Chapter 1

Introduction

Slides Adapted from '**Data Communications and Networking**'
5th Edition book by **By Behrouz A. Forouzan**

Introduction

- Data communications and networking
  - Change the way we do business and the way we live
  - Business decisions have to be made more quickly
  - Decision depends on immediate access to accurate information
  - Business today rely on computer networks and internetworks

  - We need to know:
    - How networks operate
    - What types of technologies are available
    - Which design best fills which set of needs

Introduction

- Development of the PC changes a lot in business, industry, science and education.
- Similar revolution is occurring in data communication and networking
  - Technologies advances are making it possible for communications links to carry more and faster signals
  - Services are evolving to allow the use of this expanded capacity
  - For example telephone services extended to have:
    - Conference calling, Call waiting
    - Voice mail, Caller ID

Data Communications

Communication:

- Means sharing information
  - Local (face to face) or remote (over distance)
- Telecommunication
  - Telephone, telegraph and television
  - Means communication at a distance
  - Tele is Greek for far

Data Communications

Data:

- Refers to information
  - Presented in any form
  - Agreed upon by the parties (creating & using)

Data communication : is the exchange of data between two devices via some form of transmission medium.

Data Communications

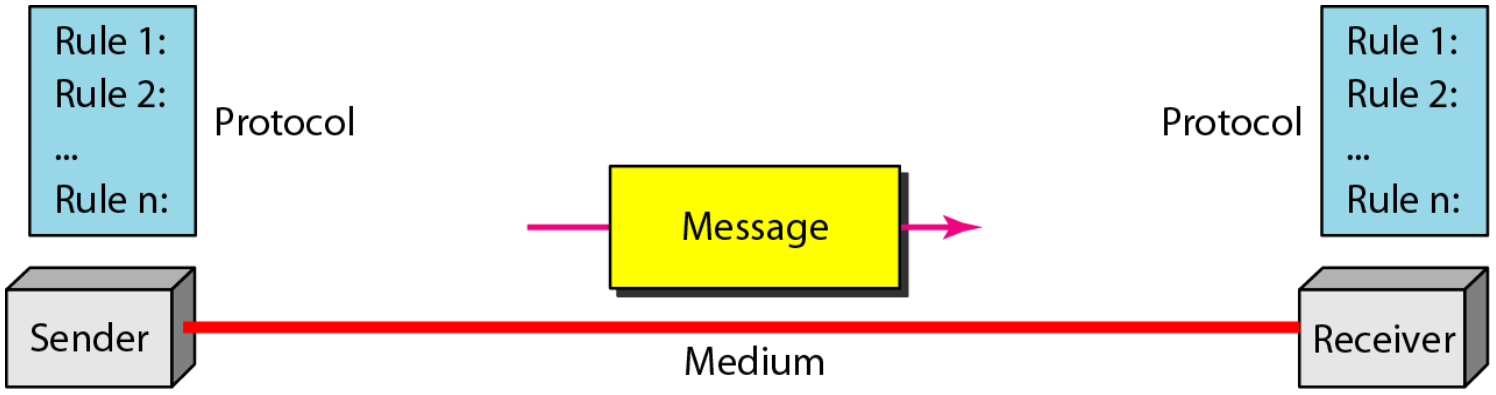
- Communication system made up of a combination of hardware and software
- Effectiveness of data communication system depends on:
  1. Delivery : The system must deliver data to correct destination. Data received by the intended user only
  2. Accuracy: The system must deliver data accurately (no change).
     - Data changed & uncorrected is unusable

Data Communications

3. Timeliness: The system must deliver data in timely manner
   - Data arrived late are useless
   - In the same order (video and audio) & without delay (Real time transmission)
4. Jitter: Variation in the packet arrival time (uneven quality in the video is the result)

Components

- A data communication system is made up of five components

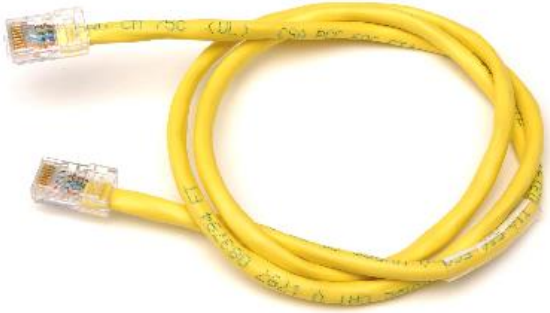


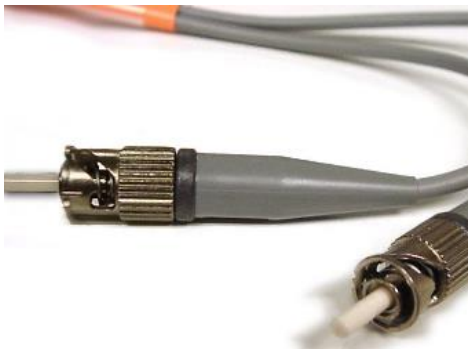
Components

1. Message: the information (data) to be communicated
   - Consist of text, numbers, pictures, audio, or video
2. Sender: the device that sends the data message
   - Computer, workstation, telephone handset, video camera, …
3. Receiver: the device that receives the message
   - Computer, workstation, telephone handset, television, ….

Components

4. Medium: The physical path by which a message travels from sender to receiver
   - twisted pair, coaxial cable, fiber-optic, radio waves





Components

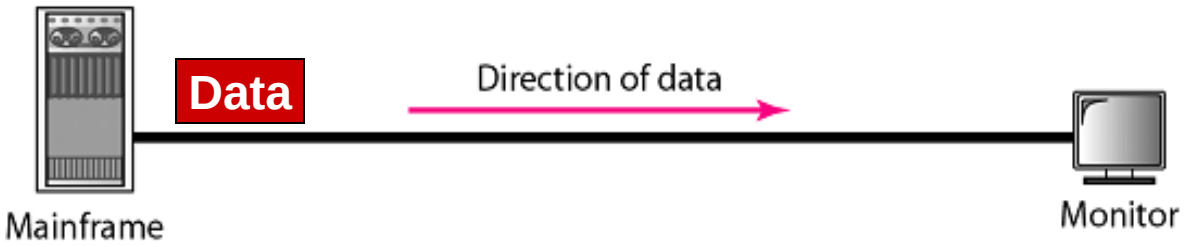
5. Protocol: a set of rules that govern data communications
   - An agreement between the communicating devices
   - Devices may be connected but not communicating (no protocol)

Data Flow

- Communication between two devices can be:
  - Simplex
  - Half-Duplex
  - Full-Duplex

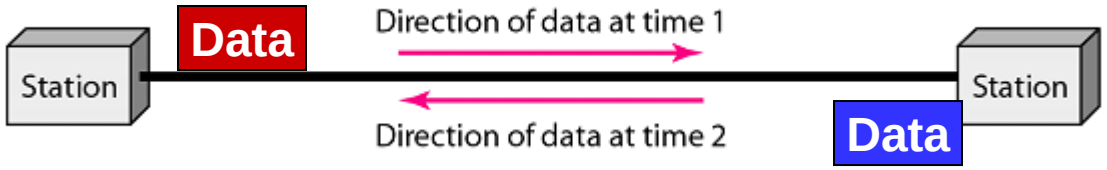
Data Flow

- **Simplex** (one way street)
  - The communication is unidirectional
  - Only one device on a link can transmit; the other can only receive
  - Use the entire capacity of the channel to send data
  - Example: Keyboards, Monitors



Data Flow

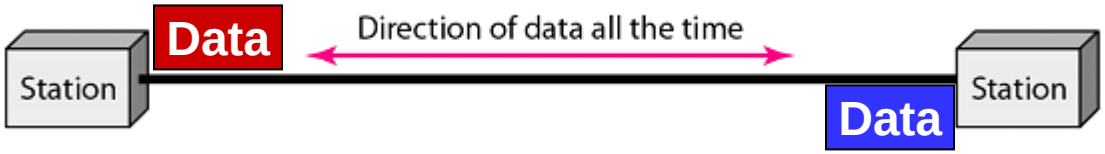
- **Half-Duplex** (one-lane with two-directional traffic)
  - Each station can both transmit and receive, but not at the same time
  - When one device is sending, the other can only receive, and vice versa
  - The entire capacity of a channel is taken over by the transmitting device
  - Example: Walkie-talkies



Data Flow

- **Full-Duplex (Duplex)** (two-way street)
  - Both stations can transmit and receive at same time
  - Signals going in either direction sharing the capacity of the link
  - Sharing can occur in two ways:
    - Link has two physically separate transmission paths
      - One for sending and the other for receiving
    - The capacity of the channel is divided between signals travelling in both directions
  - Example: Telephone network

Full-Duplex (Duplex)



Networks

- Network : A set of devices (nodes) connected by communication links

  Node : computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.

  - Distributed Processing :
    - Most networks used it
    - Task is divided among multiple computers instead of one single large computer

Networks

- **Network Criteria**
  - Network must meet a certain number of criteria
  - The most important of the network criterions are:
    - Performance
    - Reliability
    - Security

Networks

- Performance
  - Transit time: A mount of time required for a message to travel from one device to another
  - Response time: Elapsed time between an inquiry and a response

Networks

- Performance
  - Performance depends on :

    1- Number of users: large number slow response time.

    2- Type of transmission medium: fiber-optic cabling faster than others cables.

    3- Capabilities of the connected hardware: affect both the speed and capacity of transmission.

    4- Efficiency of the software: process data at the sender and receiver and intermediate affects network performance.

Networks

- Performance
  - Performance is evaluated by two contradictory networking metrics:
    - Throughput (high): a measure of how fast we can actually send data through a network
    - Delay (low)

Networks

- Reliability
  - Reliability is measured by:
    1. Frequency of failure
    2. Recovery time of a network after a failure
    3. Network's robustness in a catastrophe: protect by good back up network system

Networks

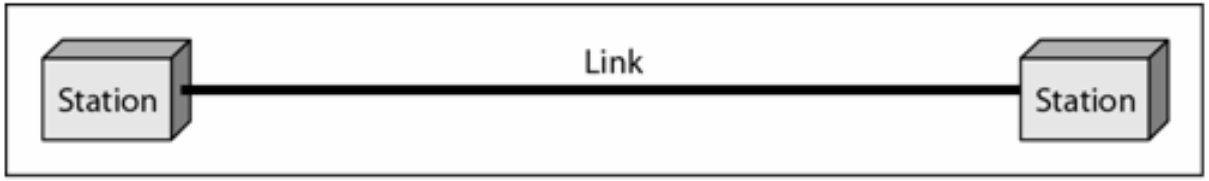
- Security
  - Protecting data from unauthorized access
  - Protecting data from damage and development
  - Implementing policies and procedures for recovery from breaches and data losses (Recovery plan)

Networks - Physical Structures:

- Type of connection
  - Network: Two or more devices connected through links
  - Link: Communication pathway that transfers data from one device two another
  - Two devices must be connected in some way to the same link at the same time. Two possible types:
    - Point-to-Point
    - Multipoint

Networks

- **Point-to-Point**
  - Dedicated link between two devices
  - Entire capacity of the link is reserved for transmission between those two devices
  - Use an actual length of wire or cable



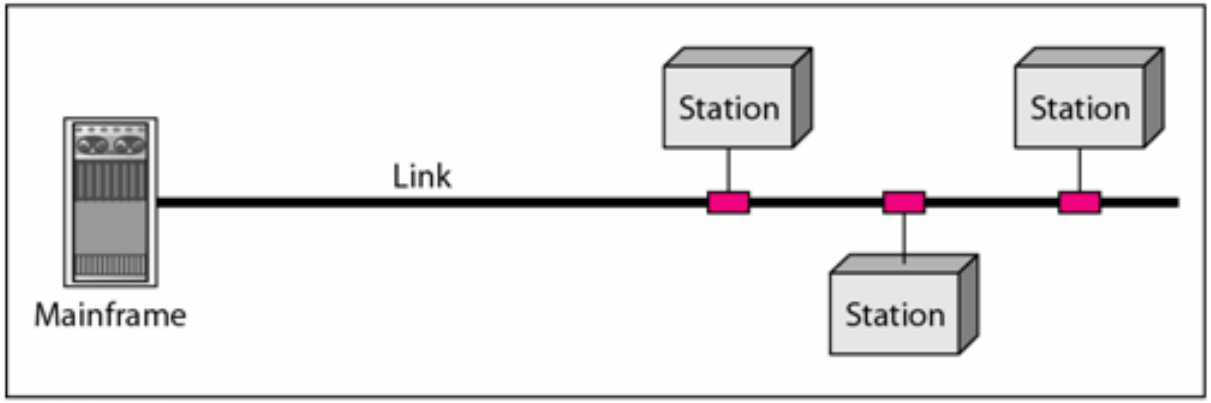
a. Point-to-point

Networks

- **Point-to-Point**
  - Other options, such as microwave or satellite is possible
  - Example: Television remote control

Networks

- **Multipoint (multidrop)**
  - More than two devices share a single link
  - Capacity is shared
  - Channel is shared either spatially or temporally
    - Spatially shared: if devices use link at same time
    - Timeshare: if users must take turns

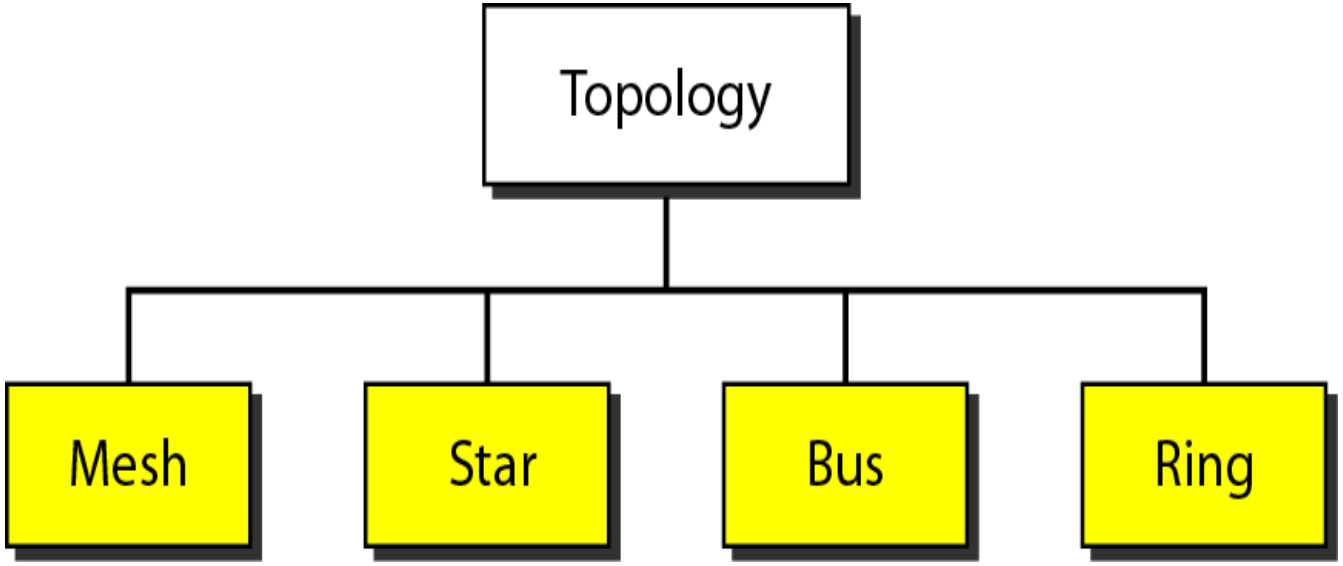


b. Multipoint

Networks - Physical Topology

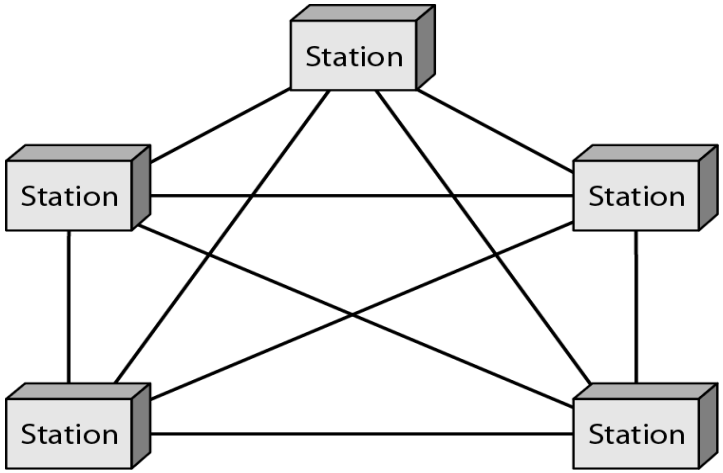
- The way a network is laid out physically
  - Two or more links form a topology
  - The topology of a network is the geometric representation of the relationship of all the links and linking devices (nodes) to one another.
  - Four topologies : Mesh, Star, Bus, and Ring

Physical Topology



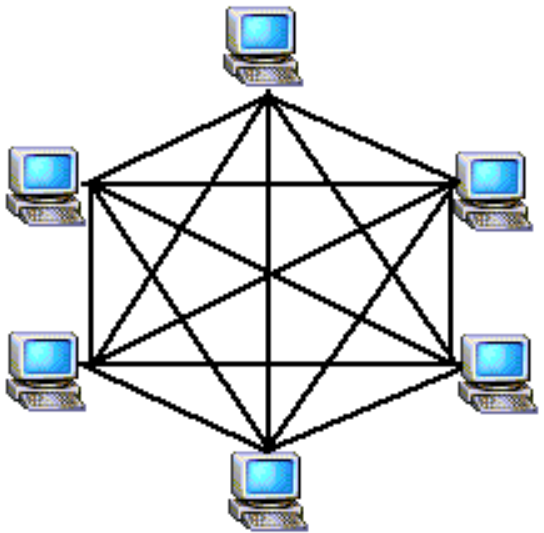
Physical Topology

- **Mesh**
  - Every link is dedicated point-to-point link
  - The term dedicated means that the link carries traffic only between the two devices it connects

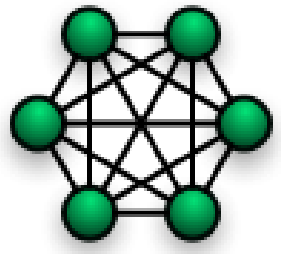


Physical Topology

- **Mesh**
  - To link ***n*** devices fully connected mesh has:
    n (n - 1) / 2 physical channels (Full-Duplex)
  - Every Device on the network must have
    n - 1 ports



Physical Topology



- Mesh
  - Example:

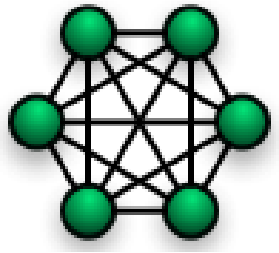
    8 devices in mesh has links: n(n-1) / 2

    number of links = 8 (8-1)/2 = **28**

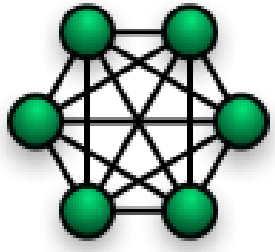
    number of ports per device = n – 1 = 8 –1 = **7**

Physical Topology

- **Mesh**
  - Advantages
    - Each connection carry its own data load (no traffic problems)
    - A mesh topology is robust
    - Privacy or security
    - Fault identification and fault isolation



Physical Topology

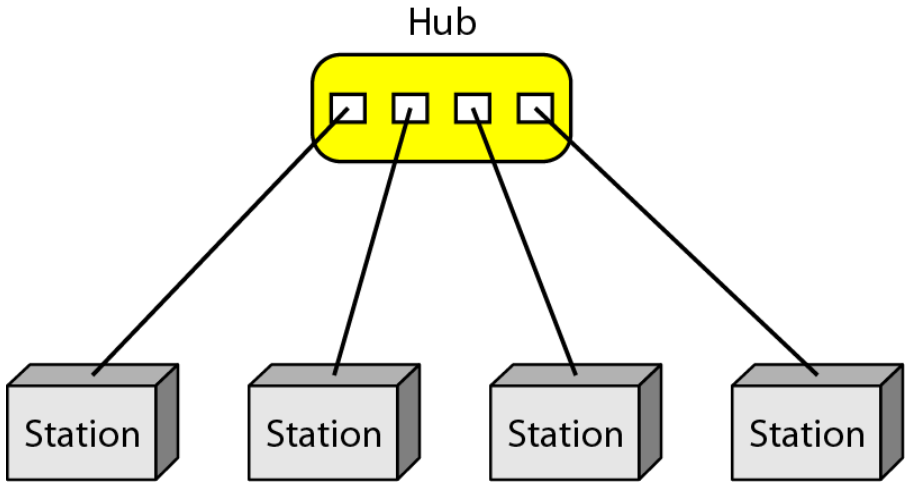


- Mesh:
  - Disadvantages
    - Big amount of cabling
    - Big number of I/O ports
    - Installation and reconnection are difficult
    - Sheer bulk of the wiring can be greater than the available space
    - Hardware connect to each I/O could be expensive

- Mesh topology is implemented in a limited fashion; e.g., as backbone of hybrid network

Physical Topology

- **Star:**
  - Dedicated point-to-point to a central controller (Hub)
  - No direct traffic between devices
  - The control acts as an exchange



Physical Topology

- **Star**
  - Advantages
    - Less expensive than mesh (1 Link + 1 port per device)
    - Easy to install and reconfigure
    - Less cabling
    - Additions, moves, and deletions required one connection
    - Robustness : one fail does not affect others
    - Easy fault identification and fault isolation

Physical Topology

- Star
  - Disadvantages
    - Dependency of the whole topology on one single point (hub)
    - More cabling than other topologies (ring or bus)

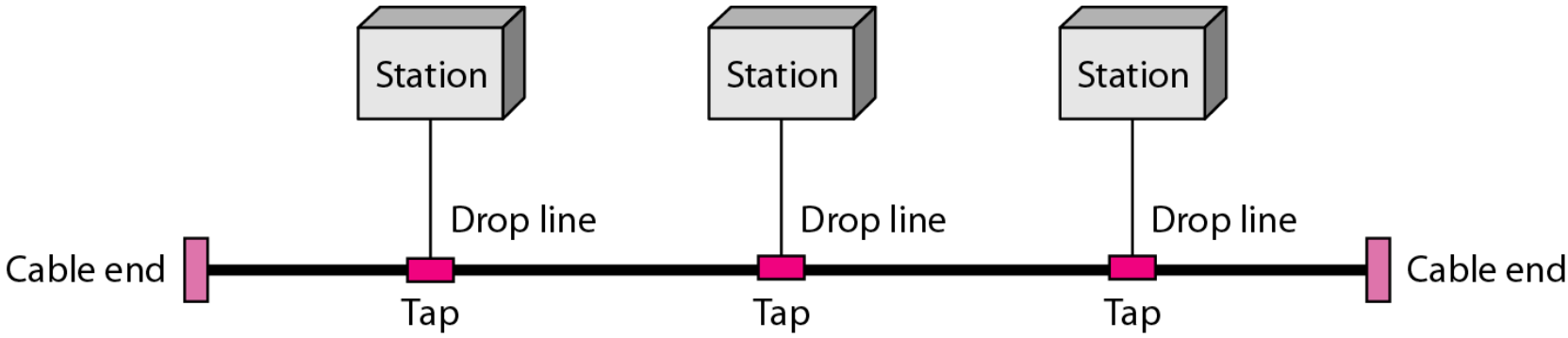
- Used in LAN

Physical Topology

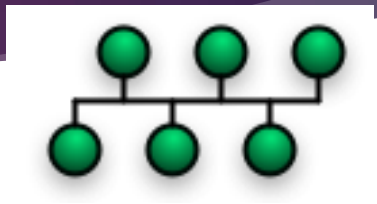
- **Bus**
  - It is multipoint
  - One long cable acts as a backbone
  - Used in the design of early LANS, and Ethernet LANs

Physical Topology

- **Bus**
  - Nodes connect to cable by drop lines and taps
  - Signal travels along the backbone and some of its energy is transformed to heat
  - Limit of number of taps and the distance between taps



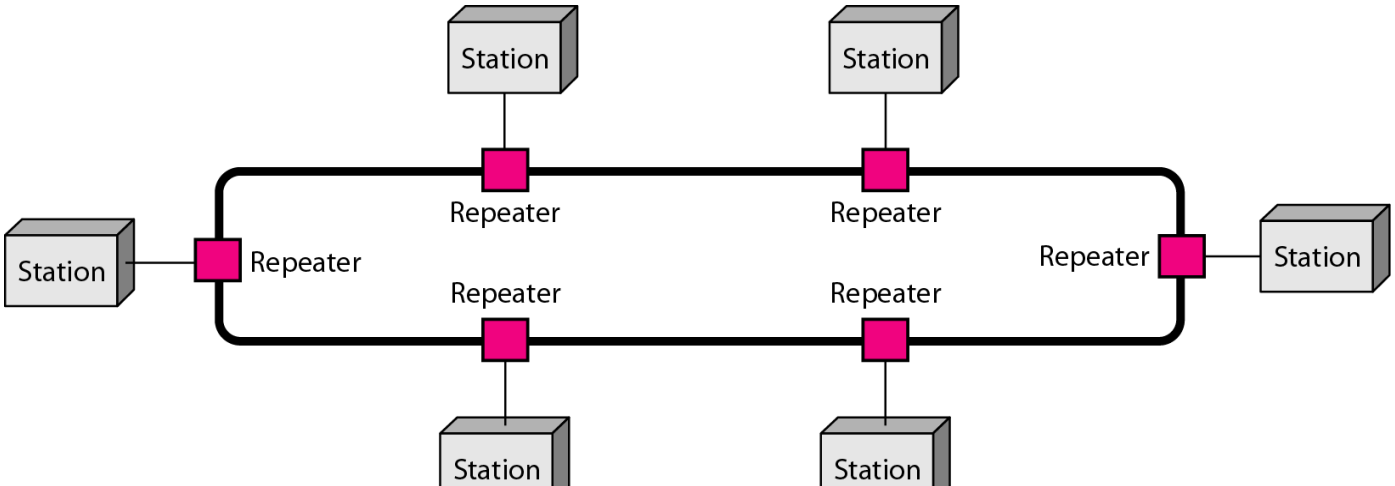
Physical Topology



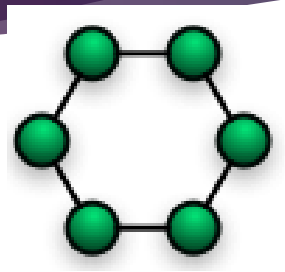
- **Bus**
  - Advantages
    - Ease of installation
    - Less cables than mesh, star topologies
  - Disadvantages
    - Difficult reconnection and fault isolation (limit of taps)
    - Adding new device requires modification of backbone
    - Fault or break stops all transmission
    - The damaged area reflects signals back in the direction of the origin, creating noise in both directions

Physical Topology

- **Ring**
  - Each device has 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 devices incorporates a Repeater



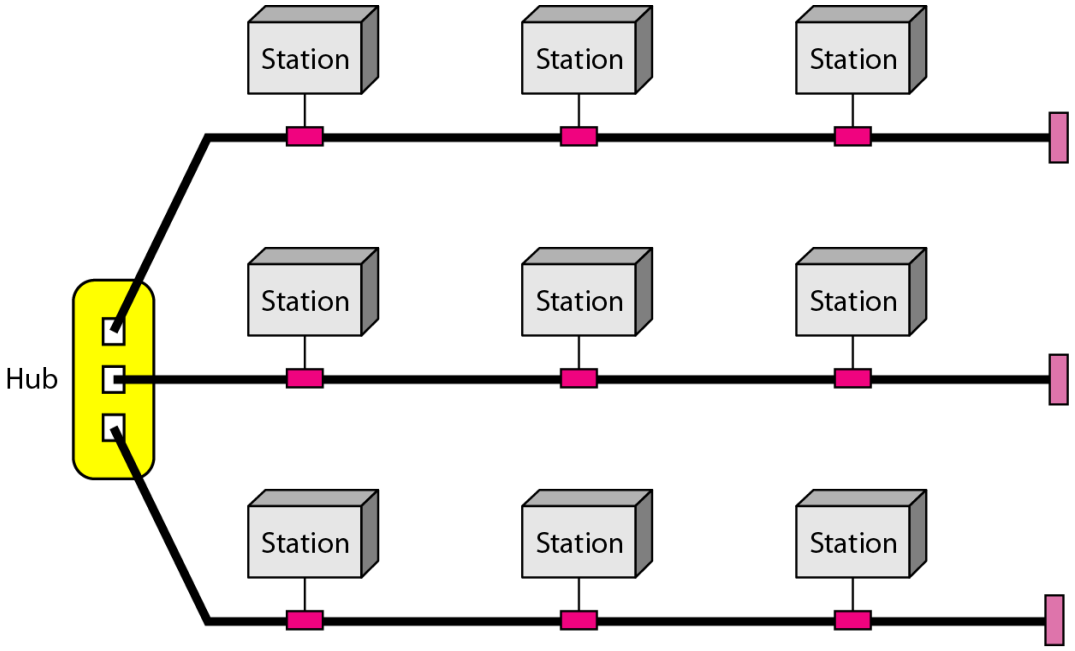
Physical Topology



- **Ring**
  - Advantages
    - Easy of install and reconfigure
    - Connect to immediate neighbors
    - Move two connections for any moving (Add/Delete)
    - Easy of fault isolation
  - Disadvantage
    - Unidirectional
    - One broken device can disable the entire network. This weakness can be solved by using a dual ring or a switch capable of closing off the break

Physical Topology

- Hybrid Topology
  - Example: having a main star topology with each branch connecting several stations in a bus topology



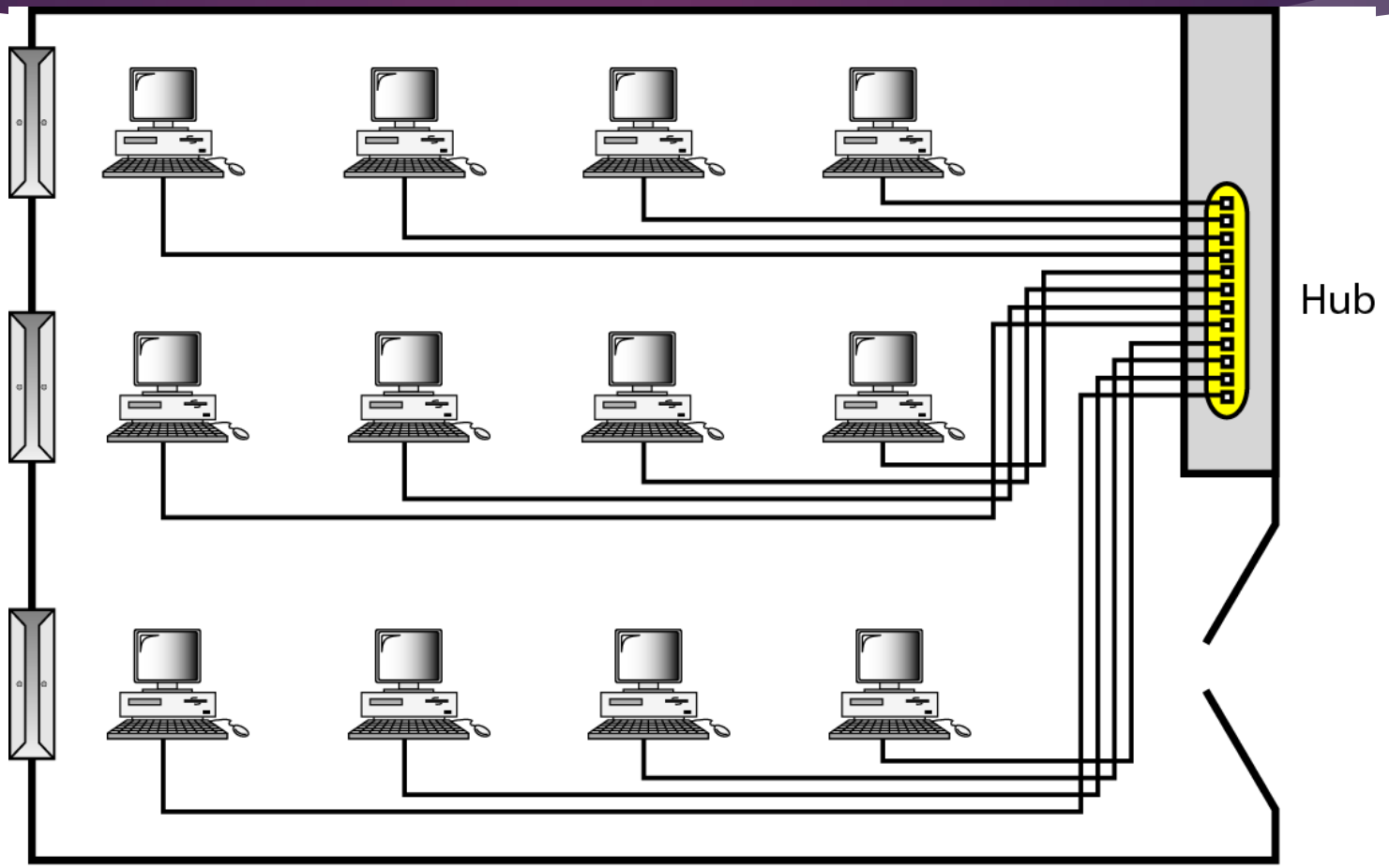
Categories of Networks

- Network Category depends on its size
- Two primary categories
  - **LAN**: Covers area < 2miles
  - **WAN**: Can be worldwide
  - **MAN**: Between LAN & WAN, span 10s of miles

Local Area Network (LAN)

- Privately owned
- Links devices in the same office, building, or campus
- Simple LAN: 2 PCs & 1 printer in home or office
- Size is limited to a few kilometers
- Allow resources to be shared (hardware, software, or data)

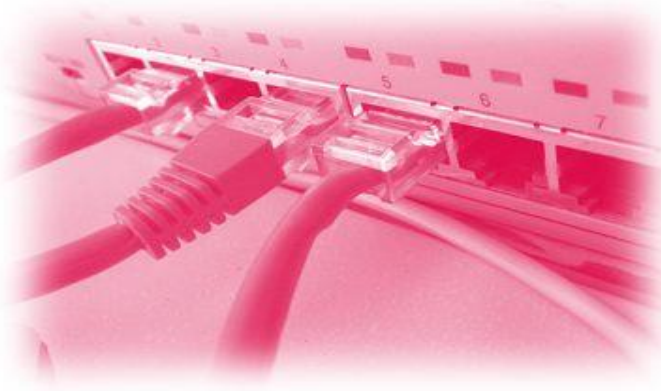
Local Area Network (LAN)



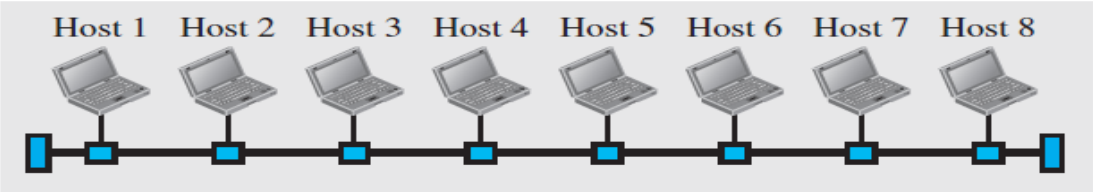
An isolated LAN connecting 12 computers to a hub in a closet

Local Area Network (LAN)

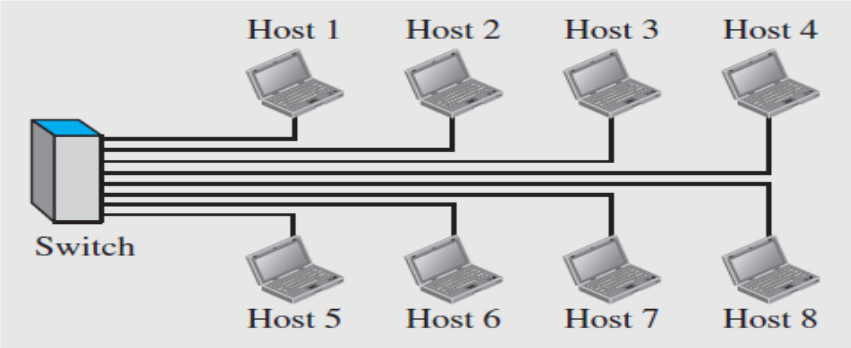
- LAN is distinguished by:
  - Size (# users of OS, or licensing restrictions), transmission medium (only one type), topology (bus, ring, star)
  - Each host in a LAN has an
  - Identifier, an address, that uniquely defines the host in the LAN. A packet sent by a host
  - To another host carries both the source host's and the destination host's addresses.
- Data rates (speed):
  - Early: 4 to 16 mbps
  - Today: 100 to 1000 mbps



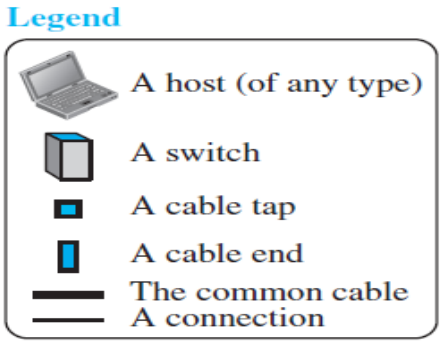
LAN using either a common cable or a switch



a. LAN with a common cable (past)

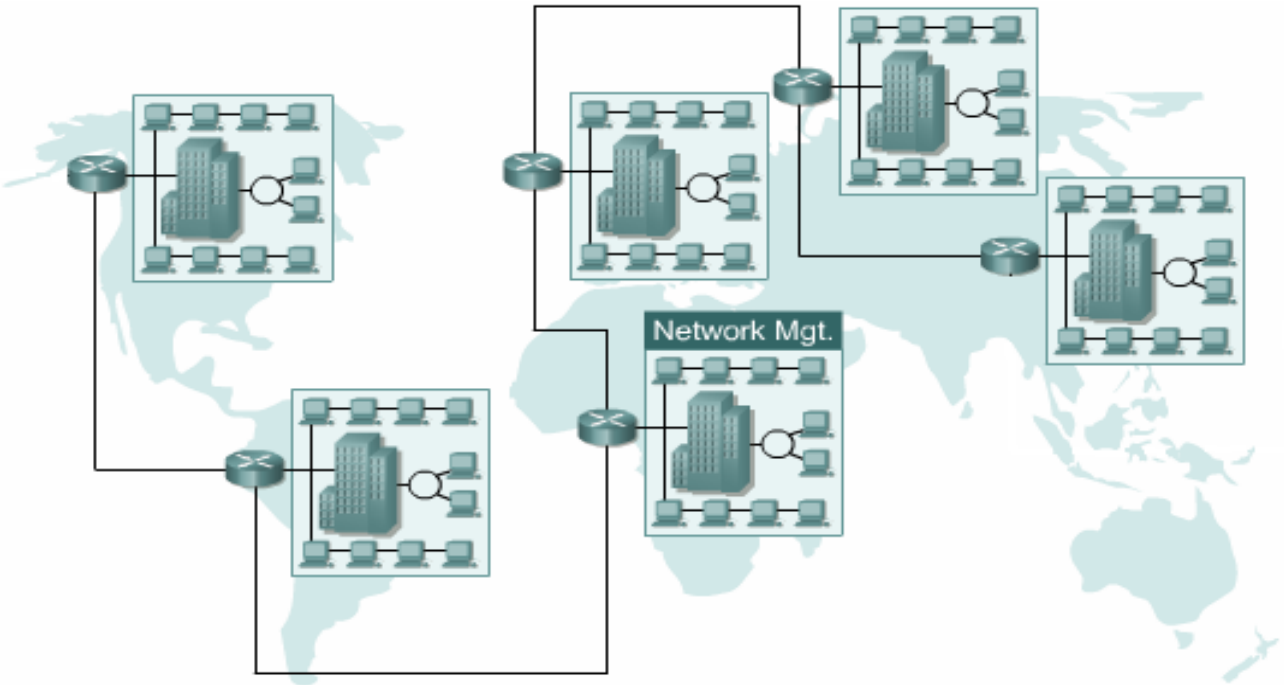


b. LAN with a switch (today)



Wide Area Networks (WAN)

- Provides long-distance transmission of data over large geographic areas (country, continent, world)

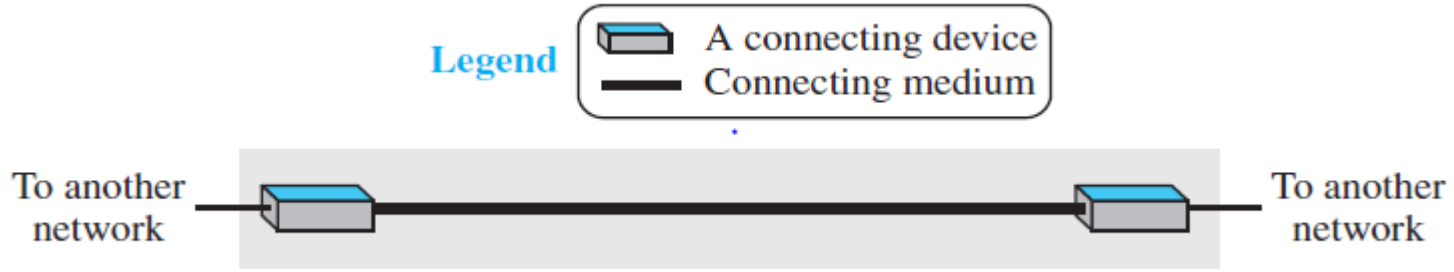


WAN

- A WAN has a wider geographical pan, spanning a town, a state, a country, or even the world.
- A WAN interconnects connecting devices such as switches, routers, or modems.
- A LAN is normally privately owned by the organization that uses it;
- A WAN is normally created and run by communication companies and leased by an organization that uses it

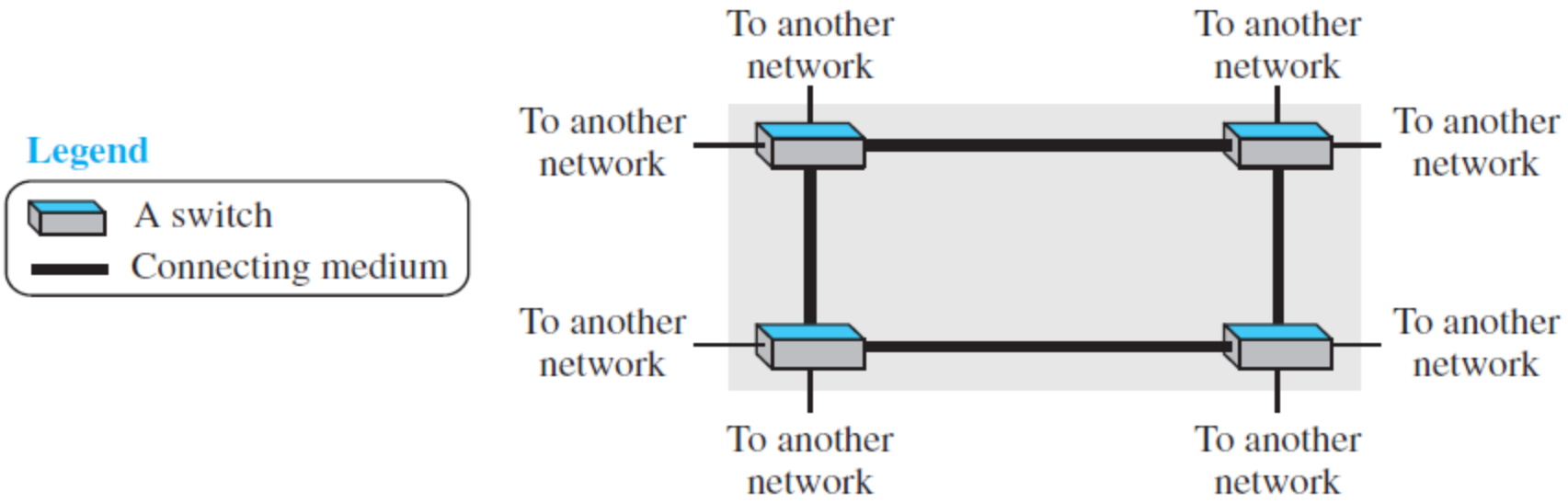
Wide Area Networks (WAN)

- Point-to-point WAN
  - a network that connects two communicating devices through a transmission media (cable or air)

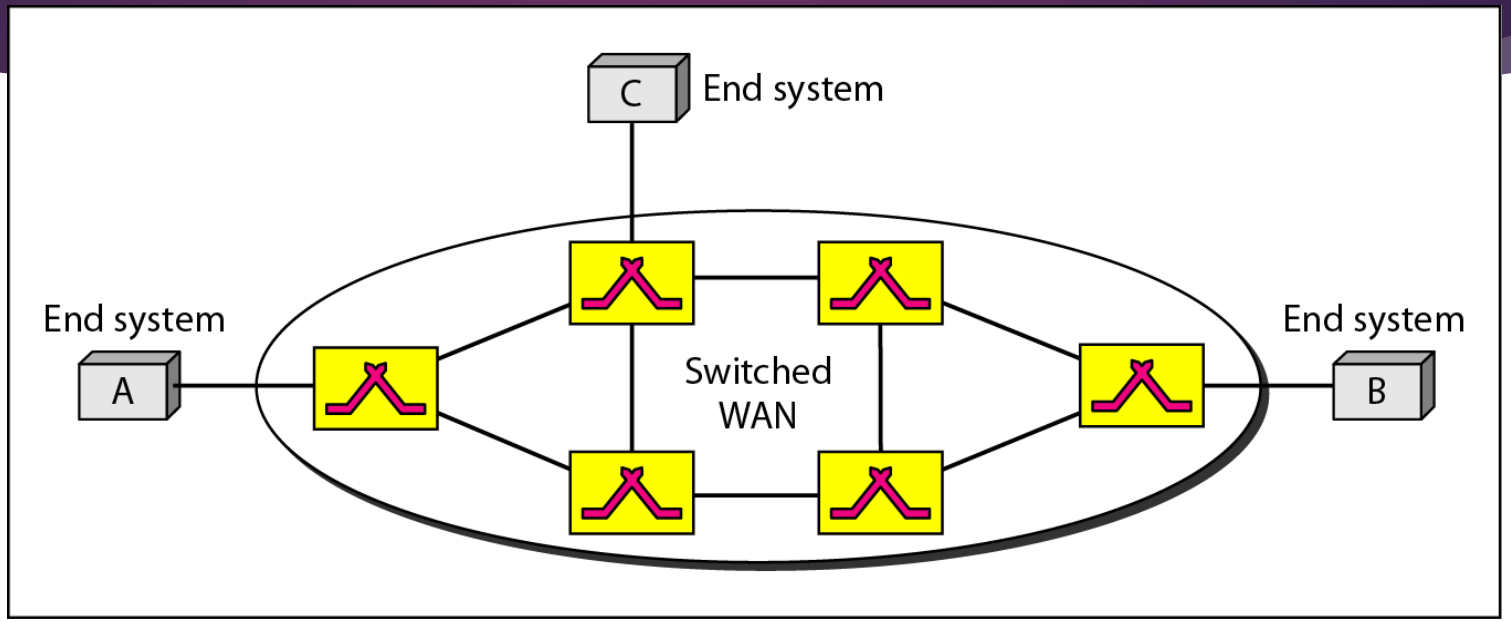


Switched WAN

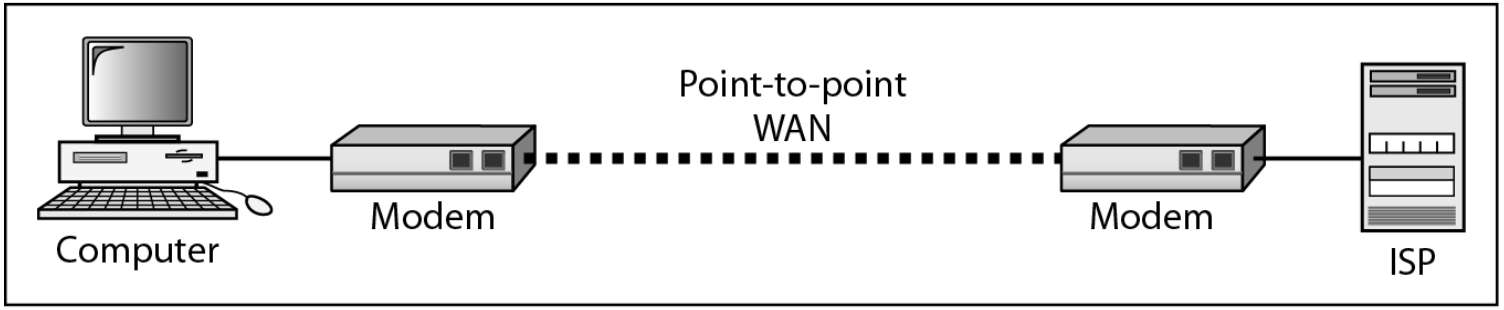
- A netork with more than two ends; used in the backbone of global communication today
- A combination of several point-to-point wans that are connected byswitches.



Wide Area Networks (WAN)



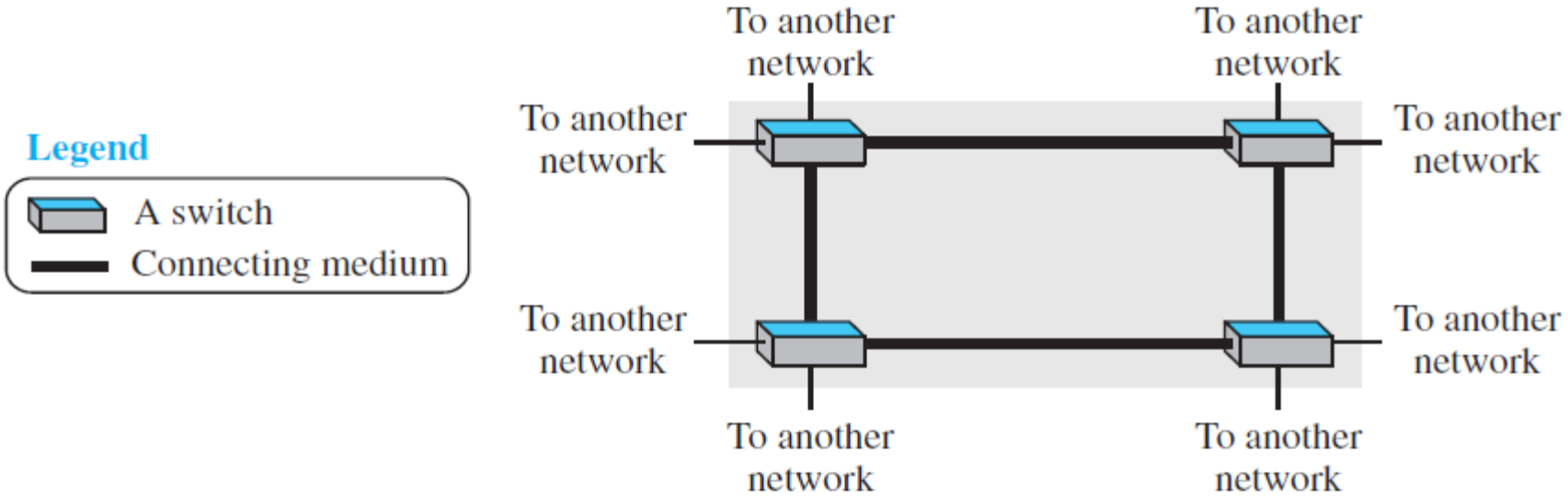
a. Switched WAN



b. Point-to-point WAN

Switched WAN

- A switched WAN is a network with more than two ends
- Combination of several point-to-point WANs that are connected by switches.

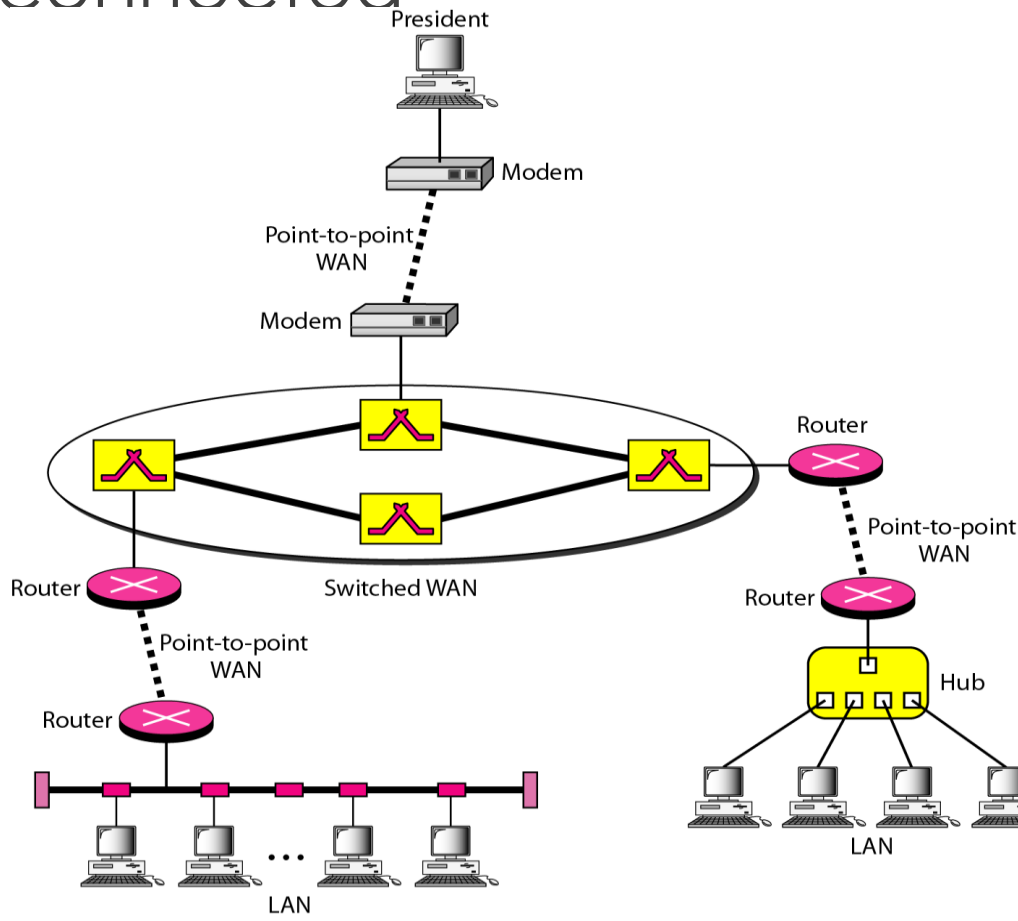


Metropolitan Area Networks (MAN)

- Size between LAN and WAN
- Inside a town or a city
- Example: the part of the telephone company network that can provide a high-speed DSL to the customer

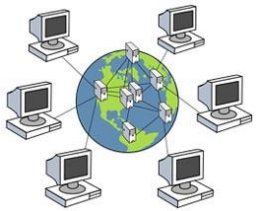
Interconnection of Networks: Internetworks

- Two or more networks connected together



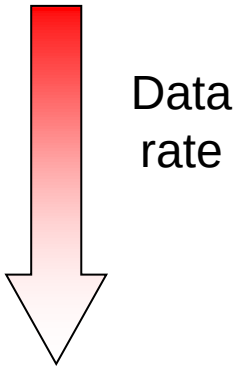
The Internet

- **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.
- Internet is a communication system that has brought a wealth of information to our fingertips and organized it for our use
- An internet is 2 or more networks that can communicate with each other
- The Internet is a collaboration of more than hundreds of thousands of interconnected networks

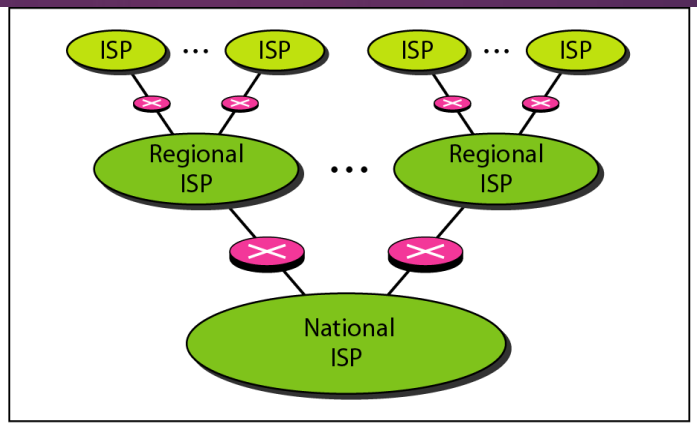


The Internet

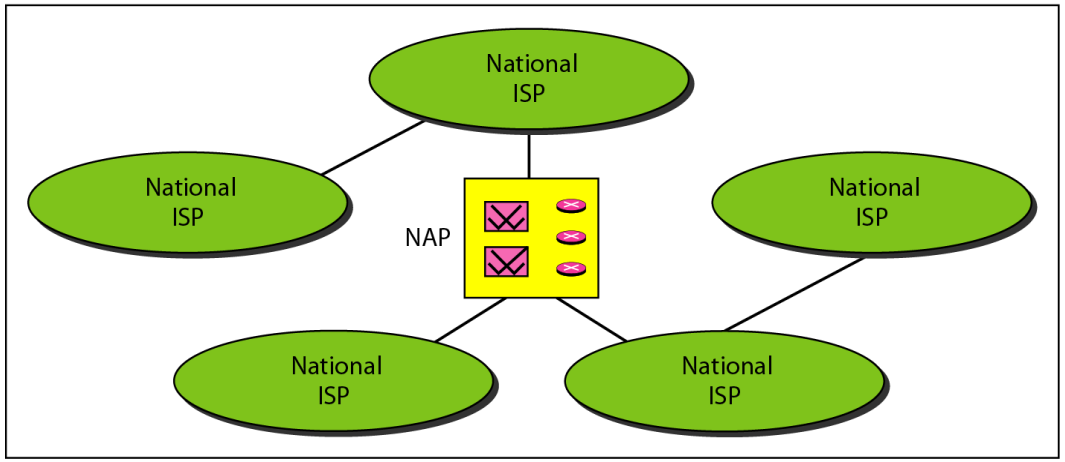
- Internet Today
  - Made of many LANs and WANs
  - Every day new networks area added and removed
  - Internet services Providers (ISPs) offer services to the end users
    - International service providers
    - National service providers
    - Regional service providers
    - Local service providers



The Internet



a. Structure of a national ISP



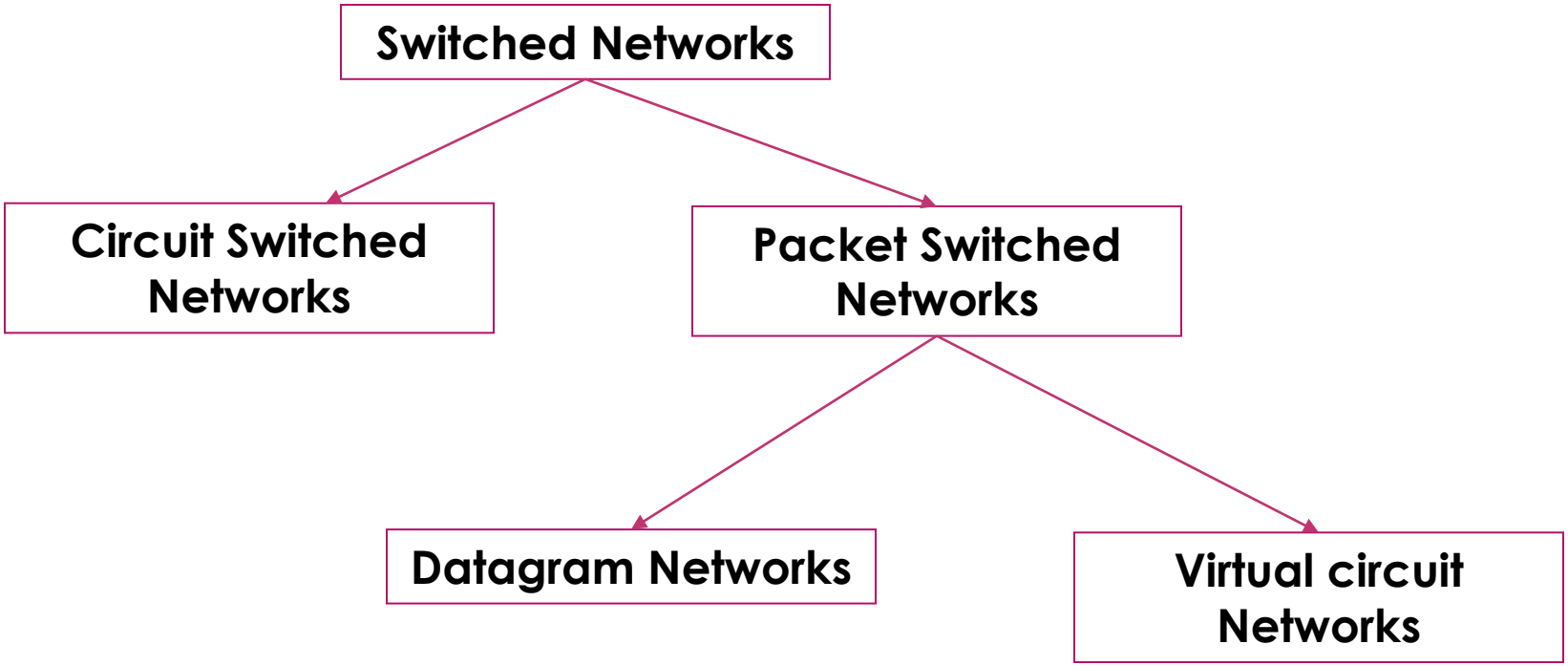
b. Interconnection of national ISPs

Hierarchical organization of the Internet

Switching

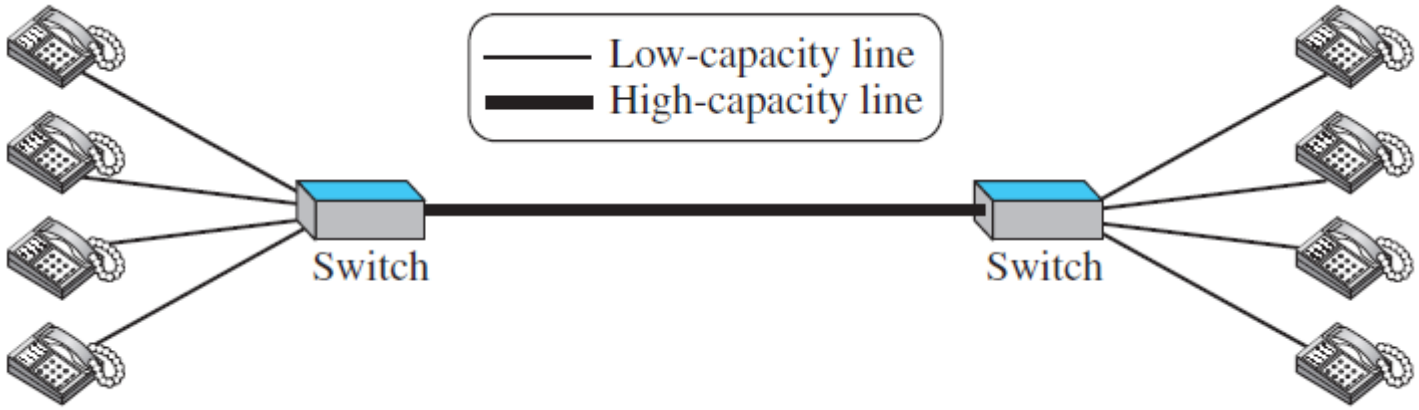
- An internet is a switched network in which a switch connects at least two links together.
- A switch needs to forward data from a network to another network when required.
- Types:
  - Circuit-switched and
  - Packet-switched networks

Switching


Switched Networks
Circuit Switched Networks
Packet Switched Networks
Datagram Networks
Virtual circuit Networks

Circuit-Switched Network

- A dedicated connection, called a circuit, is always available between the two end systems;
- The switch can only make it active or inactive

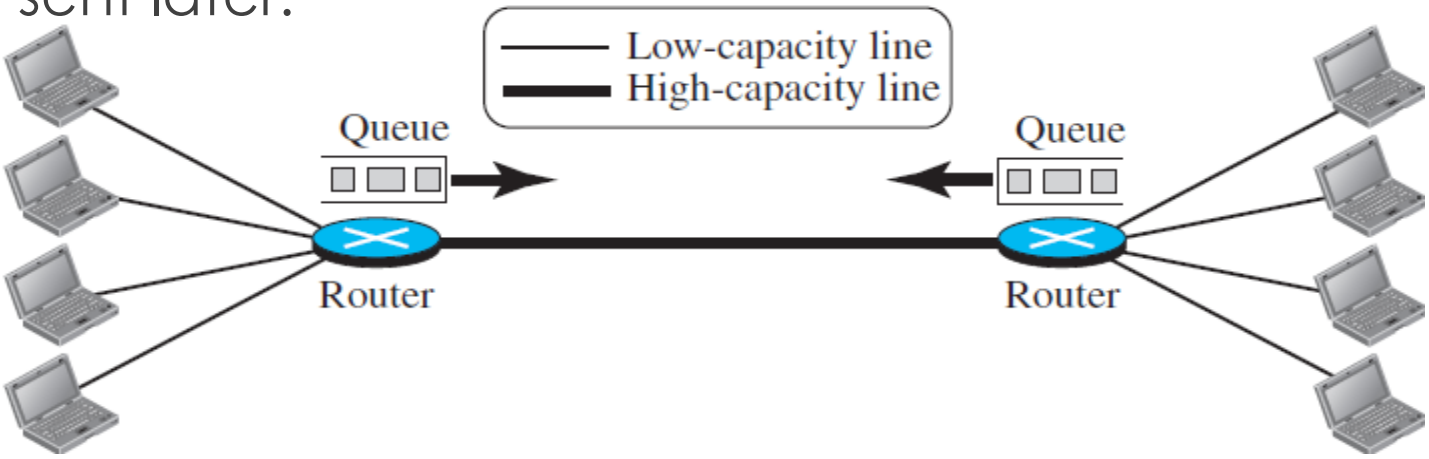


Circuit-Switched Network

- Circuit switching was very common in telephone networks in the past
- The switches used in this example have forwarding tasks but no storing capability.
- A circuit-switched network is efficient only when it is working at its full Capacity
- Most of the time, it is inefficient because it is working at partial capacity

Packet-Switched Network

- The communication between the two ends is done in blocks of data called packets.
- This allows us to make the switches function for both **storing and forwarding**
- Because a packet is an independent entity that can be stored and sent later.



Packet-Switched Network

- A router in a packet-switched network has a queue that can store and forward the Packet.
- If packets arrive at one router when the line is already working at its full capacity, the packets should be stored and forwarded in the order they arrived.
- Packet-switched network is **more efficient** than a circuits witched network, but the packets may encounter **some delays**.

Protocols and Standards

- Protocol synonymous with rule
- Standards: agreed-upon rules

- Protocols
  - A protocol is a set of rules that govern data communications
  - Defines What, How, and When it is communicated

Protocols and Standards

- Elements of a protocol:
  - ***Syntax:*** structure or format of data
    - Example: 8-bits address of sender, 8-bits address of receiver
  - ***Semantics:*** meaning of each section of bits
    - Example: Does the address is a route to be taken or the final destination of the message
  - ***Timing:*** when data should be sent and how fast they can be sent
    - 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

Summary

- A data communications system must transmit data to the correct destination in an accurate and timely manner.
- A network is a set of communication devices connected by media links.
- Topologies: 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.

Test Your knowledge

- The five components of a data communication system are ……..
- Line configurations (or types of connections) are……..
- The number of cables for each type of network is:

  a. Mesh: ----------

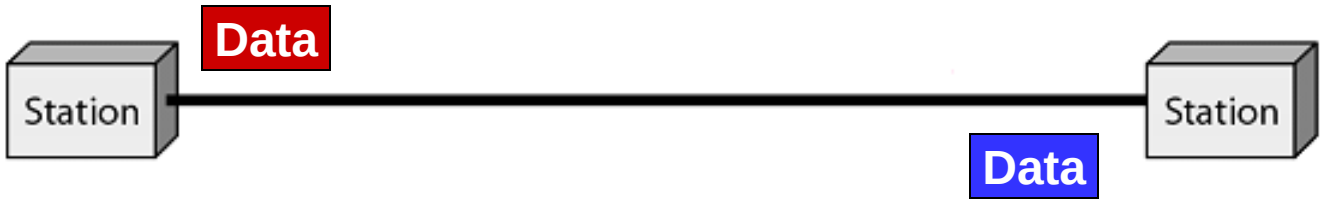
  b. Star: ----------

  c. Ring: ----------

  d. Bus: ----------
- An internet is----------

Test Your knowledge

- What mode of data flow the following exhibits shows?



- What are the three criteria necessary for an effective and efficient network?
- Name the four basic network topologies