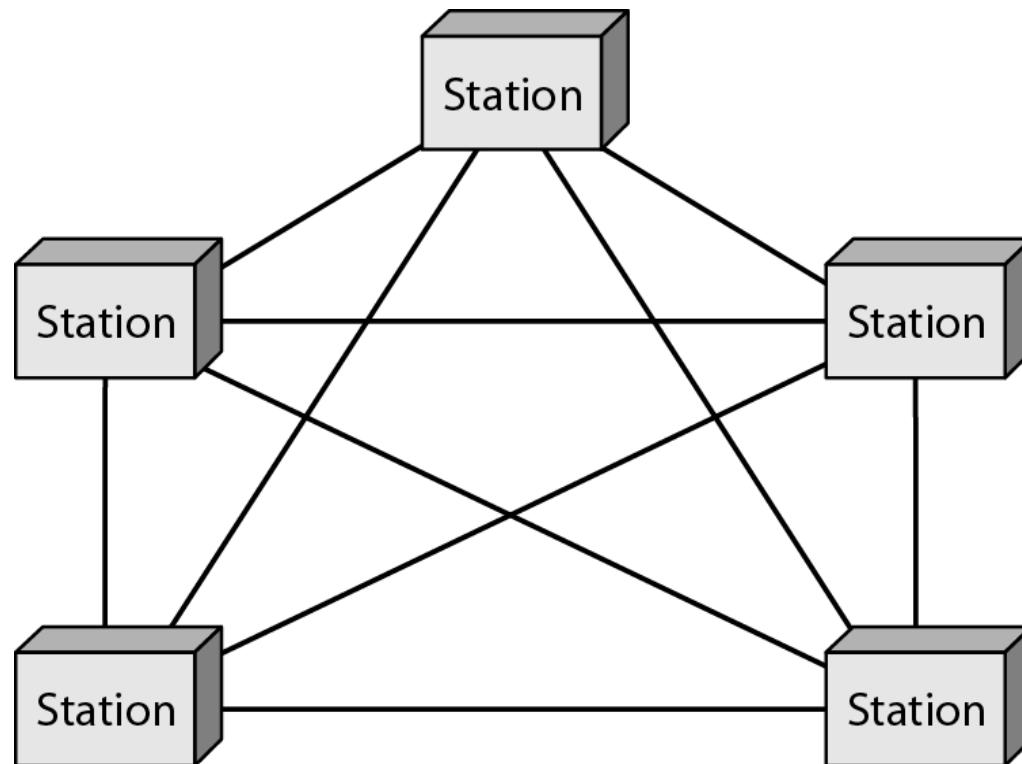
# MESH Topology

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- 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

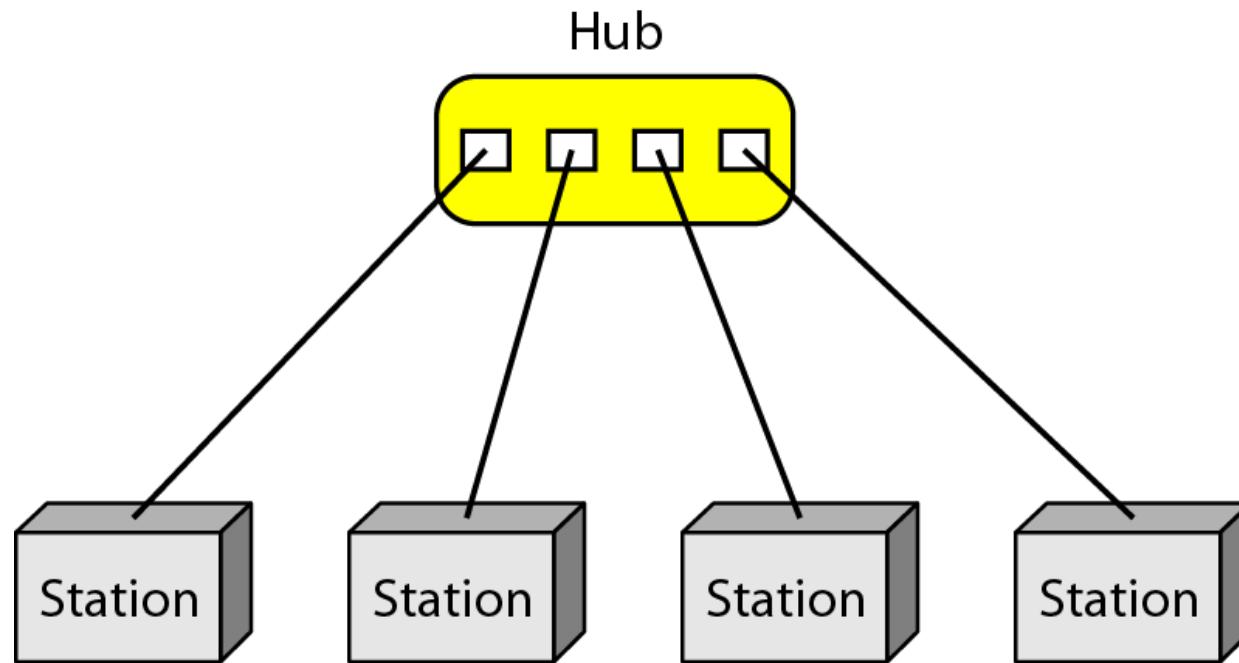
**Figure 1.5** *A fully connected mesh topology (five devices)*

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

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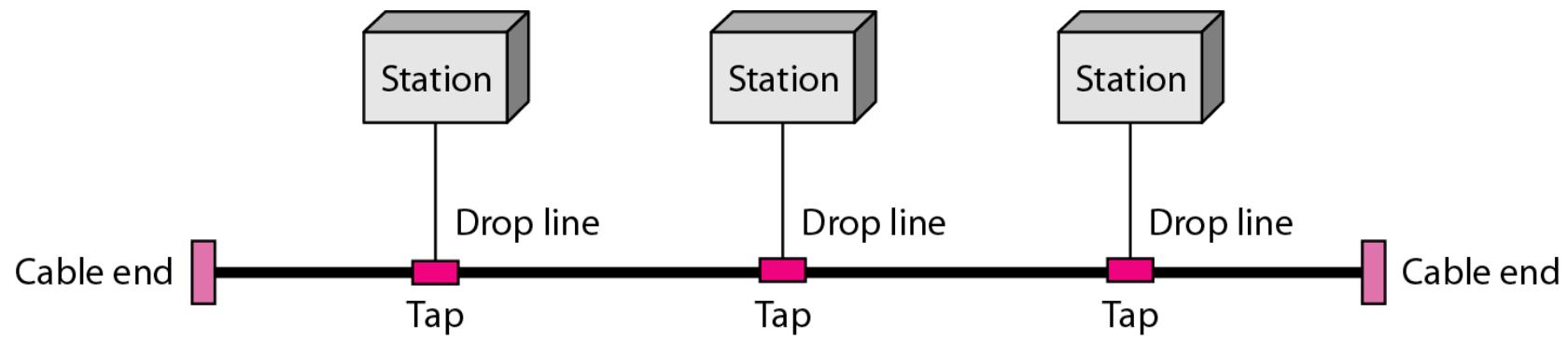


# STAR Topology

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- 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

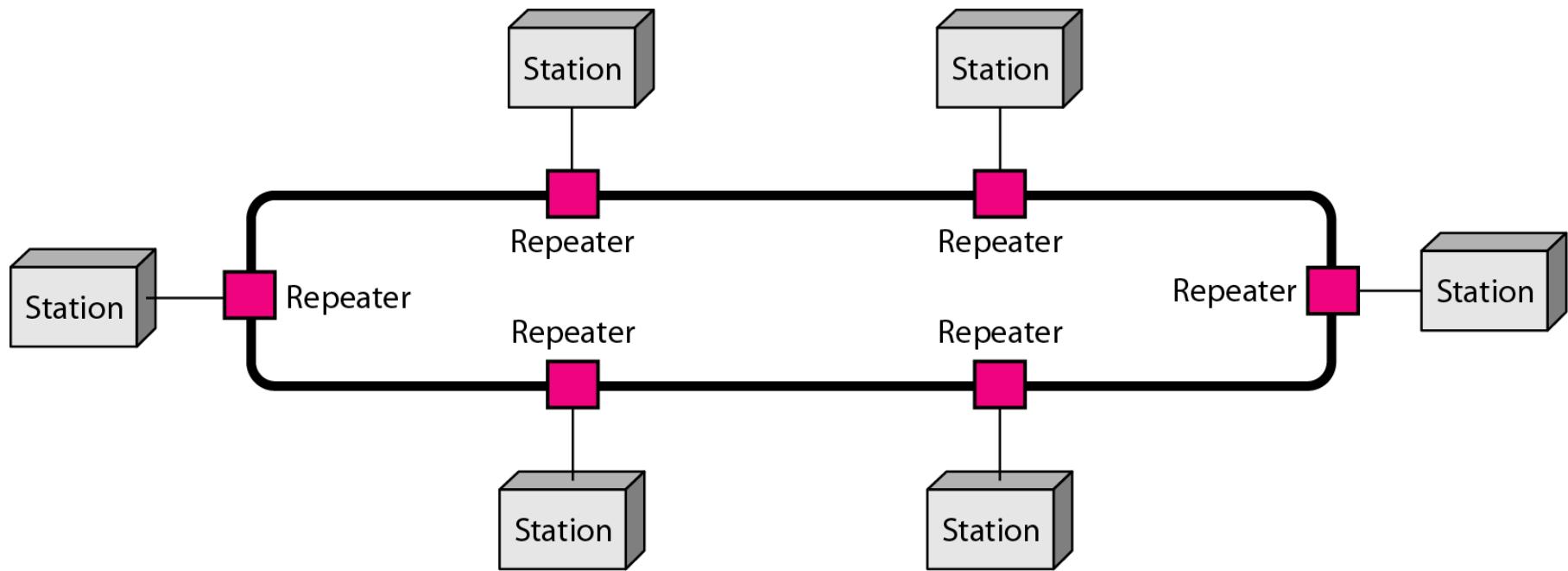


# BUS Topology

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- 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*

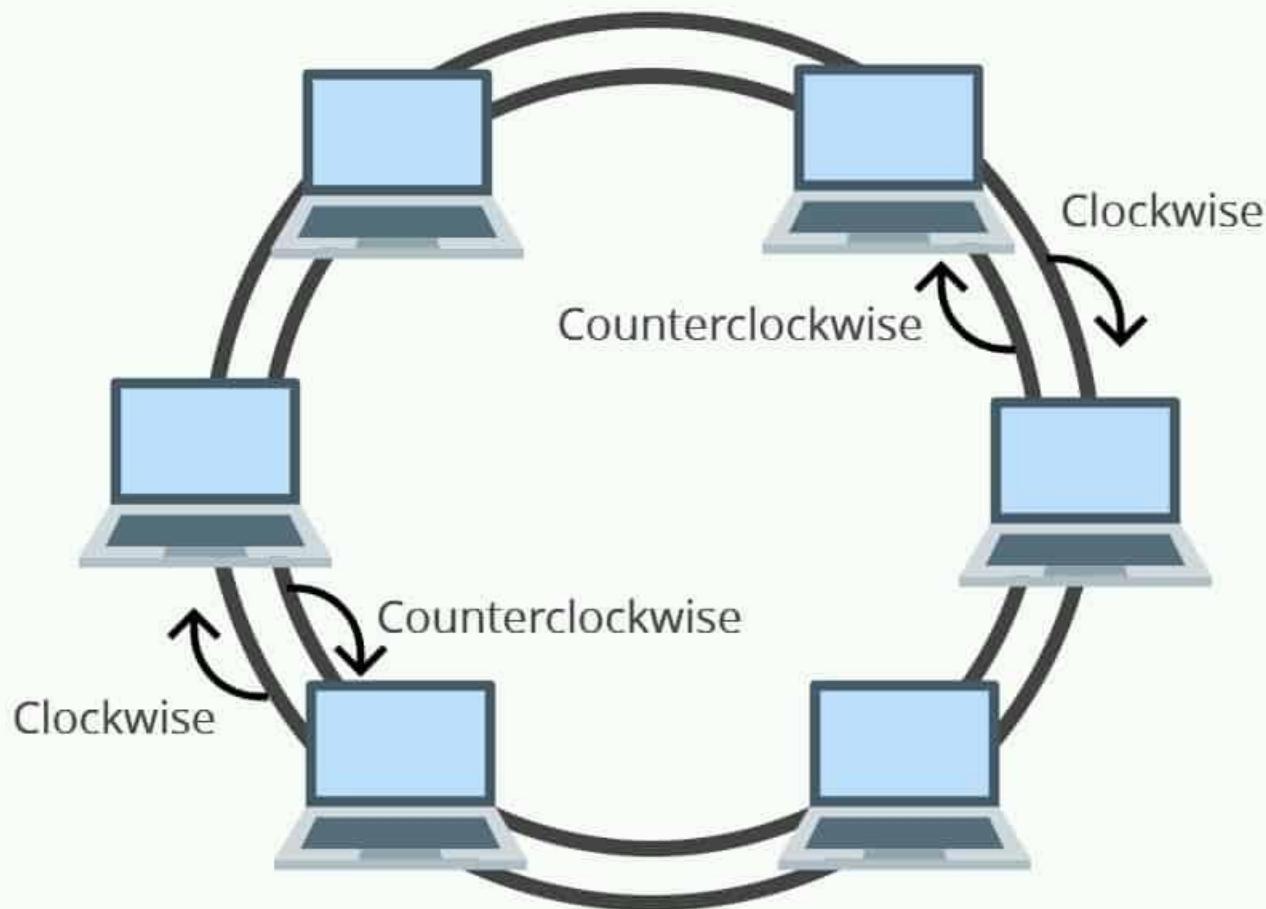


# Ring Topology

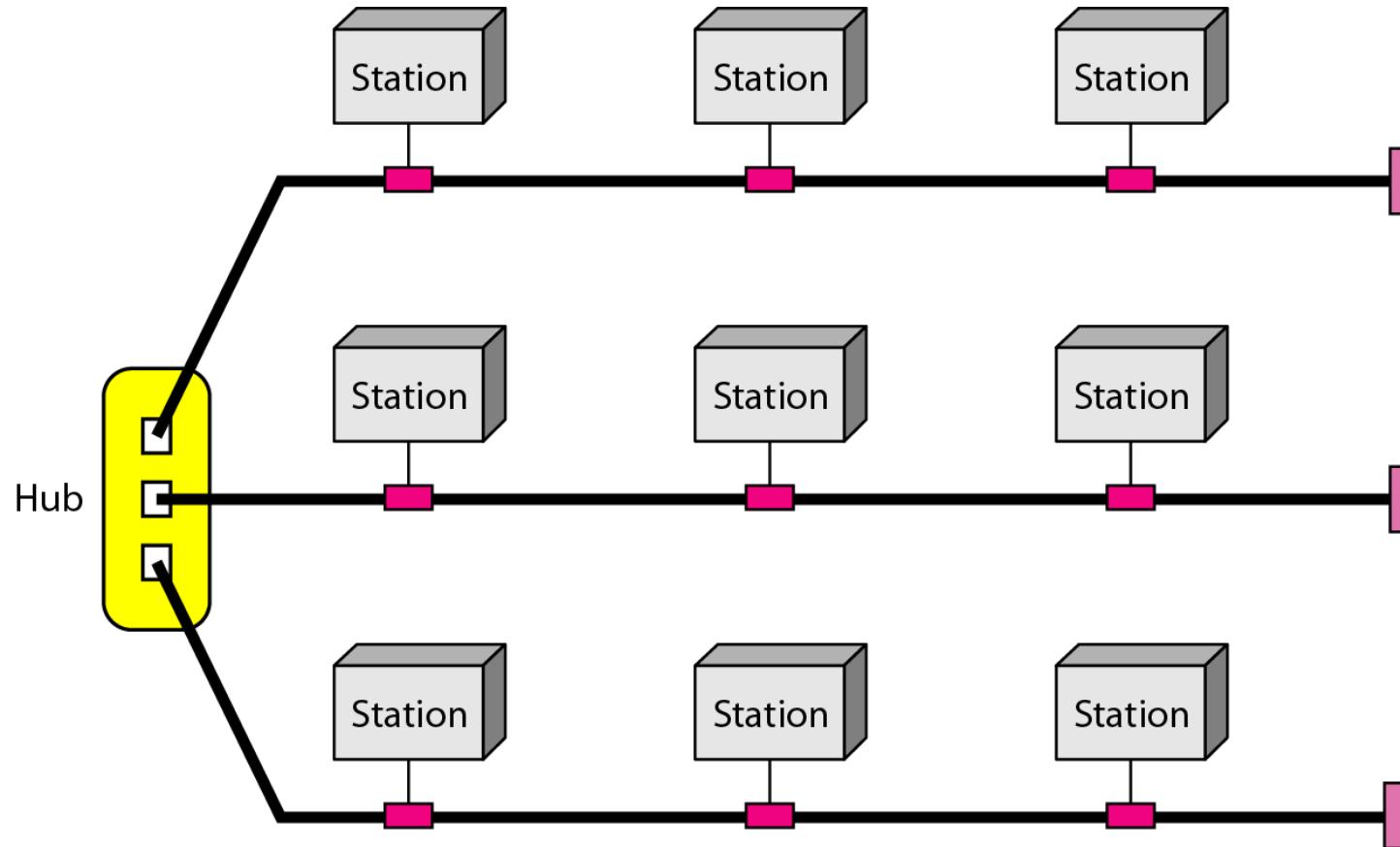
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- Each device has a dedicated point-to-point connection to only two devices on either side of it
- Each device incorporates a **repeater**
- Signal passed along the ring in one direction
  - Easy to install and reconfigure; Less expensive than Mesh
  - 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



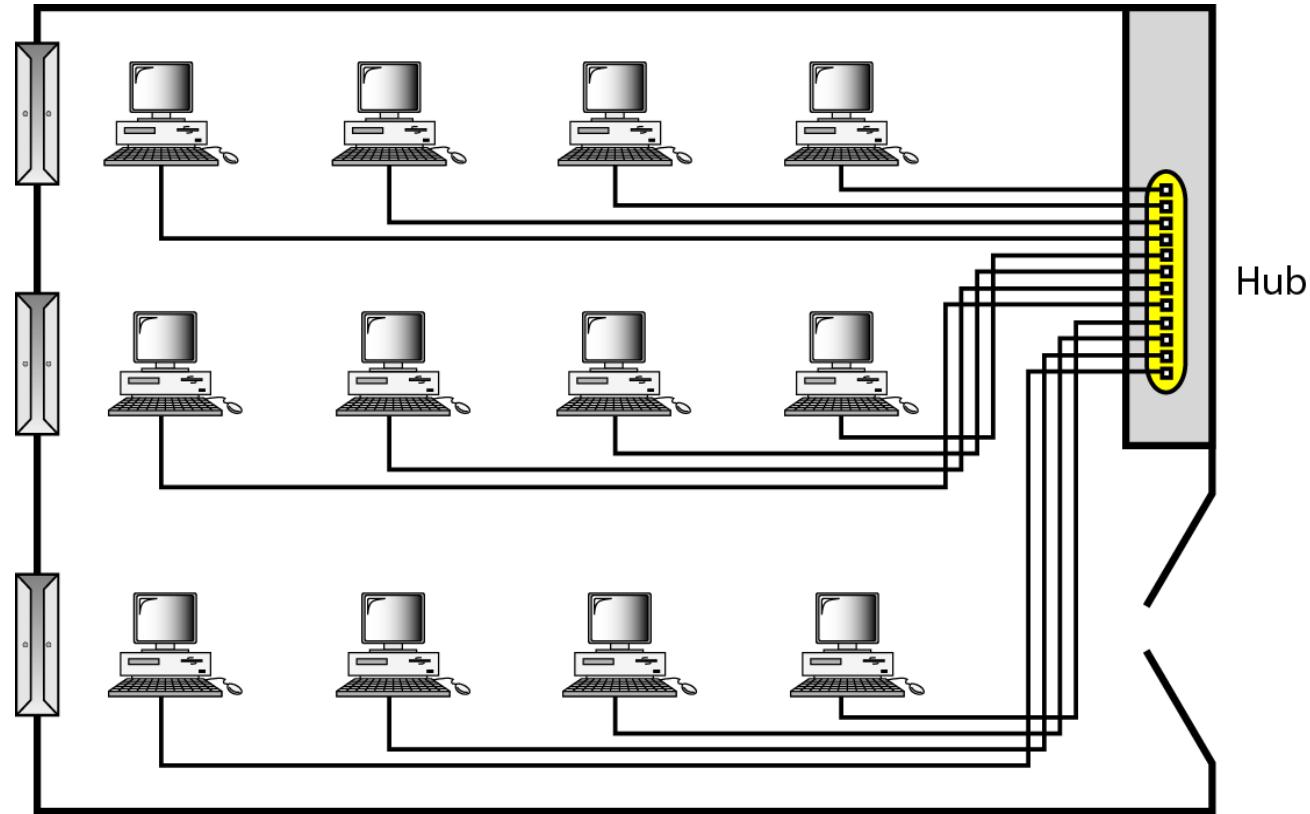
# Types of Networks: LAN, MAN, WAN

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## ■ 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*



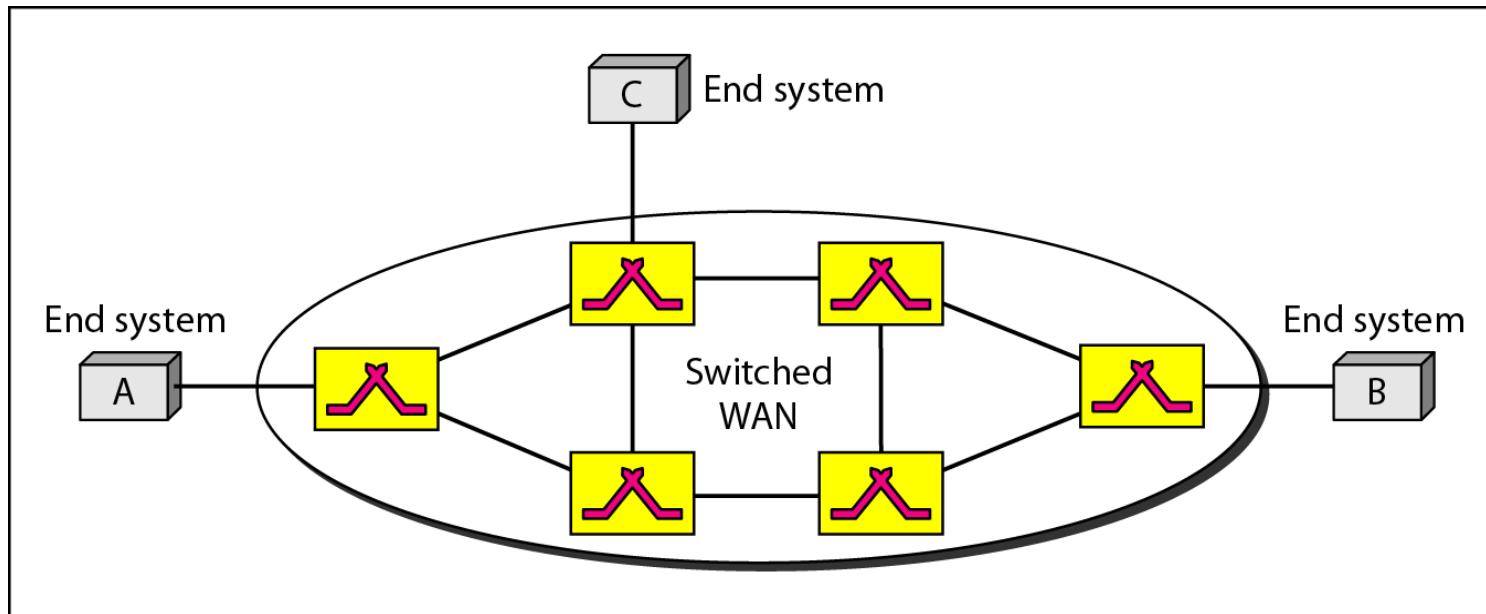
# Types of Networks: LAN, MAN, WAN

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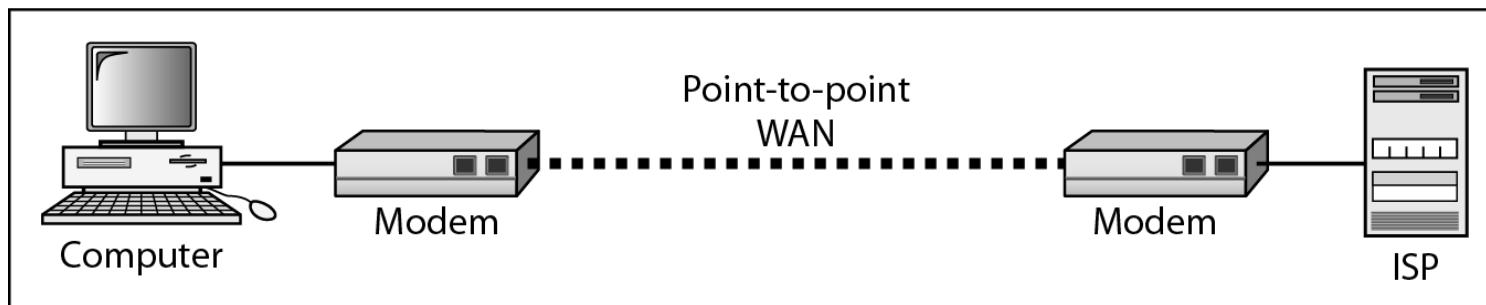
## ■ WAN- Wide Area Network

- 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

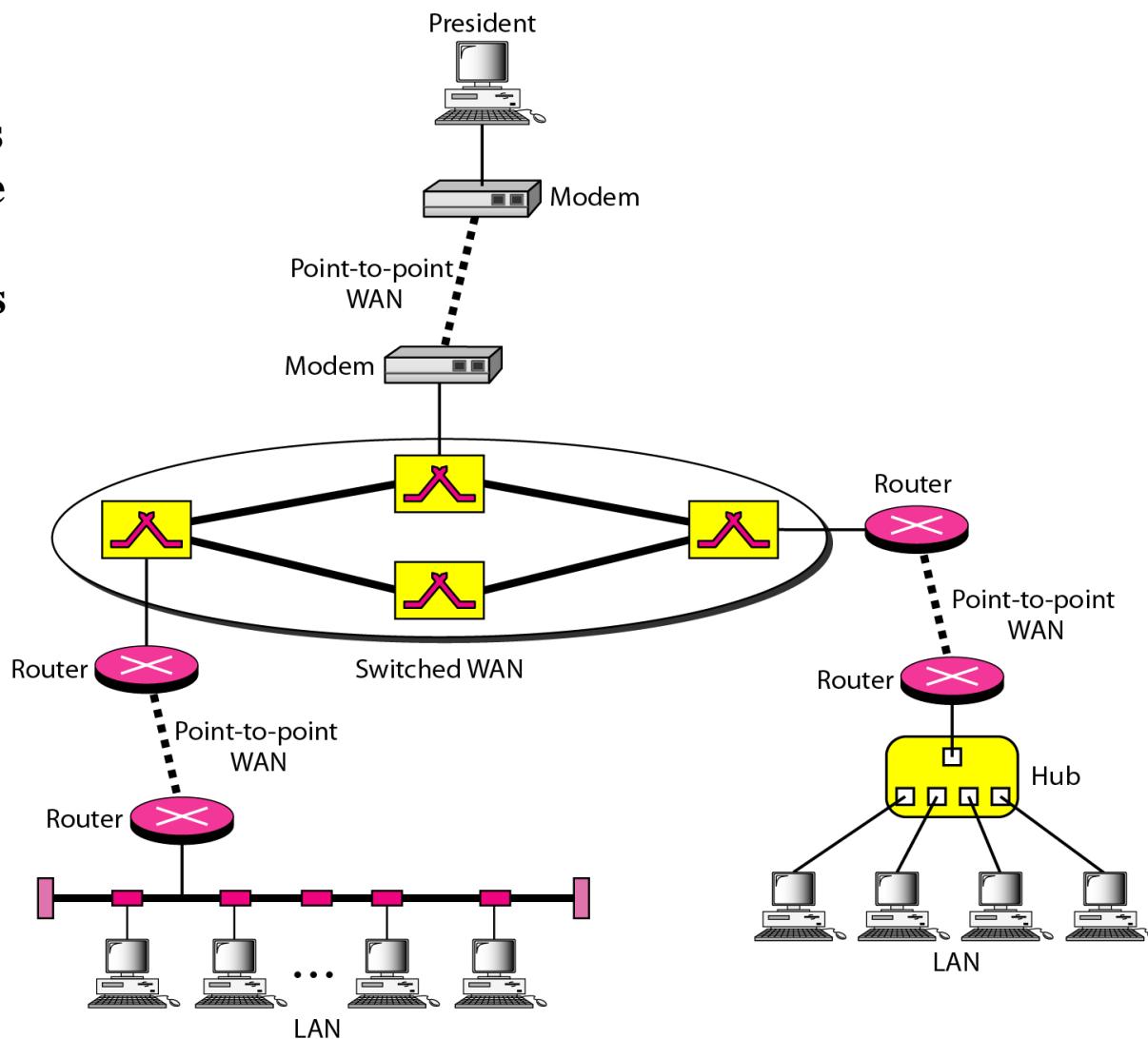
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## ■ MAN- Metropolitan Area Network

- 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

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- 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 Angels (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

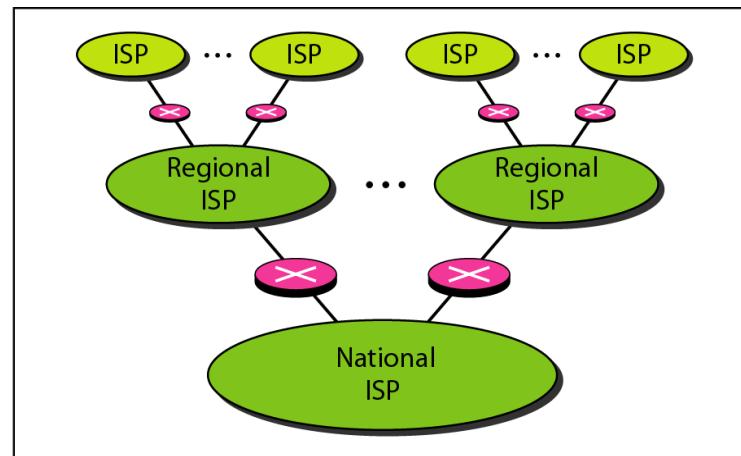
# Internet Service Providers (ISPs)

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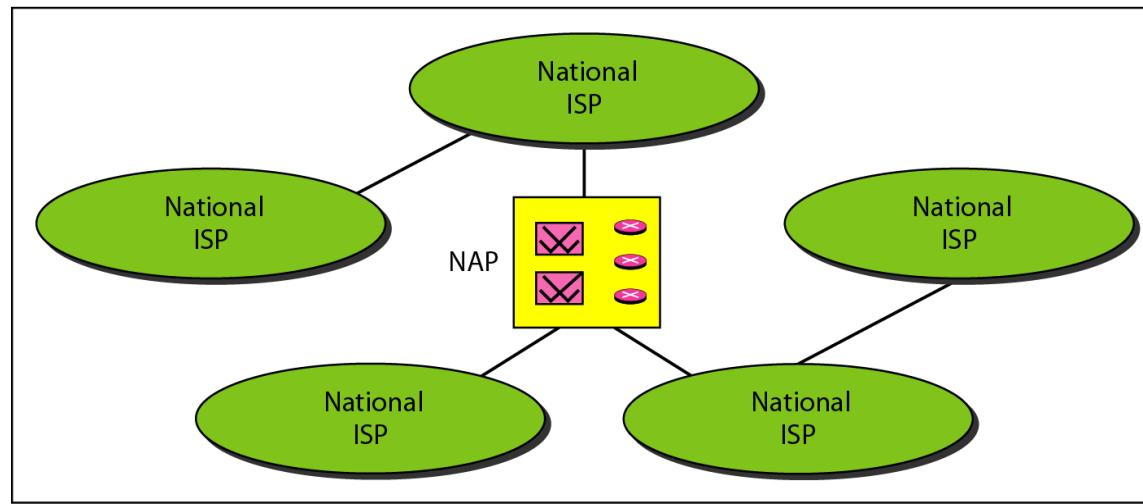
- For connecting to Internet, end users use the service of **Internet Service Providers (ISPs)**
  - Types: International service providers, national service providers, regional service providers and local service providers
- **Local ISPs**- provide direct service to end users and are connected to regional 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*

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a. Structure of a national ISP



b. Interconnection of national ISPs

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# 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

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- 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

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- 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

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- 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
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- 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