Data Communication

UNIT-1

1. Introduction and

2. Network Models

1. INTRODUCTION (Ch 1.1 to 1.5)

i. Data Communications
ii. Networks
iii. Network Types
iv. Standards and Administration

i. Data Communications

- Data communications and networking have changed the way we do business and the way we live.
- Business decisions have to be made ever more quickly, and the decision makers require immediate access to accurate information.
- Data communication and networking have found their way not only through business and personal communication, they have found many applications in political and social issues.

Communities in the world are not isolated anymore.

i. Data Communications

- When we communicate, we are sharing information (local or remote).
- 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.

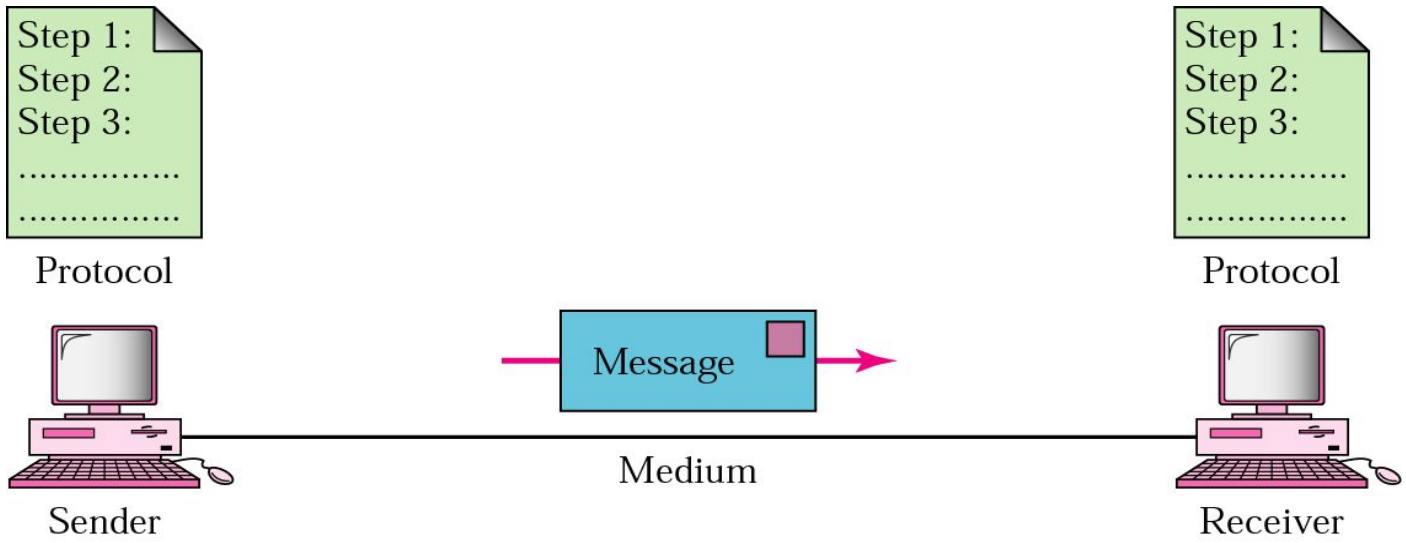
Fundamental Characteristics

- The effectiveness of a data communication system depend on four fundamental characteristics:
  - Delivery
  - Accuracy
  - Timelines
  - Jitter

Fundamental Characteristics

- **Delivery:** must deliver data to the correct destination, *received by the intended device or user* and only by that device or user.
- **Accuracy:** Data that have been altered in transmission and left uncorrected are unusable *(unchanged data)*.
- **Timelines:** Data delivered late are useless. In the case of video and audio, timely delivery means *delivering data as they are produced*, in the same order that they are produced, and without significant delay. This kind of delivery is called *real-time transmission.*
- **Jitter:** The variation in the packet arrival time. It is the *uneven delay in the delivery* of audio or video packets. An uneven quality in the video is the result.

Five Components of Data Communication



1. Message
2. Sender
3. Receiver
4. Medium
5. Protocol

Five Components of Data Communication

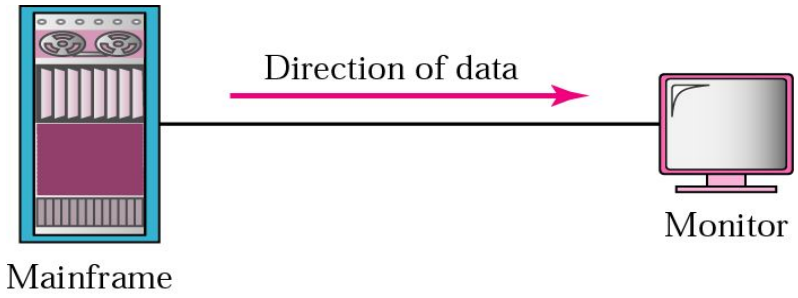
- Message: The information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video..
- Sender: The device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.
- Receiver: The device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.
- Transmission medium: The physical path by which a message travels from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves..
- Protocol: A set of rules that govern data communications. It represents an agreement between the communicating devices.

Data Representation

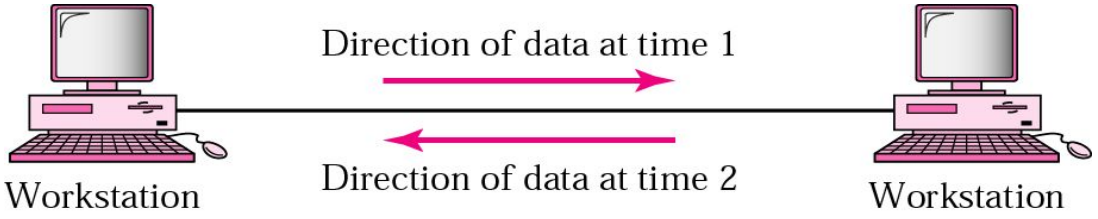
Data can be represented using:

1. Number
2. Text
3. Image
4. Audio
5. Video

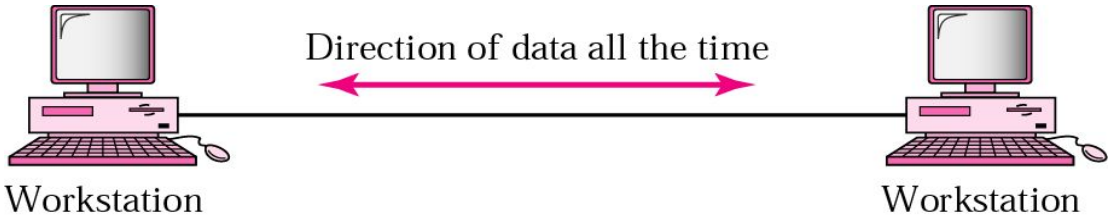
Direction of data flow (Simplex, Half-duplex, and Full-duplex)



Simplex



Half Duplex



Full Duplex

ii. Networks:

- The interconnection of a set of devices/noes capable of communication.
- A device can be a **host** (or an *end system* as it is sometimes called) such as a large computer, desktop, laptop, workstation, cellular phone, or security system.
- A device can also be a **connecting device** such as a router - connects the network to other networks, a switch - connects devices together, a modem - changes the form of data, and so on.
- All the devices are connected using wired or wireless transmission media such as cable or air.

ii. Networks: key issues

- **Network criteria**
  - Performance (Depends on No. of factors, viz. No. of Users, the type of transmission medium, the capabilities of the connected H/W, and the efficiency of the S/W.)
    - Transit time
    - Response time
    - Throughput
    - Delay
  - Reliability (Depends on and the network's robustness in a catastrophe)
    - Data transmitted are identical to data received.
    - Measured by the frequency of failure
    - The time it takes a link to recover from a failure
  - Security
    - Protecting data from unauthorized access and damage, implementing policies and procedures for recovery from breaches and data losses.

Terminology

- The ***throughput*** or ***bandwidth*** of a channel is the number of bits it can transfer per second

- The ***latency*** or ***delay*** of a channel is the time that elapses between sending information and the earliest possible reception of it

Type of connection:

Two or more devices connected through **LINKS -** a communications pathway that transfers data from one device to another.

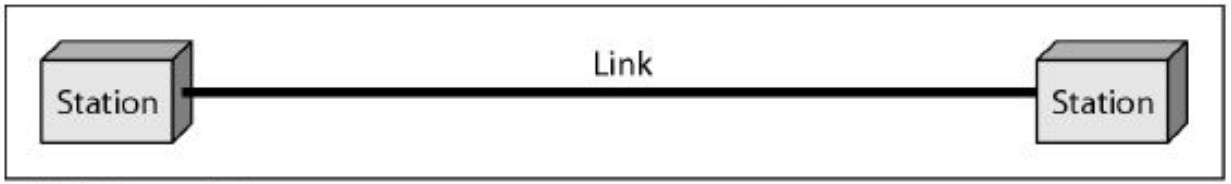
- Point to Point: A dedicated link between two devices, uses an actual length of wire or cable to connect the two ends.

  (E.g.: Changing Television channels by infrared remote control)

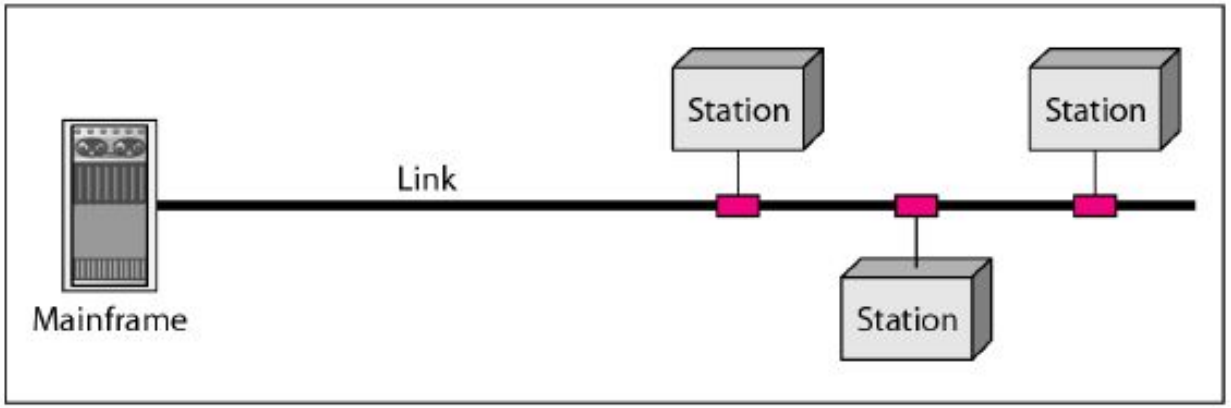
- Multipoint: More than two specific devices share a single link.
  - The capacity of the channel is shared, either spatially or time shared.
  - If devices can use the link simultaneously, it is a *spatially shared* connection.
  - If users must take turns, it is a *timeshared connection.*

Type of connection:…

Types of connections: point-to-point and multipoint



a. Point-to-point



b. Multipoint

If several devices can use the link simultaneously, it is a *spatially shared* connection. If users must take turns, it is a *timeshared* connection.

Type of connection:…

Point to Point vs. Multipoint

Network Topologies/Physical Topology

- Refers to the way in which a network is laid out physically/Topology defines the way hosts are connected to the network
- Two or more devices connect to a **link**; 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 (usually called ***nodes***) to one another.
- There are four basic topologies possible: ***mesh, star, bus, and ring.***

Network topology issues

A goal of any topology

1. high **throughput** (bandwidth)
2. low **latency**

Bandwidth and Latency

Bandwidth

1. telecommunications: **range of radio frequencies:** a range of radio frequencies used in radio or telecommunications transmission and reception.

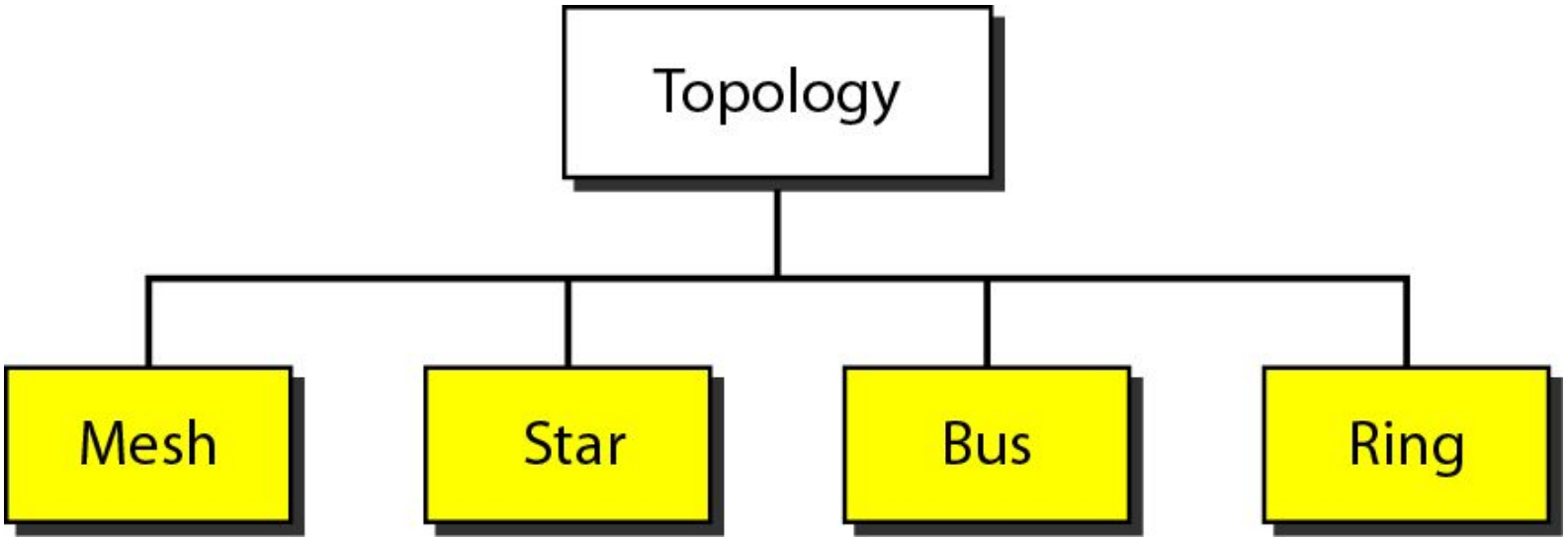
2. computing: **communications capacity:** the capacity of a communications channel, for example, a connection to the Internet, often measured in bits per second.

3. a data **transmission rate**; the maximum amount of information (bits/second) that can be transmitted along a channel.

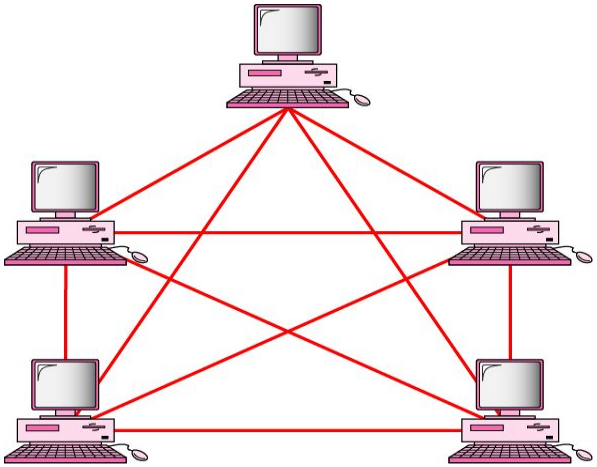
Latency

A synonym for *delay,* is an expression of how much time it takes for transmission from one designated point to another .

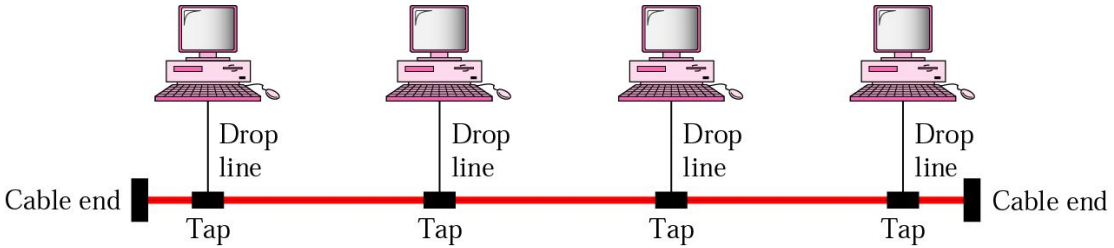
Categories of Topology



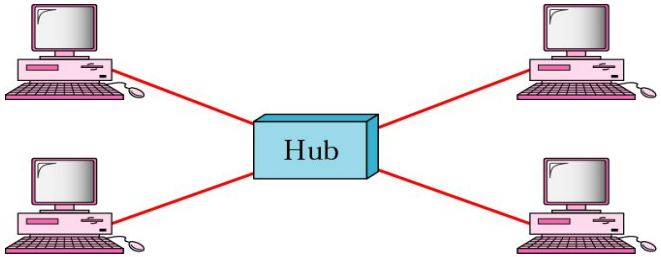
Mostly used network topologies



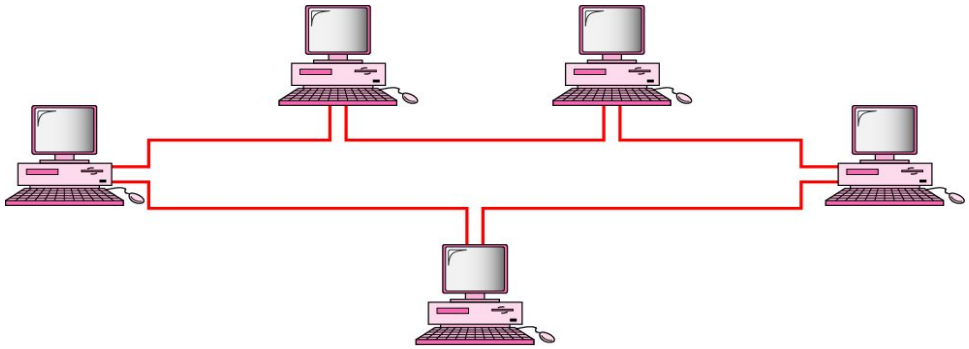
mesh



bus



star



ring

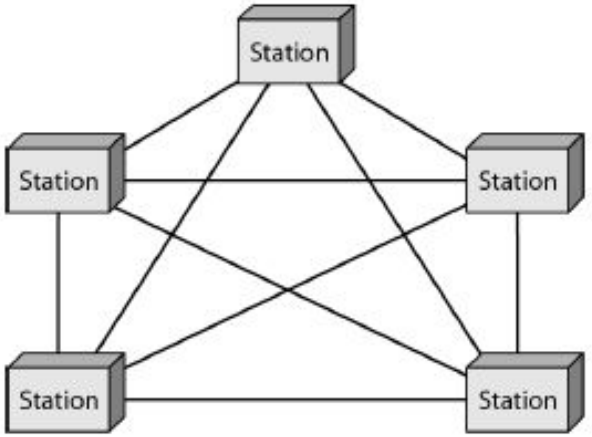
Mesh Topology (point-to-point connections)

A fully connected mesh topology (five devices)

- ***High speed, Little network failure***
- ***Privacy and Security***
- ***Fault isolation***
- ***Fault identification***

Demerits:

- ***No. of links***
- ***No. of I/O ports***
- ***Costing***



Here, we need ***n* (*n* – 1) / 2** duplex-mode links.

Mesh Topology…

Advantage:

- Only one link between pair of nodes (secure, less load, robust (if one link goes it will not cripple the entire network)

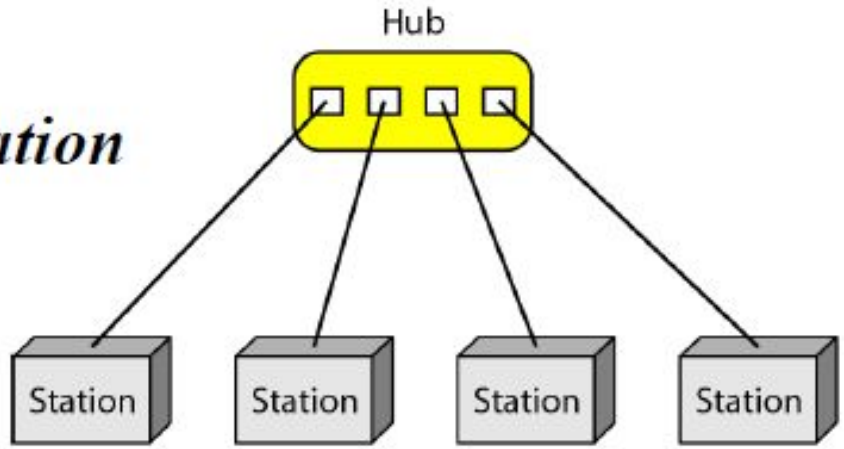
Disadvantage:

- Too much cabling and installation work
- Too much hard ware required (because of port requirement)
- Feasible for limited applications or backbone network

Here, we need ***n* (*n* – 1)** / **2** duplex-mode links.

Star Topology (point-to-point connections)

A star topology connecting four stations



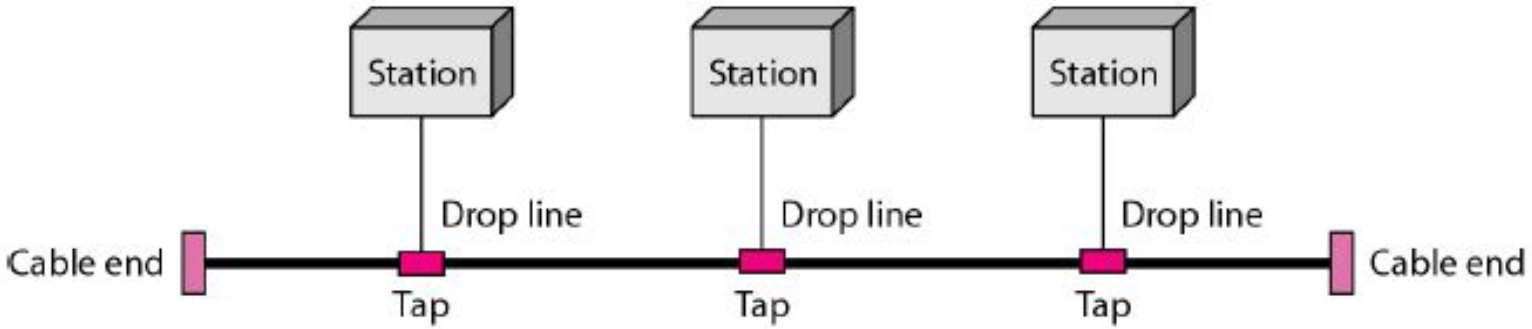
Installation, reconfigure
Fault isolation and identification
Costing, I/O ports

Demerit:
Single point of dependency

- One big disadvantage of a star topology is the dependency of the whole topology on one single point, the hub. If the hub goes down, the whole system is dead.
- Used in local-area networks (LANs).

Bus Topology (Multipoint connections)

A bus topology connecting three stations

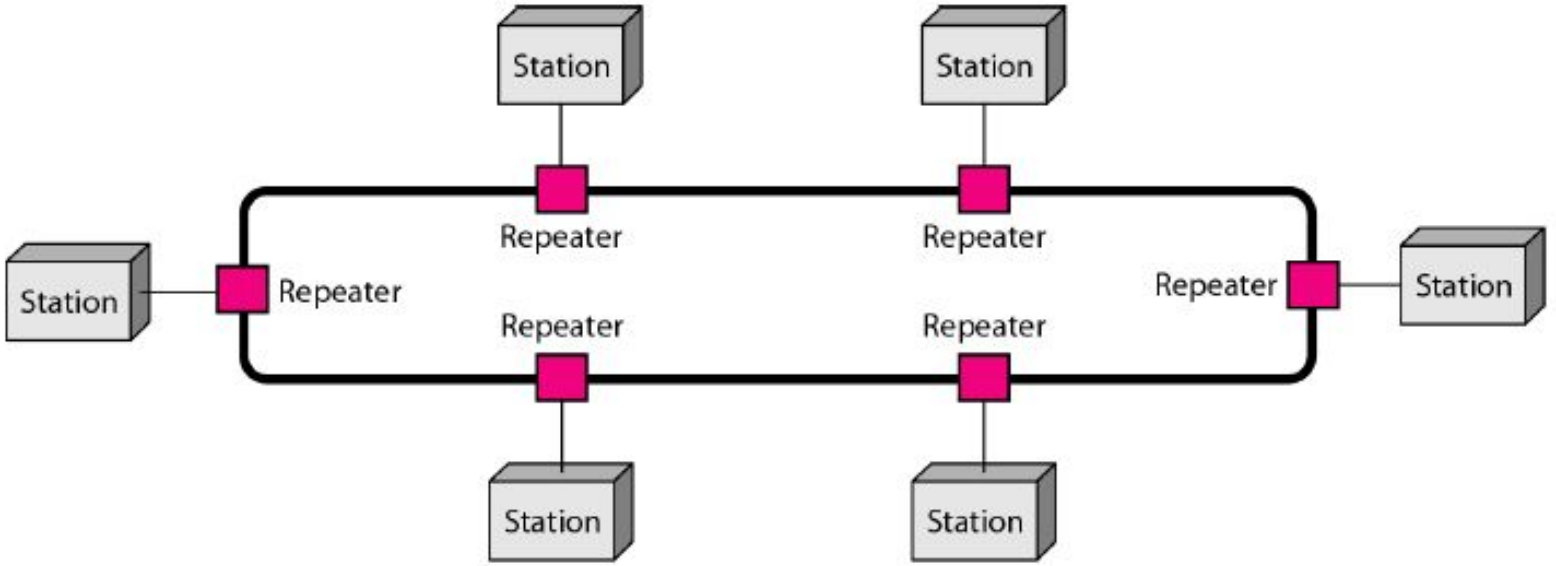


Long distance issue
Installation
Number & length of cables
Reconnection, signal reflection

Adding new devices require modification or replacement of the backbone.

Ring Topology (A dedicated point-to-point connection)

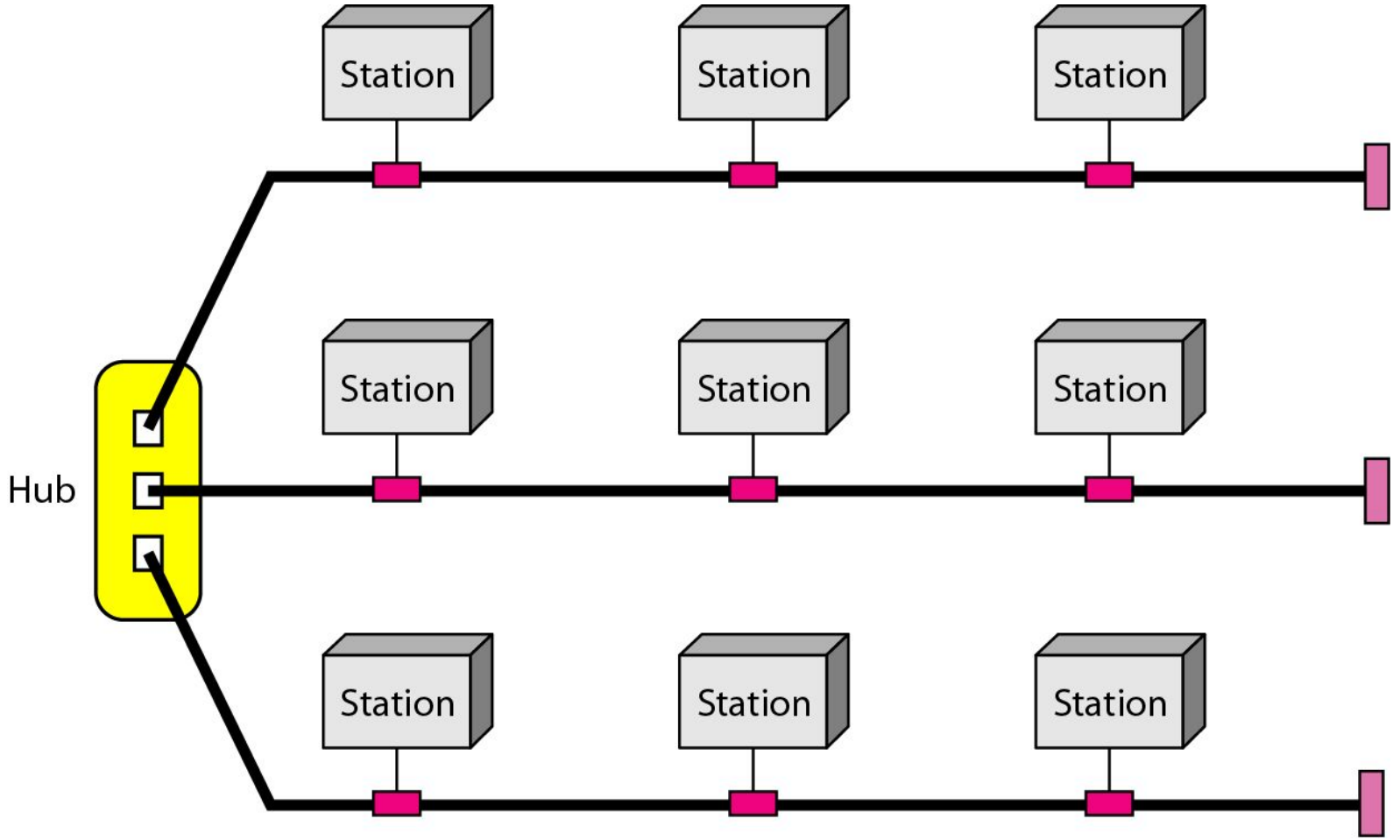
A ring topology connecting six stations



Uni-directional
Installation
Repeaters
Fault isolation

Dual ring

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



iii. Network Type

- The criteria of distinguishing one type of network from another is difficult and sometimes confusing.
- Size, geographical coverage, and ownership criteria's used to make distinction.
- Two types of networks: LANs and WANs.
- Switching - used to connect networks to form an internetwork (*a network of networks*).

iii. Network Type…

- Types of Network
  based on transmission mode
  based on scale or distance

iii. Network Type…

Categories of Networks

LAN

- Privately owned for office, home, buildings etc.
- limited to few kms.
- resource sharing
- generally one type of transmission medium
- speed
- WLAN

WAN

- Long distance transmission
- either complex (*Switched WAN*) or simple (*point to point WAN*)
- e.g. X.25 >> Frame Relay >> ATM
- Wireless WAN

MAN

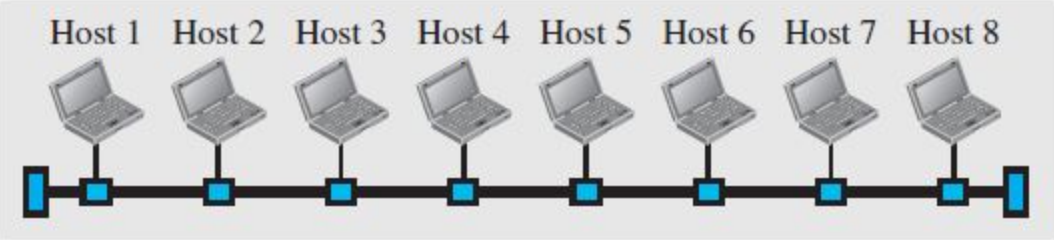
- High speed, DSL, Cable TV network

iii. Network Type - LAN

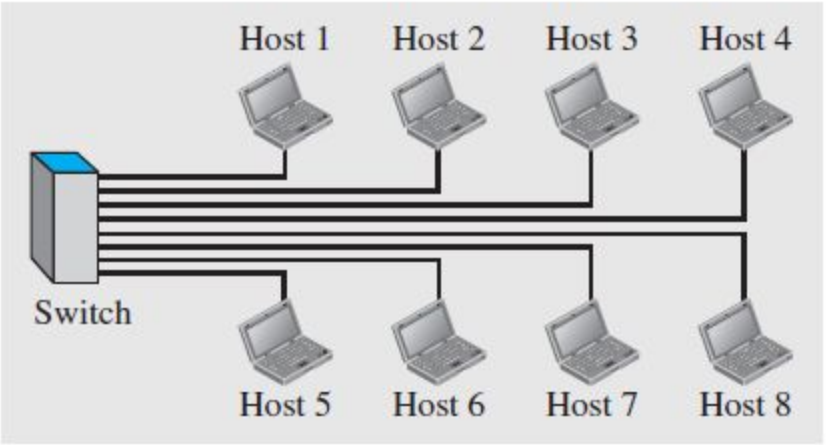
- Privately owned and connects some hosts in a single office, building, or campus.
- Depending on the needs of an organization, a LAN can be as simple as two PCs and a printer in someone's home office, or it can extend throughout a company and include audio and video devices.
- Today, most LANs use a smart connecting *switch* - able to recognize the destination address of the packet and guide the packet to its destination without sending it to all other hosts.
- LANs today are connected to each other and to WANs to create communication at a wider level.

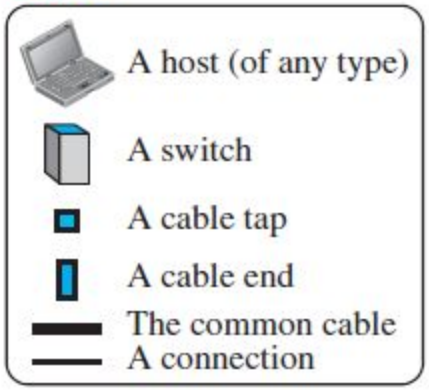
iii. Network Type - LAN…

An isolated LAN in the past and today



a. LAN with a common cable (past)





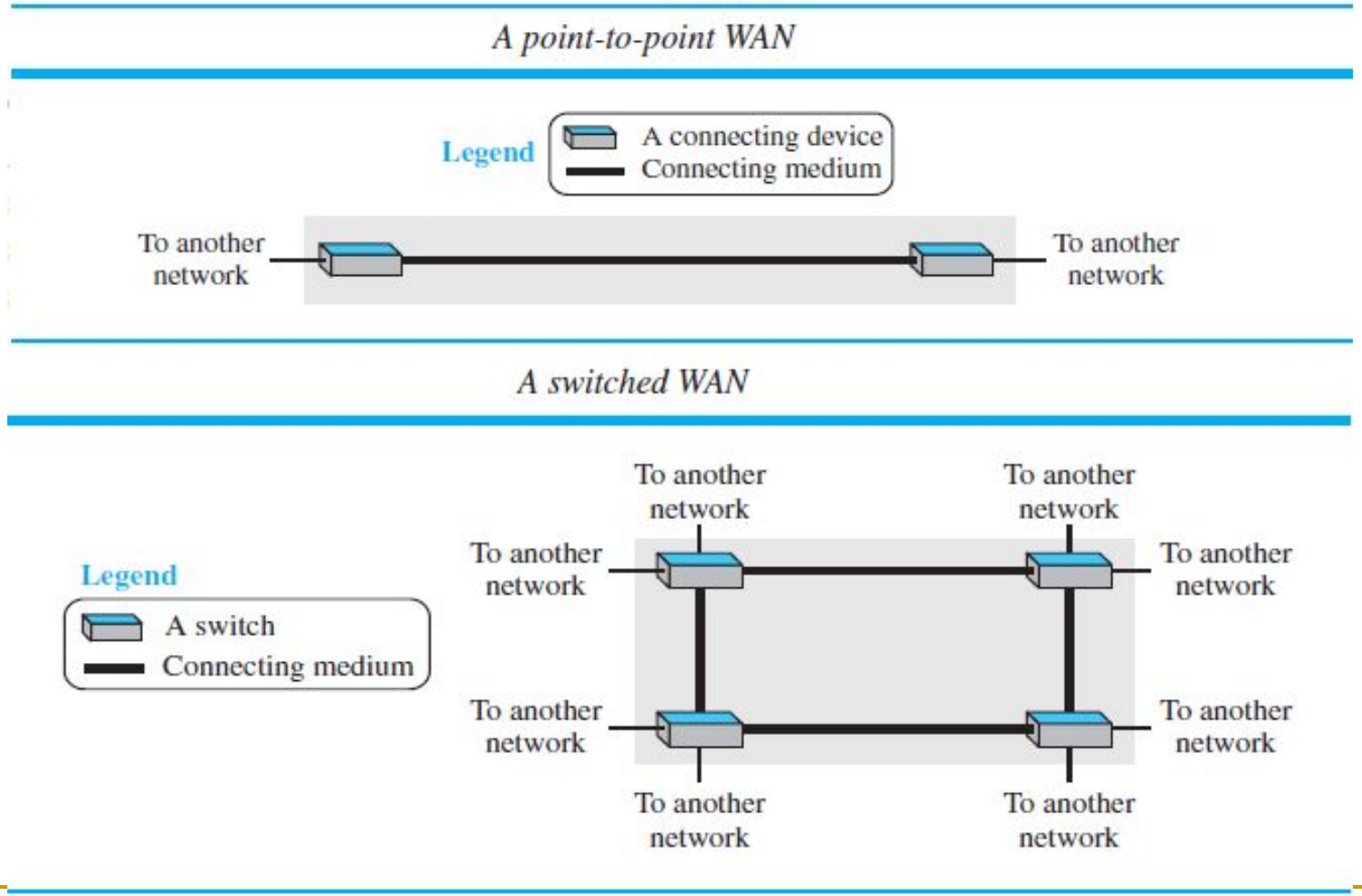
b. LAN with a switch (today)

iii. Network Type - WAN

- An interconnection of devices capable of communication, with a wider geographical span, spanning a town, a state, a country, or even the world.
- A LAN interconnects hosts; 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. We see two distinct examples of WANs today: point-to-point WANs and switched WANs.
- Two distinct examples of WANs today are point-to-point WANs and switched WANs.
- ***Point-to-Point WAN***: A network connects two communicating devices through a transmission media (cable or air).
- ***Switched WAN***: A network with more than two ends, a combination of several point-to-point WANs that are connected by switches.

iii. Network Type - WAN…

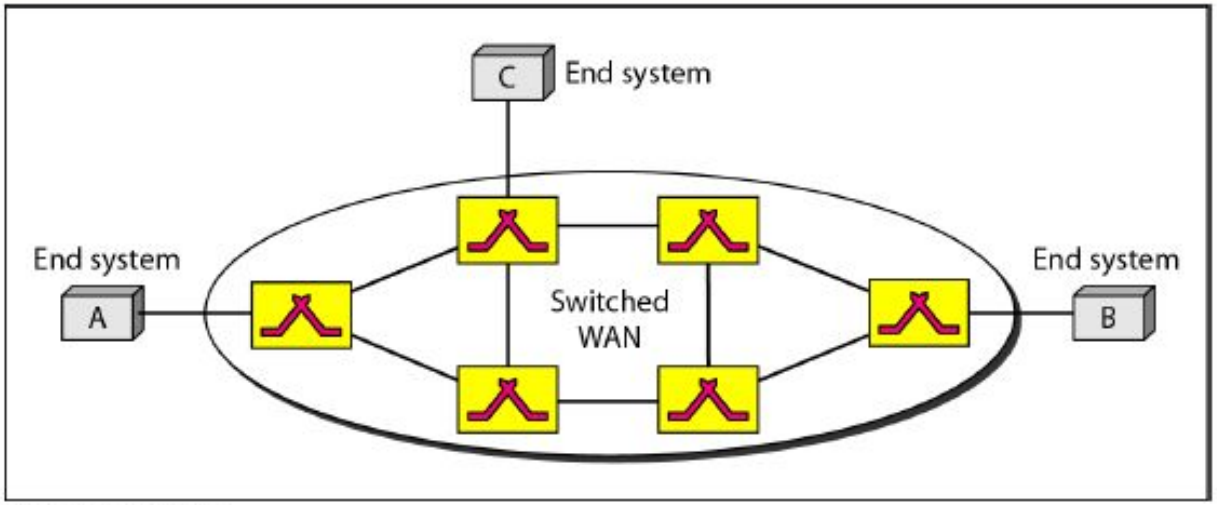
Two distinct examples of WANs today are point-to-point WANs & switched WANs.



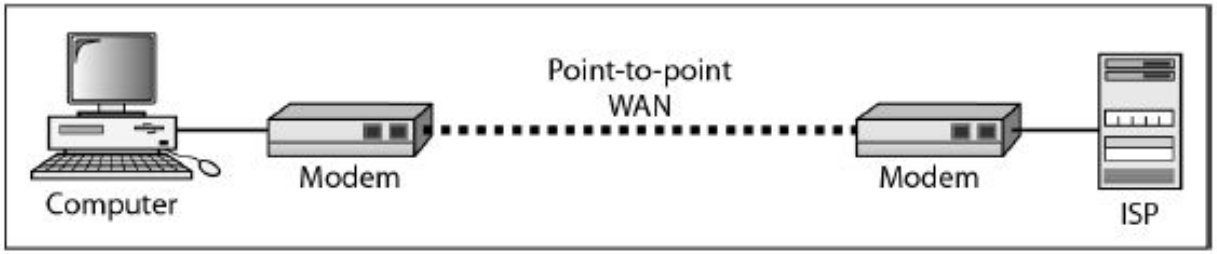
iii. Network Type - WAN…

Two dist WANs.

WANs: a switched WAN and a point-to-point WAN



a. Switched WAN

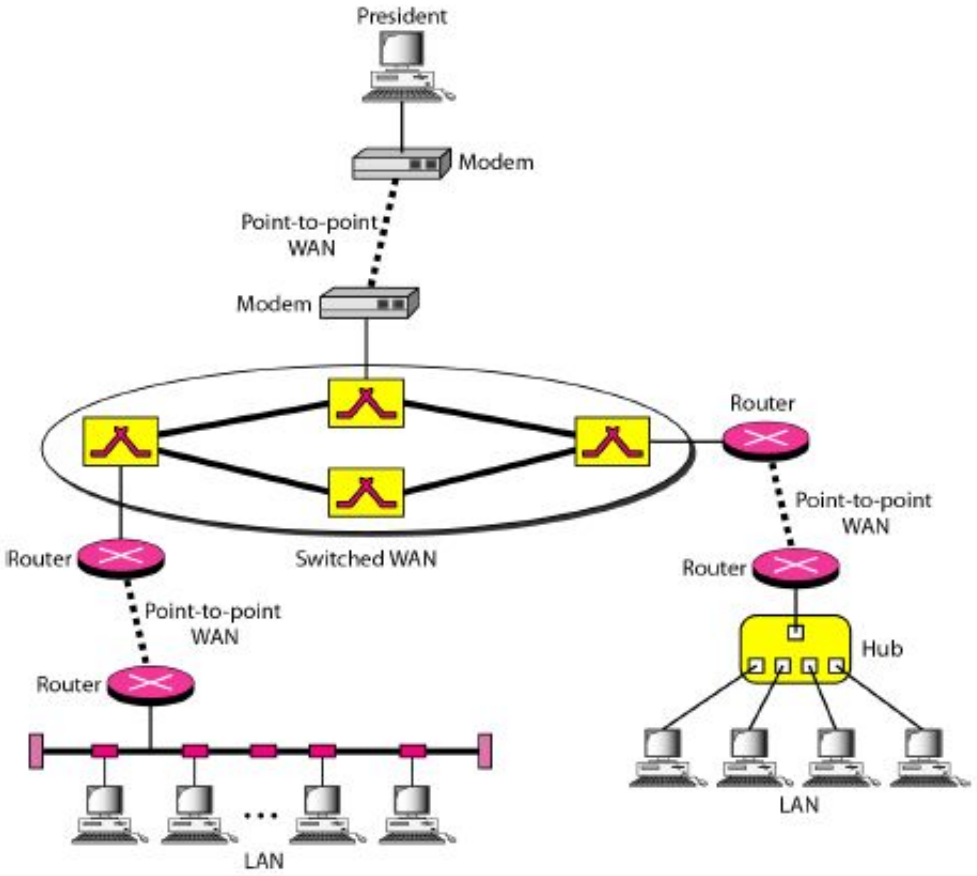


b. Point-to-point WAN

iii. Network Type - WAN…

Two disti WANs.

A heterogeneous network made of four WANs and two LANs

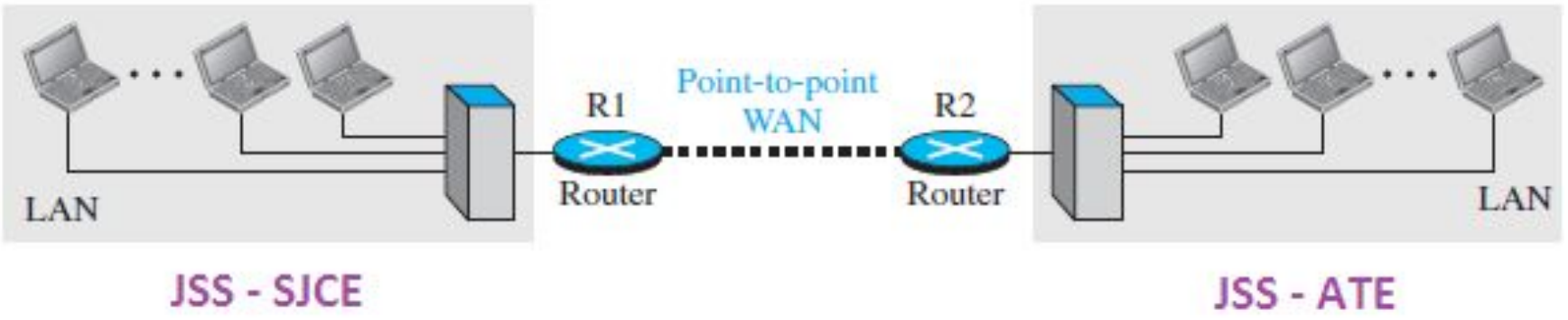


iii. Network Type - internet/internetwork

- Today, it is very rare to see a LAN or a WAN in isolation; they are connected to one another.
- When two or more networks are connected, they make an **internetwork,** or **internet.**
- As an example, JSS-SJCE and JSS-ATE has a LAN, allows all their staff to communicate with each other.
- To make the communication between SJCE and ATE, the management leases a point-to-point dedicated WAN from a service provider, such as a telephone company, and connects the two LANs. Now the company has an internetwork, or a private internet (with lowercase *i*). Communication between offices is now possible.

iii. Network Type - internet…

An internetwork made of two LANs and one point-to-point WAN



- When a host in the JSS-SJCE sends a message to another host in the same office, the router blocks the message, but the switch directs the message to the destination.
- On the other hand, when a host on the JSS-ATE sends a message to a host on the JSS-SJCE, router R1 routes the packet to router R2, and the packet reaches the destination.

iii. Network Type – LAN vs. MAN vs. INET

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. The two most common types of switched networks are circuit-switched and packet-switched networks.

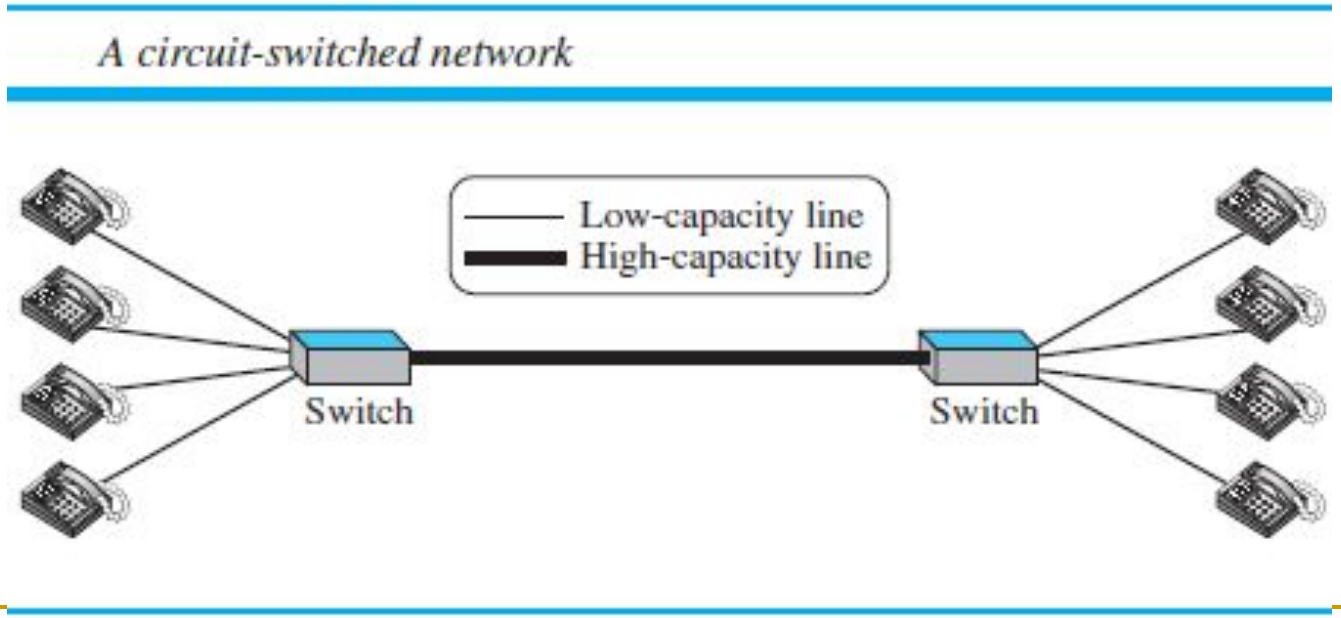
- Message switching
- Circuit switching
- Packet switching

How is the internet service made available?

- Telephone line (dial-up connection/ broad band connection)
- Cable networks
- Wireless networks
- Leased line

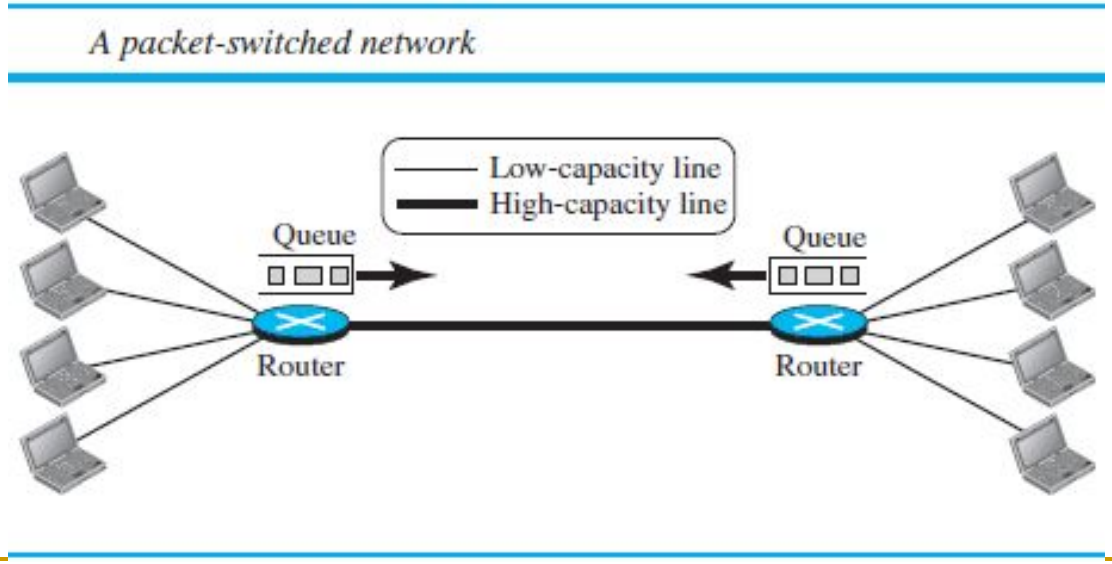
Switching:…

- **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.
- **E.g.:** Telephones to each end, because circuit switching was very common in telephone networks in the past, although part of the telephone network today is a packet-switched network.



Switching:…

- **Packet-Switched Network:** The communication between the two ends is done in blocks of data called *packets*.
- In other words, instead of the continuous communication we see between two telephone sets when they are being used, we see the exchange of individual data packets between the two computers. 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.



Circuit-switching vs. Packet-switching

iii. Network Type – The Internet

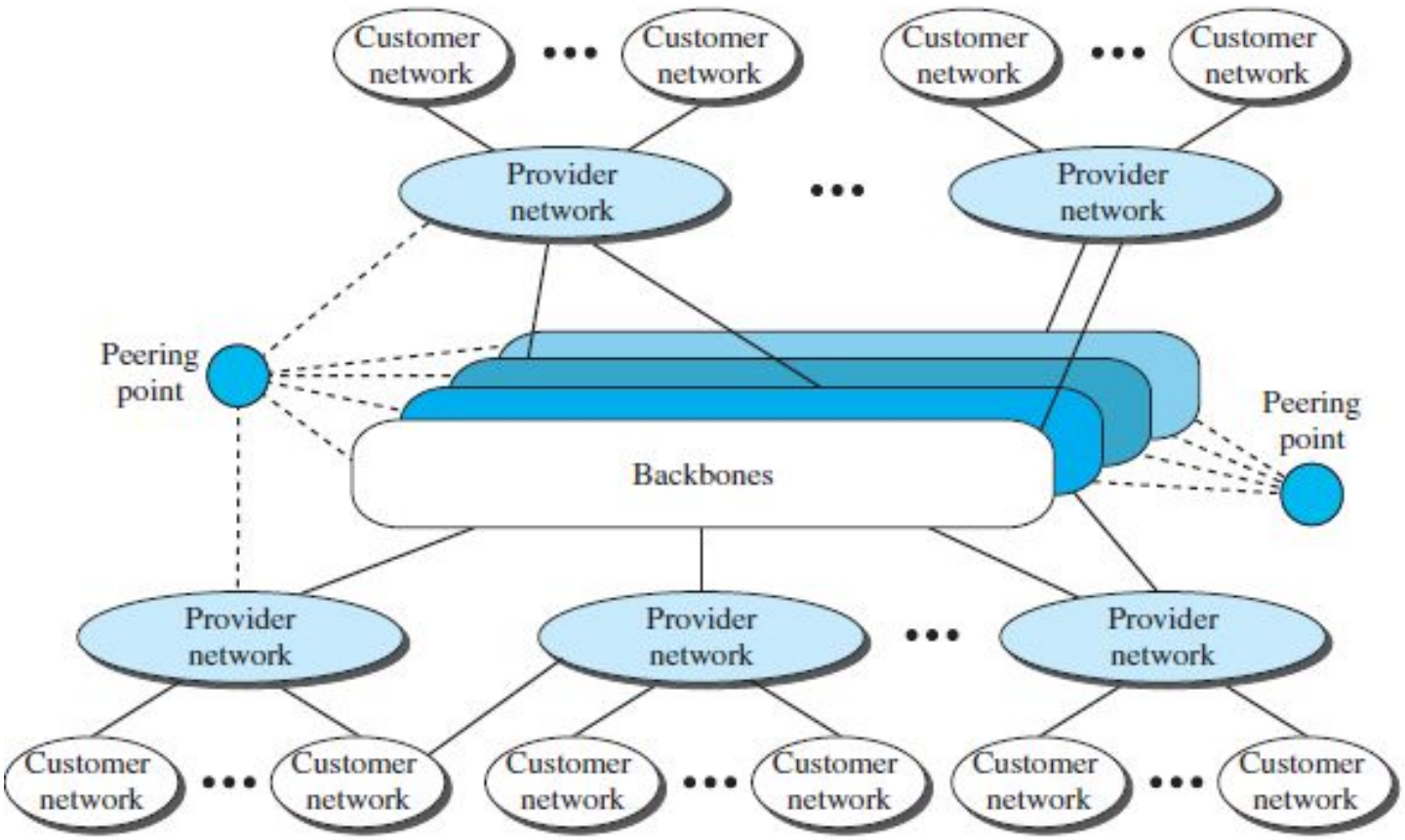
- An internet (note the lowercase *i*) is two or more networks that can communicate with each other.
- The most notable internet is called the **Internet** (uppercase *I*), and is composed of thousands of interconnected networks.
- The Internet as several backbones, provider networks, and customer networks. At the top level, the *backbones* are large networks owned by some communication companies such as Sprint, Verizon (MCI), AT&T, and NTT.

iii. Network Type – The Internet…

- The backbone networks are connected through some complex switching systems, called *peering points*.
- At the second level, there are smaller networks, called *provider networks*, that use the services of the backbones for a fee. The provider networks are connected to backbones and sometimes to other provider networks.
- Backbones and provider networks are also called **Internet Service Providers (ISPs).**
- The backbones are referred as *international ISPs;* the provider networks are often referred to as *national* or *regional ISPs*.

iii. Network Type – The Internet…

The Internet today



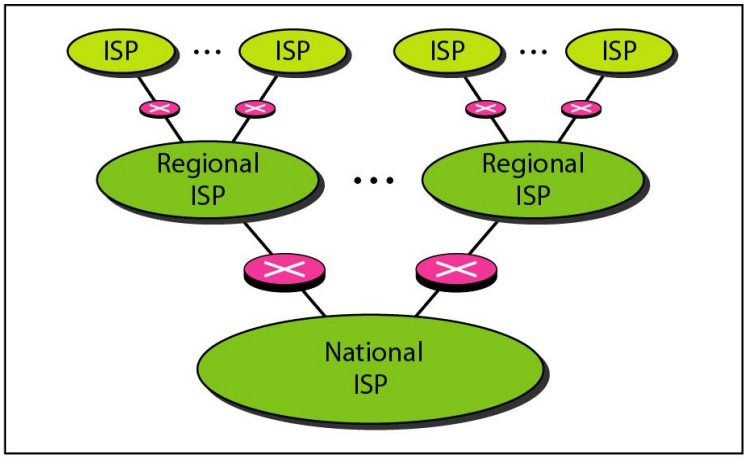
iii. Network Type – The Internet…

- **Accessing the Internet:** The Internet today is an internetwork that allows any user to become part of it. The user needs to be physically connected to an ISP, done through a point-to-point WAN.
- ***Using Telephone Networks*:** Today most residences and small businesses have telephone service. One option for residences and small businesses to connect to the Internet is to change the voice line between the residence or business and the telephone center to a point-to-point WAN. This can be done in two ways: *Dial-up service* and *DSL Service*
  - ***Dial-up service*:** The first solution is to add to the telephone line a modem that converts data to voice. The software installed on the computer dials the ISP and imitates making a telephone connection.
  - Unfortunately, the dial-up service is very slow, and when the line is used for Internet connection, it cannot be used for telephone (voice) connection. It is only useful for small residences.
  - ***DSL Servic*:** Since the advent of the Internet, some telephone companies have upgraded their telephone lines to provide higher speed Internet services to residences or small businesses. The DSL service also allows the line to be used simultaneously for voice and data communication.

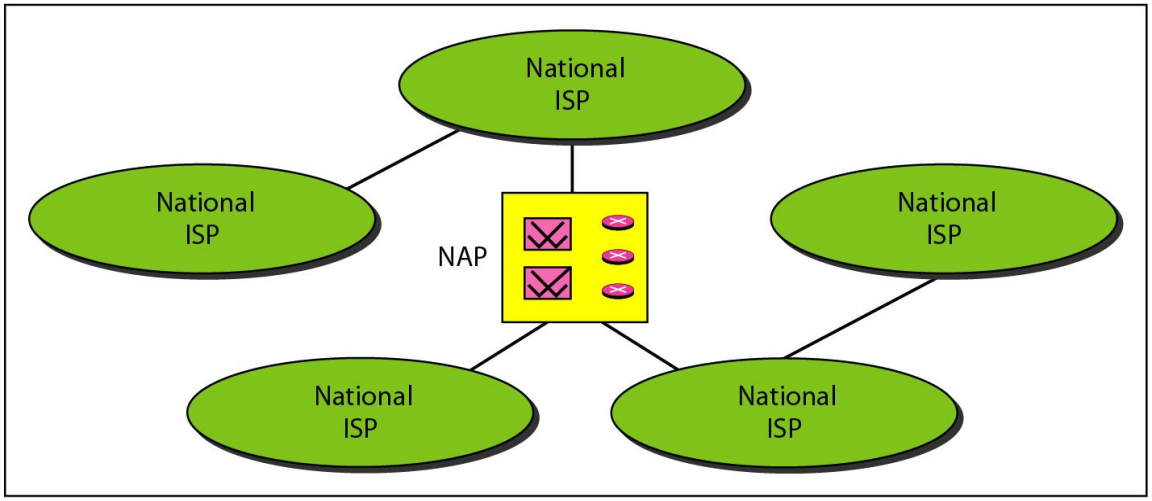
iii. Network Type – The Internet…

- ***Using Cable Networks*:** More and more residents over the last two decades have begun using cable TV services instead of antennas to receive TV broadcasting. The cable companies have been upgrading their cable networks and connecting to the Internet. A residence or a small business can be connected to the Internet by using this service. It provides a higher speed connection, but the speed varies depending on the number of neighbors that use the same cable.
- ***Using Wireless Networks*:** Wireless connectivity has recently become increasingly popular. A household or a small business can use a combination of wireless and wired connections to access the Internet. With the growing wireless WAN access, a household or a small business can be connected to the Internet through a wireless WAN.
- ***Direct Connection to the Internet*:** A large organization or a large corporation can itself become a local ISP and be connected to the Internet. This can be done if the organization or the corporation leases a high-speed WAN from a carrier provider and connects itself to a regional ISP. For example, a large university with several campuses can create an internetwork and then connect the internetwork to the Internet.

Hierarchical organization of the Internet



a. Structure of a national ISP



b. Interconnection of national ISPs

iv. Internet History (Not included in the Syllabus)

The brief history makes it clear how the Internet has evolved from a private network to a global one in less than 40 years.

- **Early History**:
  - Telegraph and telephone networks, before 1960, were suitable for constant-rate communication at that time,
  - After a connection was made between two users, the encoded message (telegraphy) or voice (telephony) could be exchanged.
  - A computer network, on the other hand, should be able to handle *bursty* data, which means data received at variable rates at different times. The world needed to wait for the packet-switched network to be invented.
  - ***ARPANET,*** In the mid-1960s, the **Advanced Research Projects Agency (ARPA)** in the Department of Defense (DOD) was interested in finding a way to connect computers so that the researchers they funded could share their findings, thereby reducing costs and eliminating duplication of effort.

iv. Internet History (Not included in the Syllabus)

- **Birth of the Internet**: In 1972, Vint Cerf and Bob Kahn, both of whom were part of the core ARPANET group, collaborated on what they called the *Internetting Project*. They wanted to link dissimilar networks so that a host on one network could communicate with a host on another. There were many problems to overcome: diverse packet sizes, diverse interfaces, and diverse transmission rates, as well as differing reliability requirements. Cerf and Kahn devised the idea of a device called a *gateway* to serve as the intermediary hardware to transfer data from one network to another.
  - **Transmission Control Protocol (TCP)** and **Internet Protocol (IP) (TCP/IP)**
  - **Military Network (MILNET)**
  - **Computer Science Network (CSNET)** by the National Science Foundation (NSF)
  - **National Science Foundation Network (NSFNET)**
  - **Advanced Network Services Network (ANSNET)**

iv. Internet History (Not included in the Syllabus)

- **Internet Today**: Today, we witness a rapid growth both in the infrastructure and new applications. The Internet today is a set of pier networks that provide services to the whole world. What has made the Internet so popular is the invention of new applications.

✔ ***World Wide Web*:** The 1990s saw the explosion of Internet applications due to the emergence of the World Wide Web (WWW). The Web was invented at CERN by Tim Berners-Lee. This invention has added the commercial applications to the Internet.

✔ ***Multimedia*:** Recent developments in the multimedia applications such as voice over IP (telephony), video over IP (Skype), view sharing (YouTube), and television over IP (PPLive) has increased the number of users and the amount of time each user spends on the network.

✔ ***Peer-to-Peer Applications*:** Peer-to-peer networking is also a new area of communication with a lot of potential.

iv. Standards and Administration

- Essential in creating and maintaining an open and competitive market for equipment manufacturers
- Guaranteeing national & international interoperability of data & telecommunication technology & process.

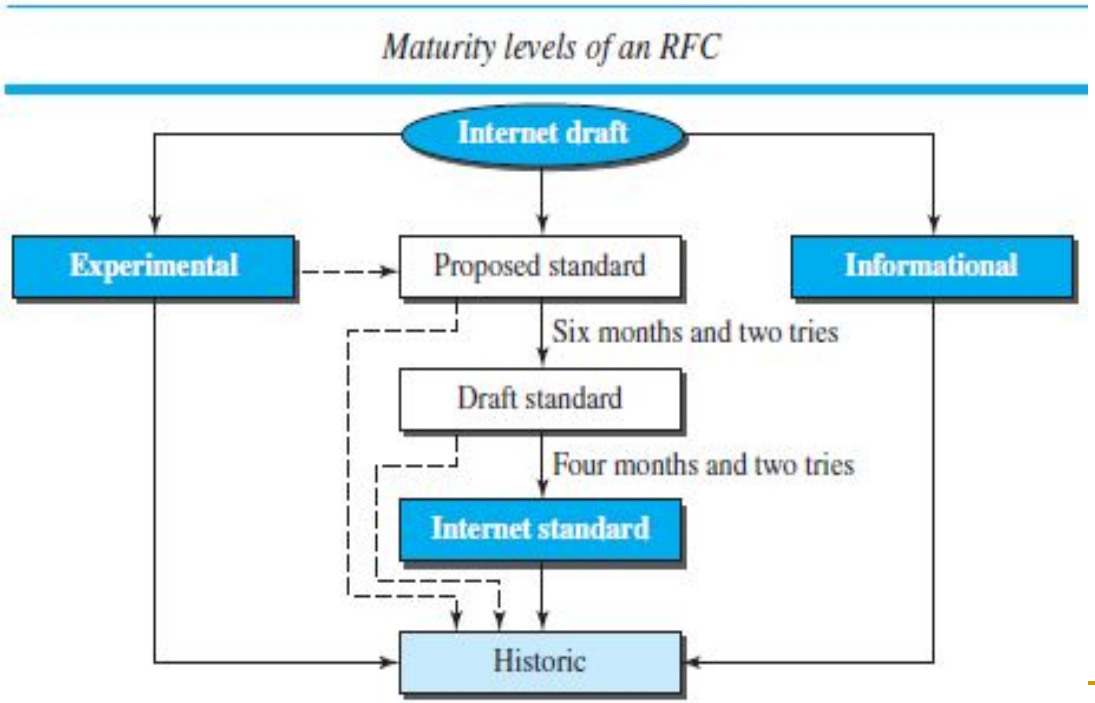
iv. Standards

- **Internet Standards:** A thoroughly tested specification, useful to and adhered to by those who work with the Internet. a formalized regulation that must be followed / a strict procedure by which a specification attains Internet standard status.
- A specification begins as an Internet draft - A working document (a work in progress/WIP) with no official status and a six-month lifetime.
- Upon recommendation from the Internet authorities, a draft may be published as a **Request for Comment (RFC).** Each RFC is edited, assigned a number, and made available to all interested parties.

iv. Standards…

RFCs go through ***maturity levels*** and are categorized according to their ***requirement level***.

- ***Maturity Levels:*** An RFC, during its lifetime, falls into one of six *maturity levels:* proposed standard, draft standard, Internet standard, historic, experimental, and informational.



iv. Standards…

- ***Requirement Levels:*** RFCs are classified into five *requirement levels:*
  - Required
  - Recommended
  - Elective
  - Limited use and
  - Not recommended

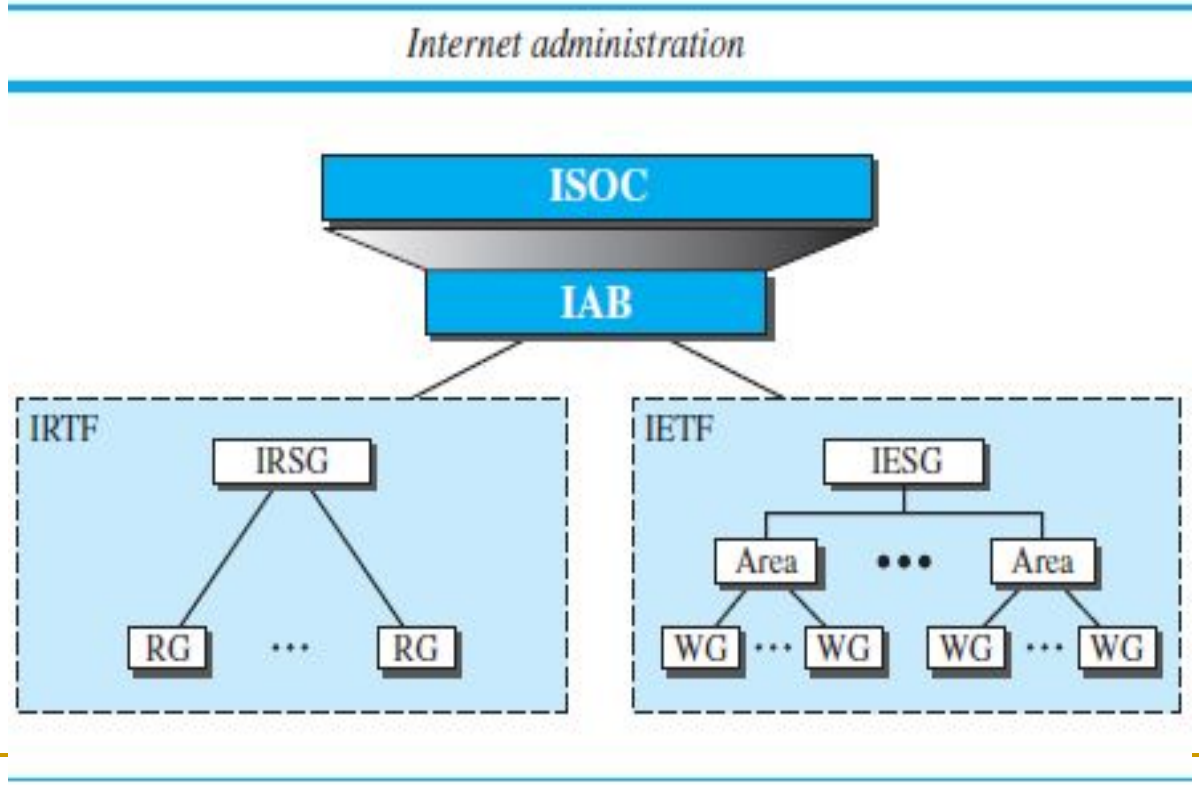
RFCs can be found at http://www.rfc-editor.org.

iv. Administration

- The Internet, with its roots primarily in the research domain, has evolved and gained a broader user base with significant commercial activity.
- Various groups that coordinate Internet issues have guided this growth and development. [Refer: Appendix G]

iv. Administration

- ISOC - Internet Society
- IAB - Internet Architecture Board
- IETF - Internet Engineering Task Force
- IRTF - Internet Research Task Force



iv. Administration

- **ISOC -** An international, nonprofit organization formed in 1992 to provide support for the Internet standards process, accomplishes through maintaining and supporting other Internet administrative bodies such as IAB, IETF, IRTF, and IANA. Also promotes research and other scholarly activities relating to the Internet.
-
- **IAB -** The technical advisor to the ISOC. the main purposes are to oversee the continuing development of the TCP/IP Protocol Suite and to serve in a technical advisory capacity to research members of the Internet community. IAB accomplishes through its two primary components, IETF and IRTF. Another responsibility is the editorial management of the RFCs and the external liaison between the Internet and other standards organizations and forums.

iv. Administration

- **IETF -** A forum of working groups managed by the Internet Engineering Steering Group (IESG), responsible for identifying operational problems and proposing solutions to these problems. Also develops and reviews specifications intended as Internet standards. The working groups are collected into areas, and each area concentrates on a specific topic. Currently nine areas have been defined: applications, protocols, routing, network management next generation (IPng), and security.

- **IRTF -** A forum of working groups managed by the Internet Research Steering Group (IRSG). Focuses on long-term research topics related to Internet protocols, applications, architecture, and technology.

Introduction - Summary

- 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.

Summary…

- 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.

- Topology refers to the physical or logical arrangement of a network. Devices may be arranged in a mesh, star, bus, or ring topology.

Summary…

- 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 states, countries, or the whole world. An internet is a network of networks. The Internet is a collection of many separate networks.

Summary… (Not included in the Syllabus)

- The Internet history started with the theory of packet switching for bursty traffic. The history continued when The ARPA was interested in finding a way to connect computers so that the researchers they funded could share their findings, resulting in the creation of ARPANET.

- The Internet was born when Cerf and Kahn devised the idea of a device called a *gateway* to serve as the intermediary hardware to transfer data from one network to another. The TCP/IP protocol suite paved the way for creation of today's Internet. The invention of WWW, the use of multimedia, and peer-to-peer communication helps the growth of the Internet.

Summary…

- An Internet standard is a thoroughly tested specification. An Internet draft is a working document with no official status and a six-month lifetime. A draft may be published as a Request for Comment (RFC). RFCs go through maturity levels and are categorized according to their requirement level.

- The Internet administration has evolved with the Internet. ISOC promotes research and activities. IAB is the technical advisor to the ISOC. IETF is a forum of working groups responsible for operational problems. IRTF is a forum of working groups focusing on long-term research topics.

Readings

- Chapter 1 (B. A Forouzan)
  - Section 1.1, 1.2, 1.3 and 1.5