CHAPTER 3

DATA COMMUNICATION AND COMPUTER NETWORKS

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Outline

- Telecommunications

- Data Communication

- Types of Network

- INTERNET

- Services of the Internet

Telecommunication

- The word communications is the social process of information exchange.

- Telecommunication is the transmission of signals, messages, words, writings, images and sounds or information of any nature by wire, radio, optical or electromagnetic systems.

Telecommunication

- Telecommunication occurs when the exchange of information between communication participants includes the use of technology.

- It is transmitted either electrically over physical media, such as cables, or via electromagnetic radiation.

Data Communication

- Data communication is the exchange of data between two devices via some form of transmission medium such as a wire cable or wireless.

- Data communication is the transmission of electronic data over some electronic media.

- The media used to transmit may be guided or unguided.

Elements of Data Communication

Five basic elements are needed for any communication system.

- Sender

- Receiver

- Medium

- Message

- Protocol

Sender

- The computer or device that is used for sending data is called sender, source or transmitter.
- In modern digital communication system, the source is usually a computer.

Receiver

- The device or computer that receives the data is called receiver.
- The receiver can be a computer, printer or a fax machine.

Medium

- The means through which data is sent from one location to another is called transmission medium.

- The media used to transmit data may be wired or wireless.

Protocols

- Protocols are rules under which data transmission takes place between sender and receiver.

- The data communication follows some communication protocols to communicate and exchange data.

  - Examples of Protocols are
    - HTTP- Hypertext Transfer Protocol
    - FTP- File Transfer Protocol
    - DHCP-Dynamic Host Configuration Protocol
    - DNS-Domain Name System

Simplified Communications Model - Diagram
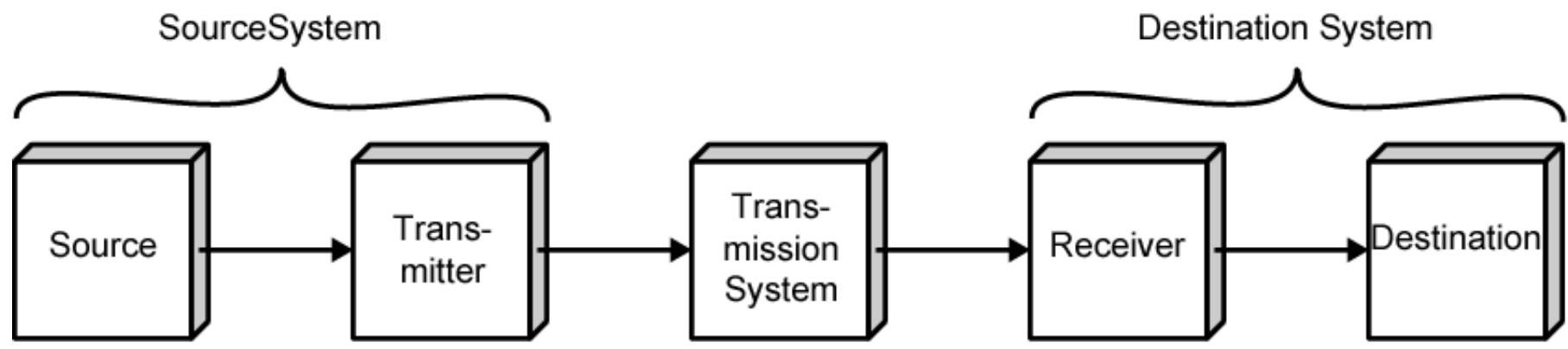
(a) General block diagram

(b) Example

Modes of Data Communication

- The manner in which data is transmitted from one location to another location is called data transmission mode.

- There are three modes for transmitting data from one location to another.

  - These are:
    - o**Simplex**
    - o**Half duplex**
    - o**Full duplex**

Simplex Data Communication Mode

- In simplex mode, data is transmitted in only one direction.

- A terminal can only send data and cannot receive it or it can only receive data but cannot send it.

- Simplex mode is usually used for a remote device that is meant only to receive data.

- It is not possible to confirm successful transmission of data in simplex mode.

Simplex Data Communication Mode

- This mode is not widely used.
  - Examples
    - Speaker, radio and television broadcasting are examples of simplex transmission, on which the signal is send from the transmission to your TV antenna.
- There is no return signal.

| SENDER	UNIDIRECTIONAL →	RECEIVER

Half-Duplex Data Communication Mode

- In half duplex mode, data can be transmitted in both directions but only in one direction at a time.

- During any transmission, one is the transmitter and the other is receiver.

- So each time for sending or receiving data, direction of data communication is reversed, this slows down data transmission rate.

Half-Duplex Data Communication Mode

- In half duplex modes, transmission of data can be confirmed

SENDER/ RECEIVER

BIDIRECTIONAL

BIDIRECTIONAL

RECEIVER/ SENDER
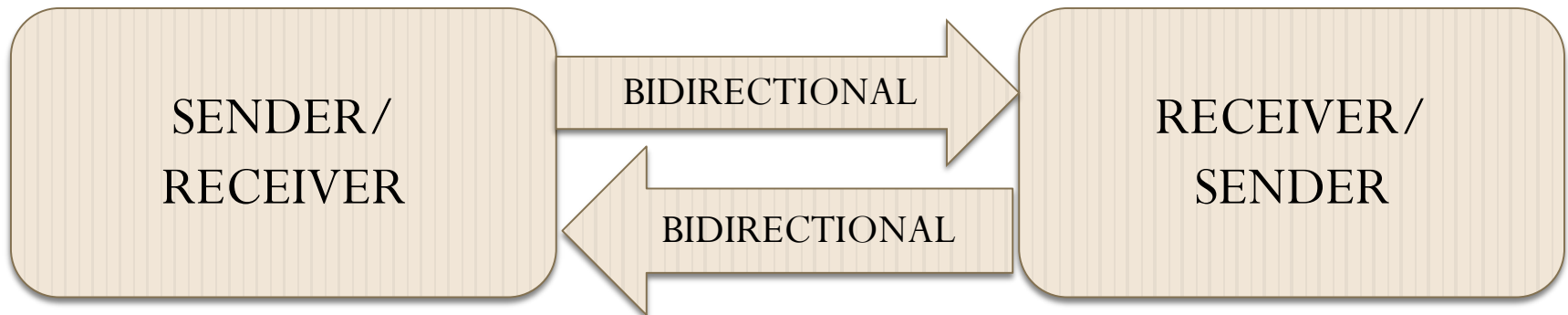
Full Duplex Data Communication Mode

- In full mode, data can be transmitted in both directions simultaneously.
- It is a faster mode for transmitting data because no time wastes in switching directions.
  - Example of full duplex is a computer network in which both the users can send and receive data at the same time.
  - Telephone conversation, Internet

Full Duplex Mode

SENDER/ RECEIVER ← BIDIRECTIONAL → RECEIVER/ SENDER

Simplex, Half Duplex & Full Duplex

	Simplex	**Half Duplex**	**Full Duplex**
Cost	Cheapest communication	Expensive	Most Expensive
Data transmission	One way	Two way one at a time	Simultaneous transmission
Bandwidth	Low	Medium	High

Communication Speed

- The communication transfer rate is measured in a unit called Band.

- In general band is identical to its bites e.g. at rate of 300 bounds bits per second (300bps)

- Different grades of channels provide a variety of speed in which data can be transmitted over the channel.

Communication Speed

The grades of channel are classified as.

- **Low speed or Narrow Band**

- **Medium speed or voice Band**

- **High speed or broadBand**

Narrow Band Channel

- Low speed or Narrow band has a bit transmission rate of 40bps to 300bps.

- Narrow band channels are normally used for low speed services.

- Narrow band is used for Tele typewriter (Texting) communication and for other low speed devices which can use low speed line.

Voice band channel

- Medium speed voice grades vary from 300bps to 9600bps.

- This speed range is accumulated by lines which are used over ordinary voice communications and hence term voice band to describe these bands.

- The most commonly used media for this speed is telephone line (Telephone Calling).

Broadband Channel

- High speed communication channels are commonly called broad band or wide band. Permit transmission rate is over 9600 bps.
- High speed channel required micro waves, fiber optics or satellite transmission.
- They are normally used for computer to computer communication since computer send data to each other faster than terminal sends data to computer

What is Computer Network?

- A computer network is defined as the interconnection of two or more computers.

- It is done to enable the computers to communicate and share available resources.

- Storing information in one centralized database can help you reduce costs and drive efficiency

Why Network ?

Networks have the following Advantages:

➢Sharing Information (or Data)

➢Sharing Hardware(Printer)

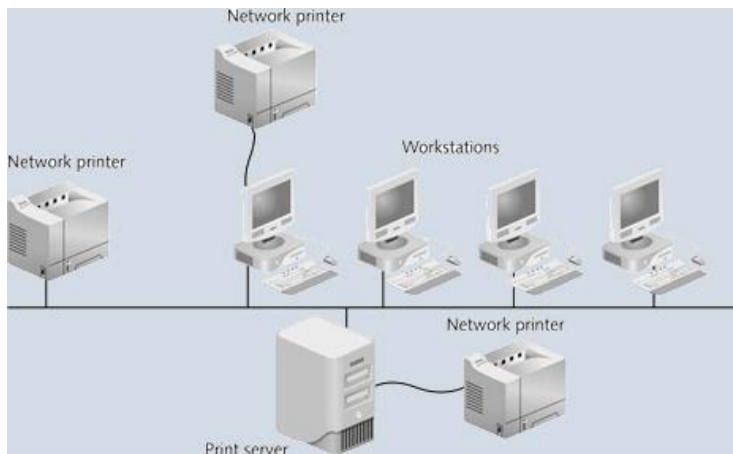➢Sharing Software (Programs)

➢Centralizing network administration and Support
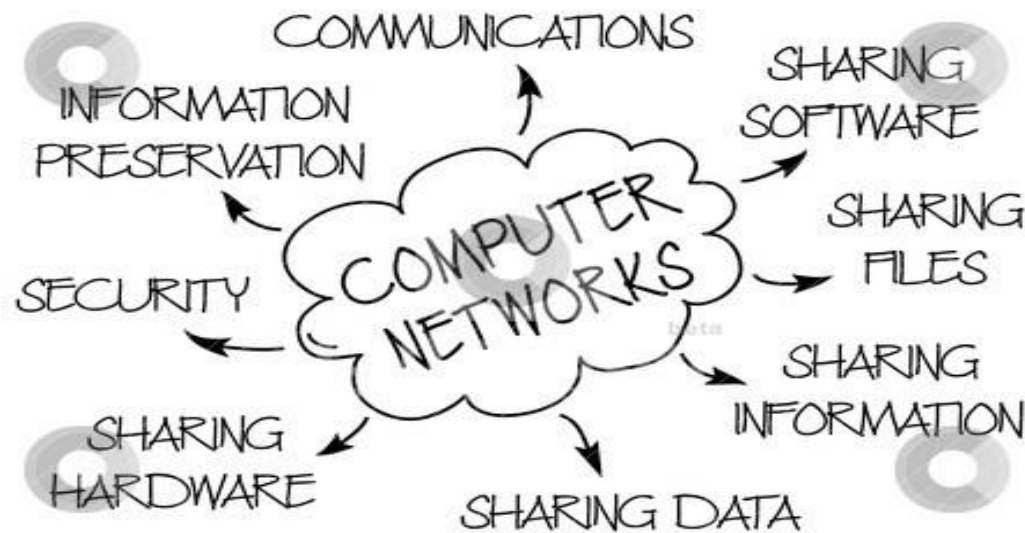
Sharing Information/data

- Users in a certain network environment have the freedom of sharing data and information across the network.
  - **Data sharing** – you can easily share data between different users, or access it remotely if you keep it on other connected devices.
  - **Information sharing using the Internet**
    - *Email*: electronic mail messages.
    - *Discussion Forums*: Messages are posted for open discussion and others post replies.

Sharing Hardware

- Computer networks enable us to share expensive hardware resource among several computers.

- A typical example of shared resources are
  - Printer
  - Central Disk storage

Sharing Programs/Software

- software sharing occurs when several users at different locations run application programs that are installed centrally in one location (application server).

- Sharing software resources reduces the cost of software installation, saves space on hard disk and reduces maintenance cost and time.

- Example: portal.aau.edu.et

Centralizing Administration & Support

- **centralized network**. A type of **network** where all users connect to a central server, which is the acting agent for all communications.

- This server would store both the communications and the user account information.

- back up data from a single point on a scheduled basis ensures consistency.

- **Centralized network** can **reduce errors** and **improve consistency** by having all staff work from a single source of information.

Advantages and Disadvantage of a Network

- **Advantages of a Network**
  - **It increases cost efficiency. (Software and Hardware)**
  - Centralized Software Management
  - Resource Sharing
  - **availability of information**
- **Disadvantages of a Network**
  - High cost of installation/expensive to set-up.
  - Requires time for administration
  - Failure of server
  - Security (Viruses and malware)
  - Cables May Break

Requirement for Network Connection

- Physical Connection

- Logical Connection

- Application/Network Operating system

Physical Network connection

- How different computing device are connected together so as to exchange information.
- The physical connection is used to transfer signals (packet) between computers within the local network and to remote devices on the Internet.

Physical Network connection

- There are wide range of hardware systems used in a computer network
- The major networking hardware are:
    - **Network Interface Card (NIC)**
    - **Network Cable**
    - **Hub/Switch**
    - **Modem**
    - **Router**
    - **RJ-45**
    - **Server**

Logical Network connection

- Some times **called protocols.**
- A protocol is a formal description of a set of rules and conventions that govern how devices on a network communicate.
- Connections to the Internet may use multiple protocols.
- TCP/IP is a suite of protocols that work together to transmit data.

Applications and Services

- Application interprets the data and displays the information in an understandable form is the last part of the connection.
  - Applications work with protocols to send and receive data across the Internet.
  - A web browser displays HTML as a web page.
  - File Transfer Protocol (FTP) is used to download files and programs from the Internet.
  - Domain Name System (DNS): is used to translate the IP address to that of Unified Resource Locator(URL)
    - Ex. www.facebook.com (URL) to 31.13.86.16 (IP address)

Classification of Networks

- Based on Geographical Location.
  - LAN
  - MAN
  - WAN
- Centralized Network
  - Dump terminal
  - Intelligent terminal
- Role of computers
  - Peer-to-peer (P2P)
  - Client/Server

Classification of Networks

Based on size(geographic Span), there are three types of networks: -

- Local area Networks (LANs)

- Wide Area Networks (WANs)

- Metropolitan Area Networks (MANs)

Local Area Network (LAN):

- A LAN covers a relatively small area such as a classroom, school, or a single building.

- LANs are inexpensive to install and also provide higher speeds.

- LAN Devices
  - Cable/Wire
  - Hubs & Switches
  - RJ 45
  - Network Interface Card (NIC)
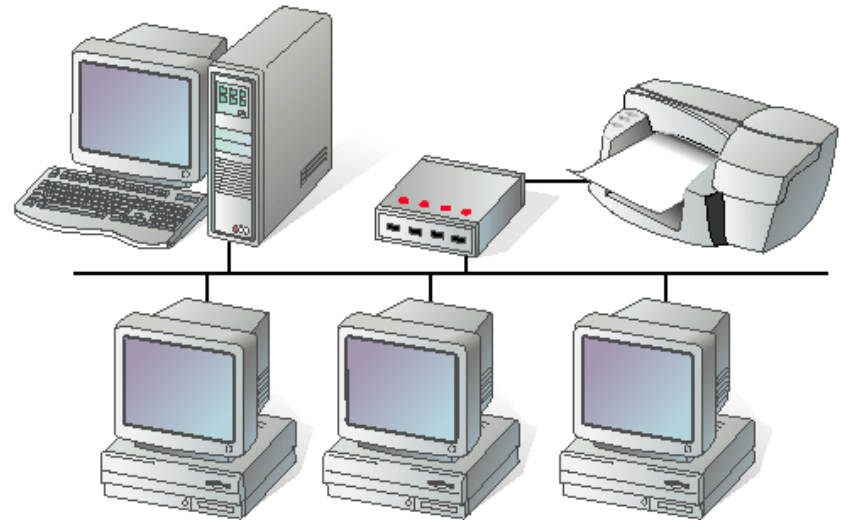
Metropolitan Area Network (MAN):

- A MAN spans the distance of a typical metropolitan city.

- MAN is composed of different LANs located within a city

- The cost of installation and operation is higher.

- MANs use high-speed connections such as fiber optics to achieve higher speeds.
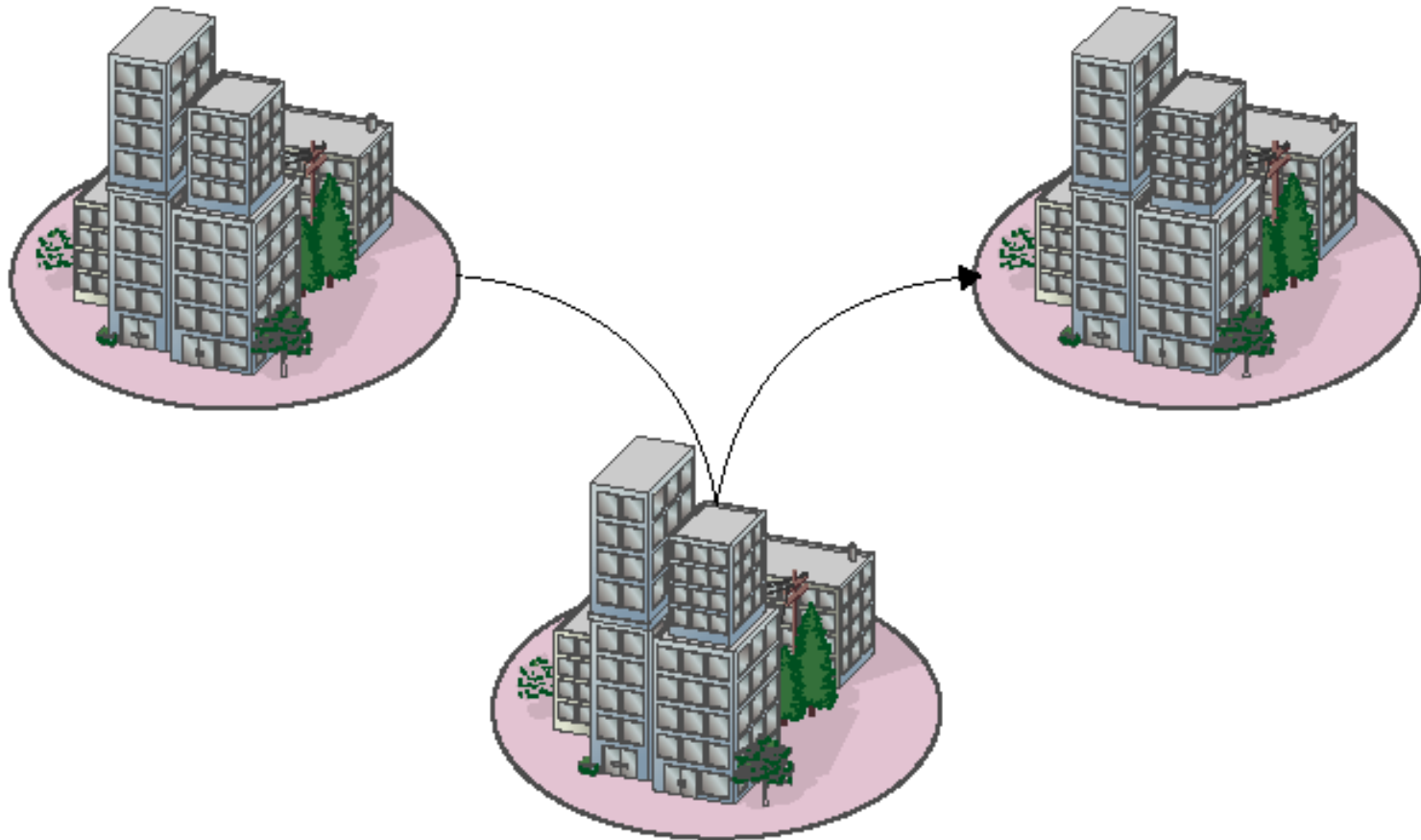
Metropolitan area network

WIDE AREA NETWORK (WAN)

- When network spans over a large distance or when the computers to be connected to each other are at widely separated locations a local area network cannot be used. A wide area network(WAN) is installed.

- The communication between different users of WAN is established using leased telephone lines, satellite links and similar channels.

Wide Area Network (WAN):

- Most WAN networks are used to transfer large blocks of data between its users.
- The Internet is a good example of a WAN.
- The most expensive to install
- WAN Devices
  - Routers
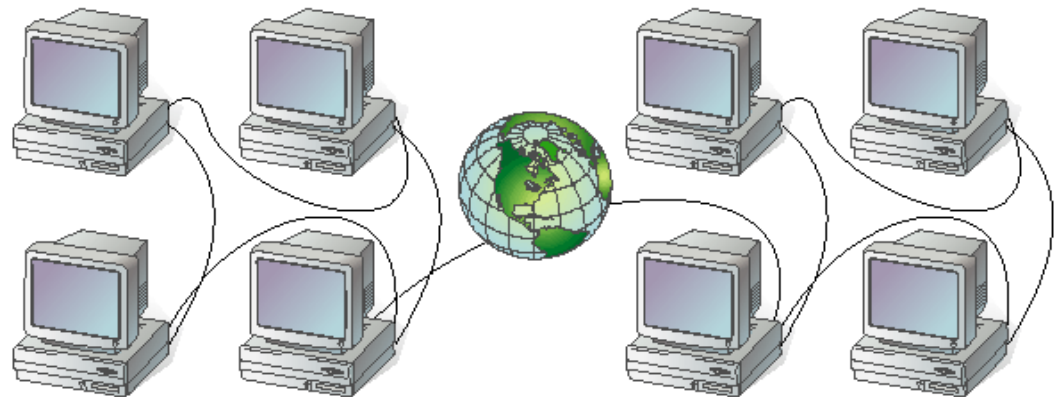
Based on Network Architecture

- Based on the architecture, or Roll of computers, networks are divided into two broad categories:
  - Peer-to-peer Networks
  - Server –based Networks

Based on Network Architecture

- The type of network you choose to implement depends on Size of the organization
  - Level of security required
  - Level of administrative support available
 - Amount of network traffic
  - Network budget

Peer-to-Peer (P2P)

- In a peer-to-peer network, all computers are considered equal.
- Each computer controls its own information and is capable of functioning as either a client or a server depending upon the requirement.

Peer-to-Peer (P2P)

- Peer-to-peer networks are inexpensive and easy to install.

- They are popular as home networks and for use in small companies.

- The maximum number of peers that can operate on a peer-to-peer network is assumed to be 10.

- Each peer shares resources and allows others open access to them.

- Peer-to-peer networks become difficult to manage when more security is added to resources, since the users control their security by password-protecting shares.

- In a peer to peer, Shares can be document folders, printers, peripherals, and any other resource that they control on their computers.

Resources are shared among equals in a peer-to-peer network.
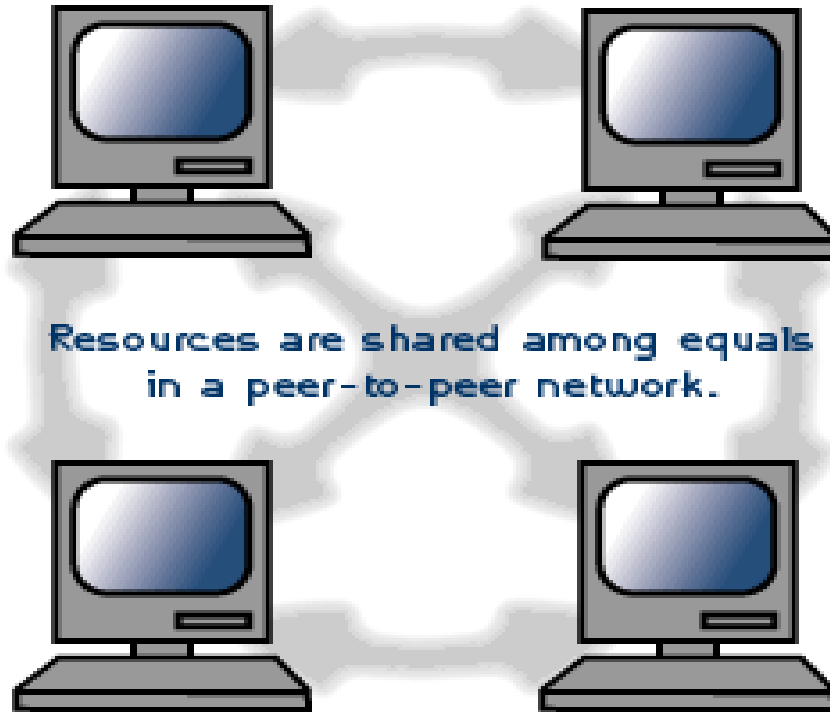
Peer-to-peer network

Client-Server Network

- The **client–server network** is a type of network that partitions tasks or loads between client and Server

- **Servers** the providers of a service and

- **Clients** service requesters
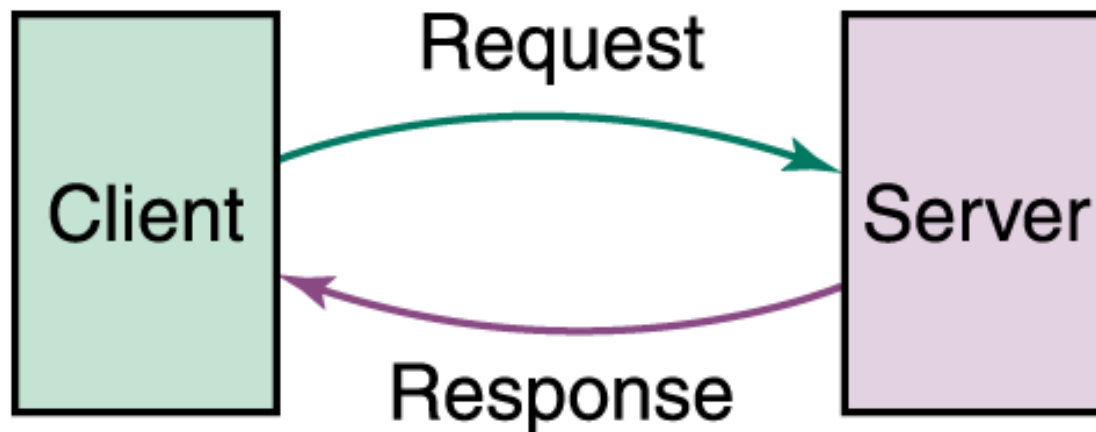
Server

- A dedicated server is one that services the network by storing data, applications, resources, and also provides access to resources required by the client.

- These servers can also control the network's security from one centralized location or share it with other specially configured servers.

Specialized Servers

- Servers must perform varied and complex tasks. Servers for large networks have become specialized to accommodate the expanding needs of users. types of servers included on many large networks.
  - **File Servers**
  - **Print Servers**
  - **Database Servers**
  - **Application Servers**
  - **Mail Servers**
  - **Web Servers**
  - **Proxy Server**

Client

- Client computer takes the advantages of powerful processing capabilities of both the client and the server.

Example of client-server network
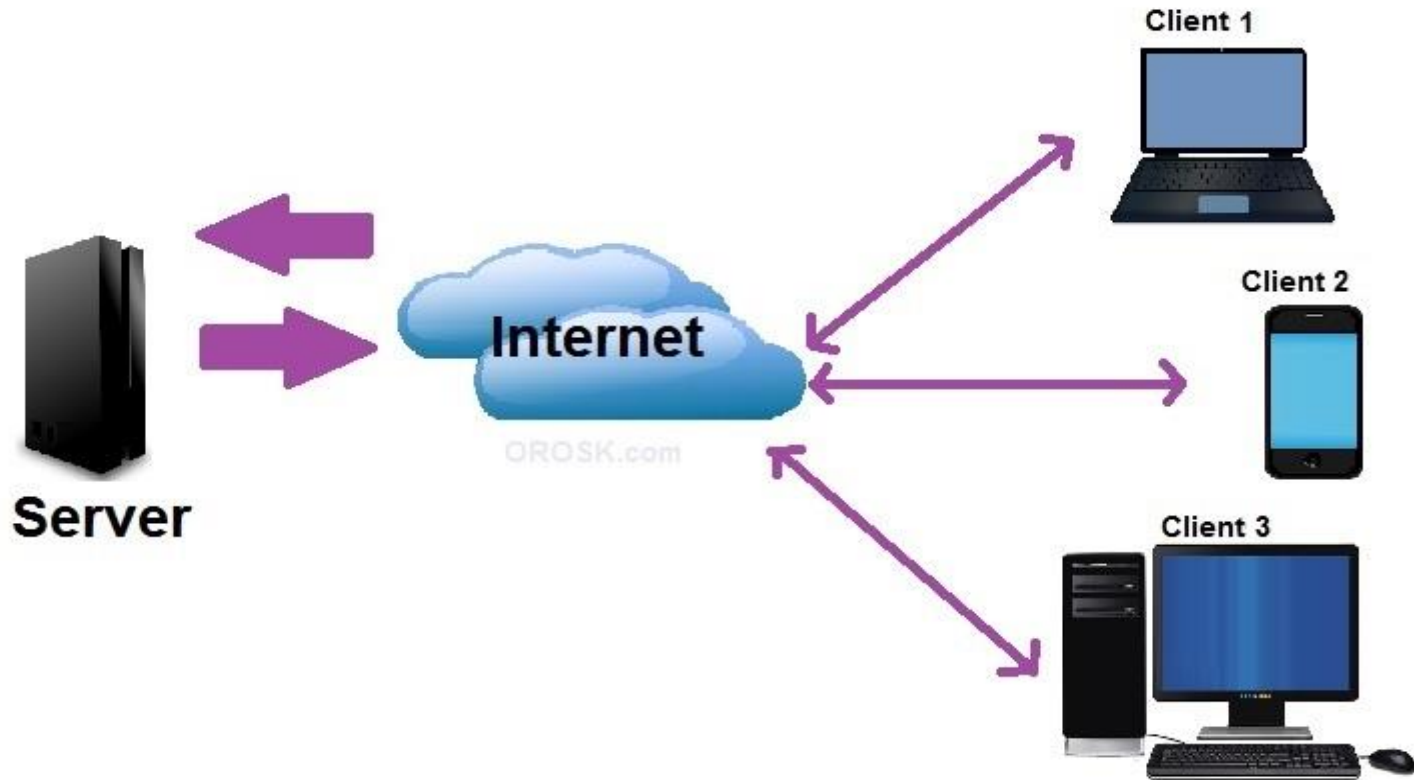
Advantages of Client/Server network

- Facilitate resource sharing – centrally administrate and control
- Facilitate system backup and improve fault tolerance
- Enhance security – only administrator can have access to Server
- Support more users – difficult to achieve with peer-to-peer networks

Disadvantages of Client/Server network

- High cost for Servers

- Need experts to configure the network

- Introduce a single point of failure to the system.

Dump and Intelligent terminal

- **Dumb terminals**
  - Terminals that have no storage or processing capabilities.
    - Has monitor, mouse and a keyboard
  - As dumb terminals do not have processing capabilities
    - they must be connected to a host computer that can perform any processing functions necessary.
- **Intelligent terminals**
  - have limited storage and processing capabilities.

Network Topology

- Topology refers to the way in which multiple devices are interconnected via communication links.

- There are two types of topology:

  - Physical Topology

  - Logical Topology

Based on Network Topology

- **Physical topology** is the mapping of the nodes of a network and the physical connections between them – i.e., the layout of wiring, cables, the locations of nodes, and the interconnections between the nodes and the cabling or wiring system.

- **Logical topology** is bound to network protocols and describe how data is moved across the network.
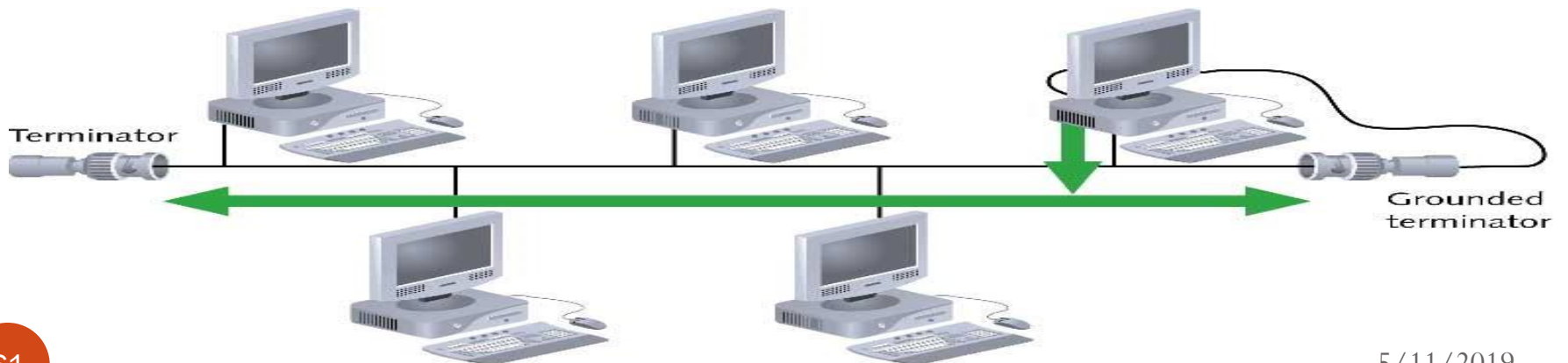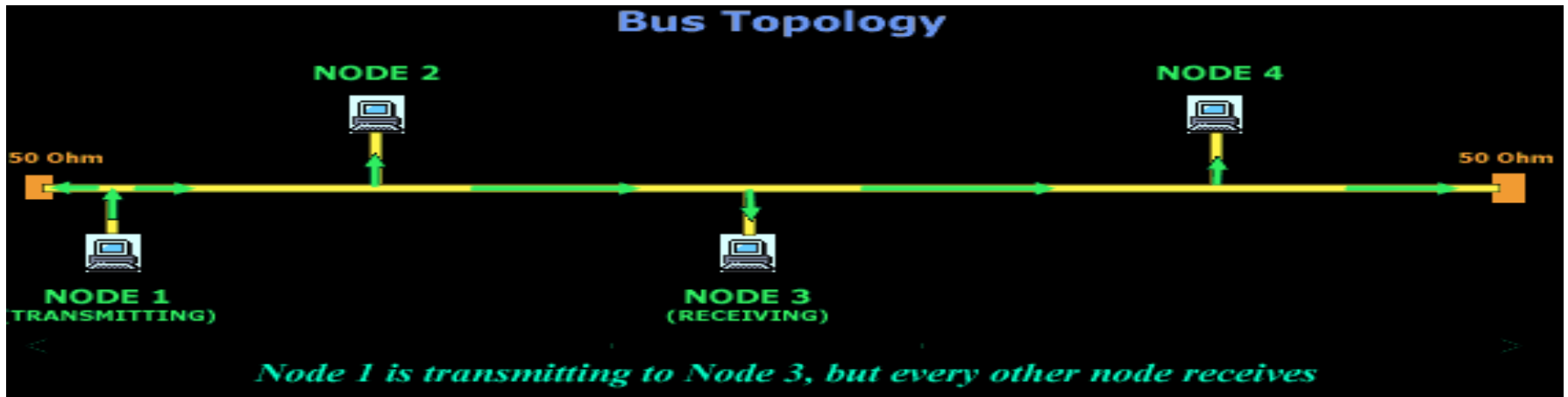 - is the method used to pass the information between the computers.

Physical Topologies

Four fundamental type of topology:

- Bus

- Ring

- Star

- Mesh

- Hybrid/tree type topologies

Bus Topology

- A **Bus topology** consists of a single cable called a **bus** connecting all nodes on a network without intervening connectivity devices

- Devices share responsibility for getting data from one point to another

- Traffic generated by any computer will travel across the backbone and be received by all workstations
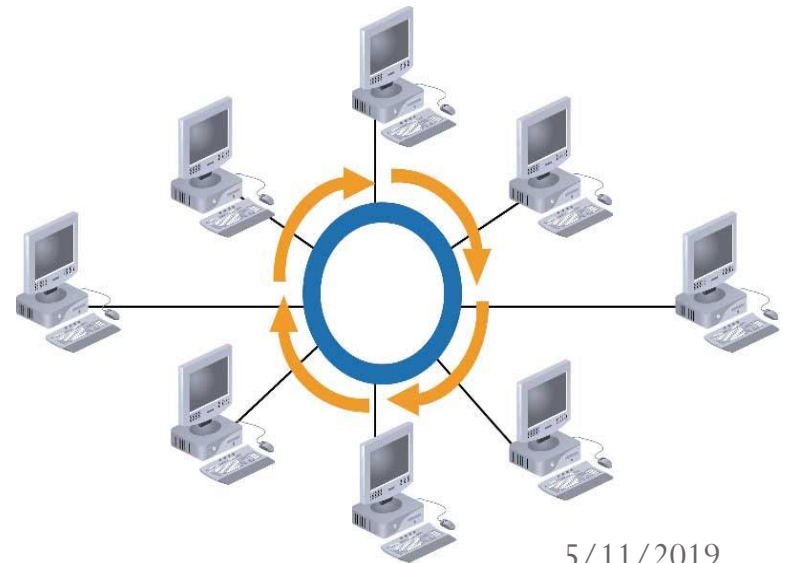
Bus Topology

Bus Topology

NODE 2   NODE 4

50 Ohm   50 Ohm

NODE 1
(TRANSMITTING)

NODE 3
(RECEIVING)

Node 1 is transmitting to Node 3, but every other node receives

Terminator

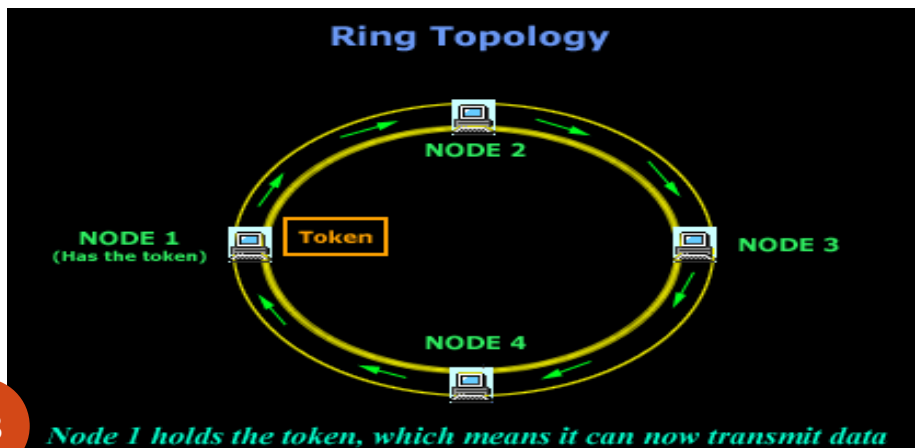Grounded terminator

Merits and Demerits of Bus Topology

- Merits
  - Works well for small networks
  - Relatively inexpensive to implement
  - Easy to add a node to it
  - Requires less cable length than a star topology
- Demerits
  - Entire network shuts down if there is a break in the main cable.
  - Difficult to identify the problem if the entire network shuts down
  - Management costs can be high
  - Potential for congestion with network traffic
  - Terminators must be there at every end
  - Not scalable
  - Difficult to troubleshoot, not fault-tolerant

Ring Topology

- Ring topology
  - A *ring network* is a *network topology* in which each node connects to exactly two other nodes, so the entire network forms a circle
  - Data travels from node to node, with each node along the way handling every packet.
    - Active topology
      - Each workstation transmits data

Ring Topology

NODE 2

NODE 1
(Has the token)   Token   NODE 3

NODE 4

Node 1 holds the token, which means it can now transmit data

5/11/2019

Merits and Demerits of Ring Topology

- **Merits**
  - Easier to manage, easier to locate a defective node or cable problem
  - Well-suited for transmitting signals over long distances on a LAN
  - Handles high-volume network traffic
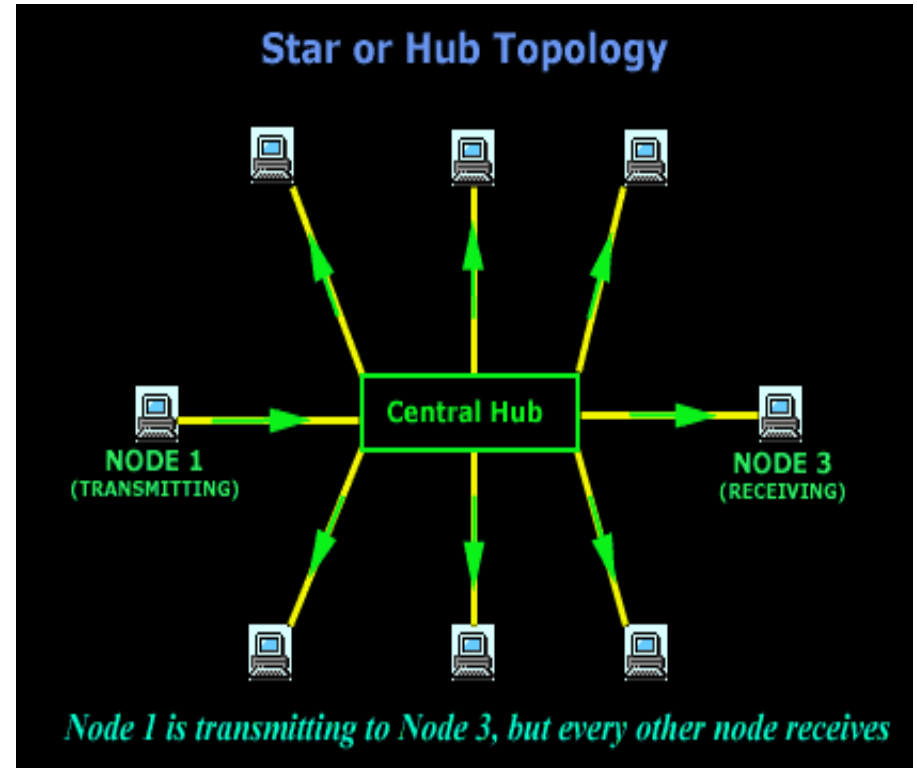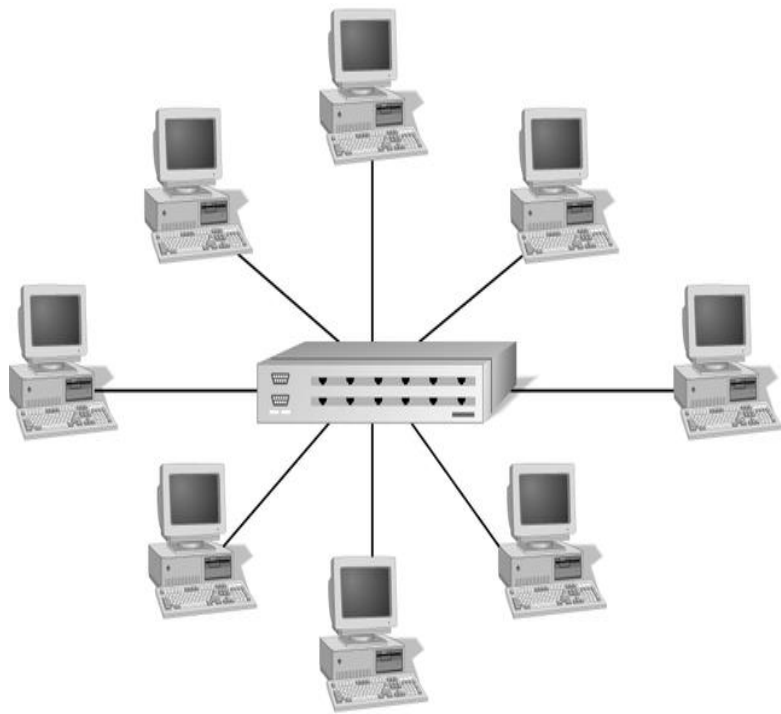 - Enables reliable communication
  - Equal access
- **Demerits**
  - Expensive
  - Requires more cable and network equipment at the start
  - Not used as widely as bus topology

Star Topology

- Any single cable connects only two devices
  - Cabling problems affect only two nodes at most
- Requires more cabling than ring or bus networks
  - More fault-tolerant
- Easily moved, isolated, or interconnected with other networks
  - Scalable
- Every node on the network is connected through a central device is called switch/hub
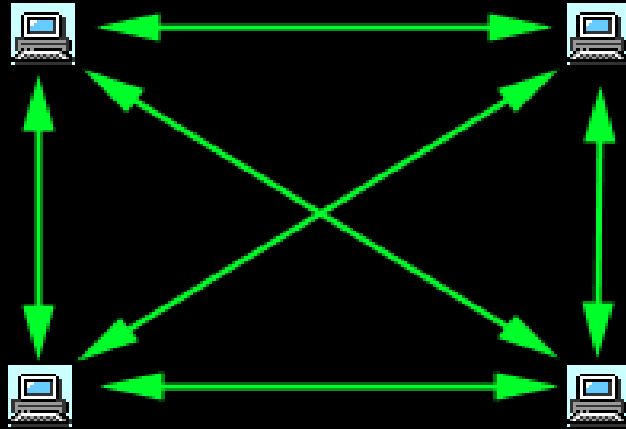
Star Topology

Star or Hub Topology

NODE 1
(TRANSMITTING)

Central Hub

NODE 3
(RECEIVING)

Node 1 is transmitting to Node 3, but every other node receives

Merits and Demerits of Star Topology

- Merits
  - Good option for modern networks
  - Low startup costs
  - Easy to manage
  - Scalable
  - Most popular topology in use;
- Demerits
  - Hub is a single point of failure
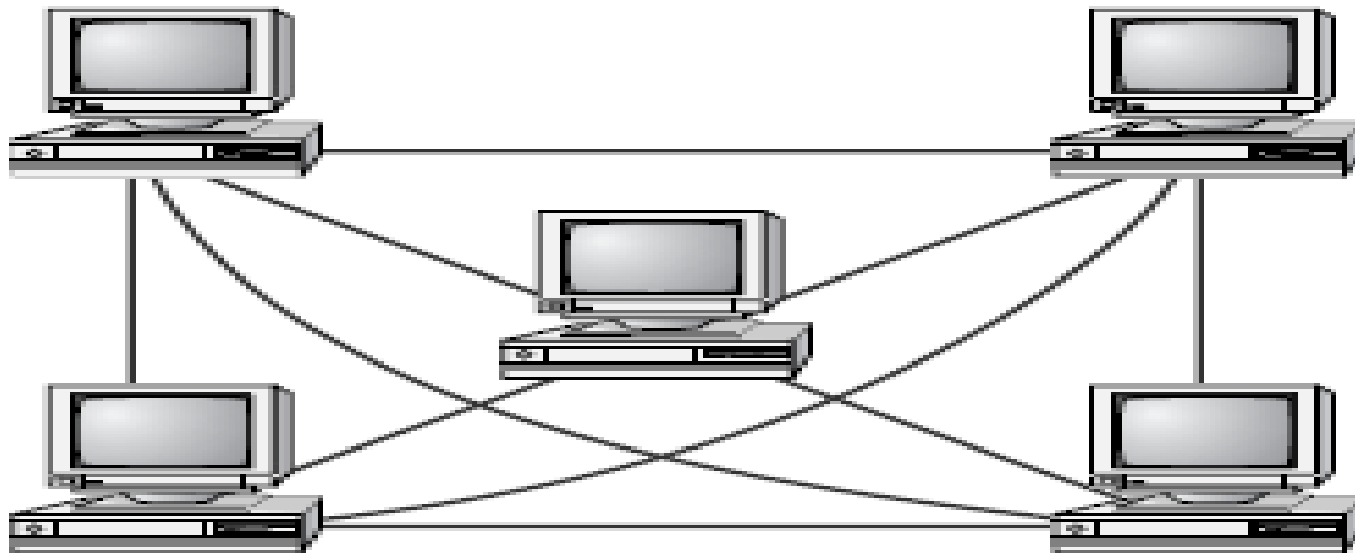 - Requires more cable than the bus

67

Mesh Topology

- Not common on LANs
- Most often used in WANs to interconnect LANS
- Each node is connected to every other node
- Allows communication to continue in the event of a break in any one connection

Mesh Topology

Every node is connected with each other, in a fully redundant path
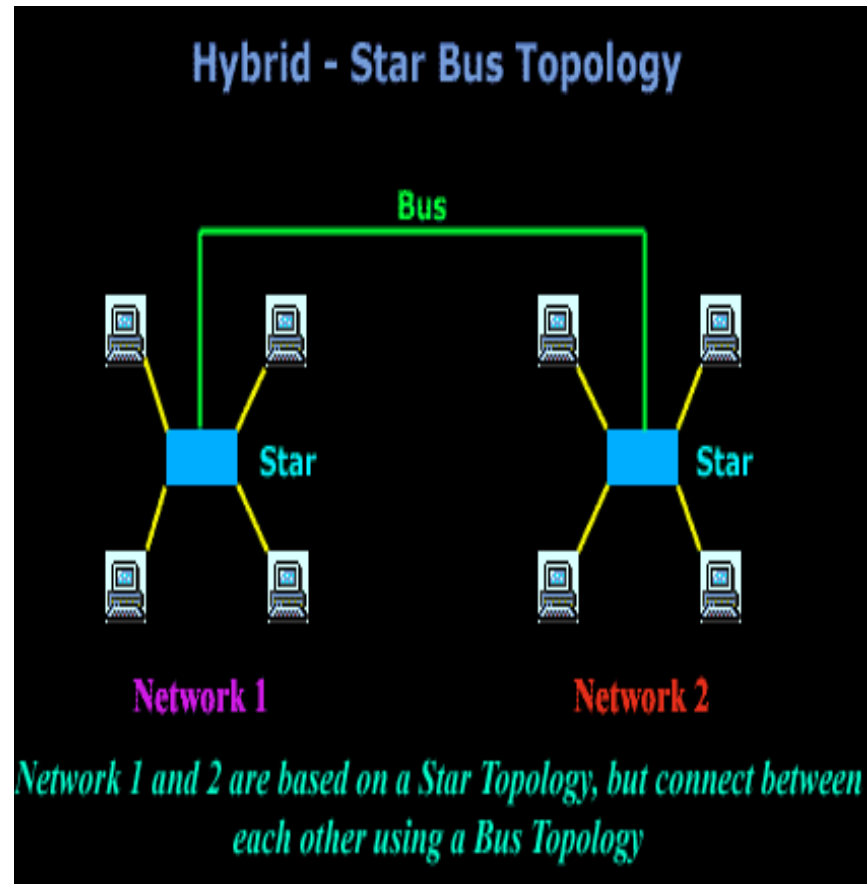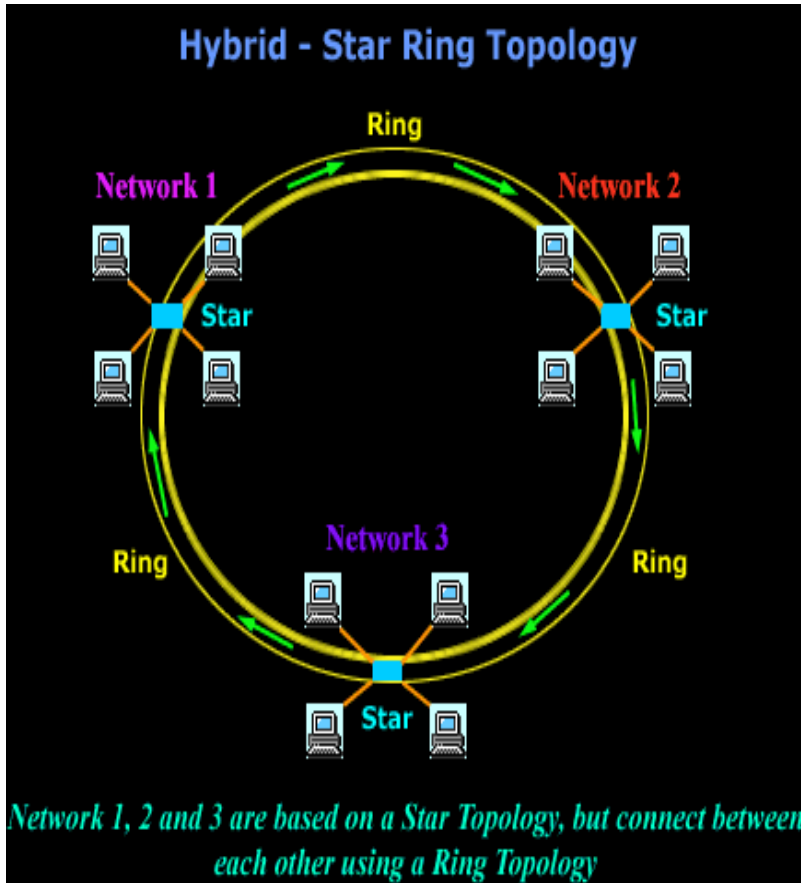
Merits and Demerits of Star Topology
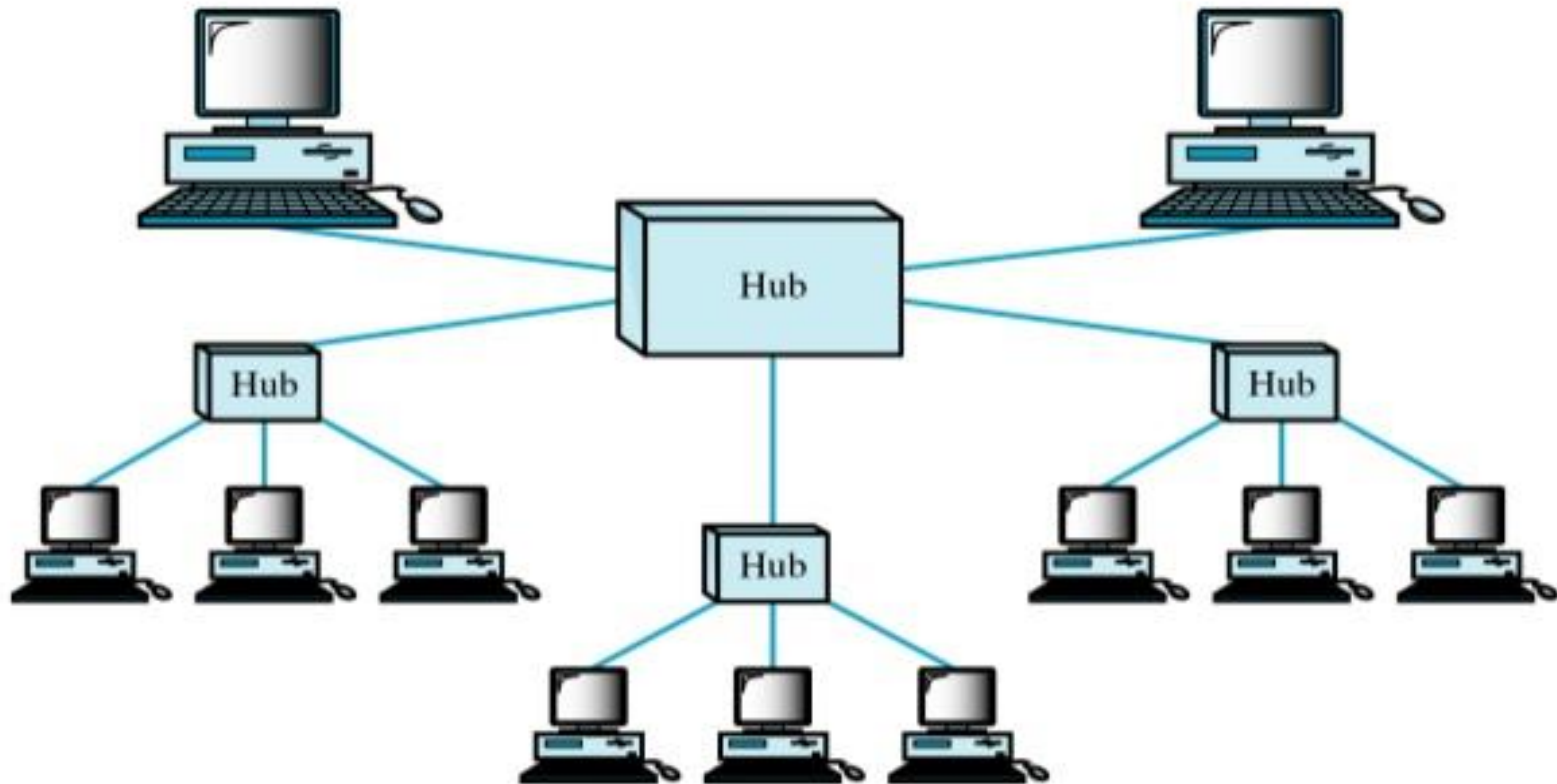
Merits

- Improves Fault Tolerance

Demerits

- The most Expensive
- Difficult to install
- Difficult to manage
- Difficult to troubleshoot

Hybrid Topology Types

Hybrid - Star Ring Topology

Ring

Network 1   Network 2

Star   Star

Ring   Network 3   Ring

Star

Network 1, 2 and 3 are based on a Star Topology, but connect between each other using a Ring Topology

Hybrid - Star Bus Topology

Bus

Star   Star

Network 1   Network 2

Network 1 and 2 are based on a Star Topology, but connect between each other using a Bus Topology

TREE TOPOLOGY

Transmission Media

- **Transmission media** is a pathway that carries the information from sender to receiver.

- The means through which data is transformed from one place to another is called transmission or communication media
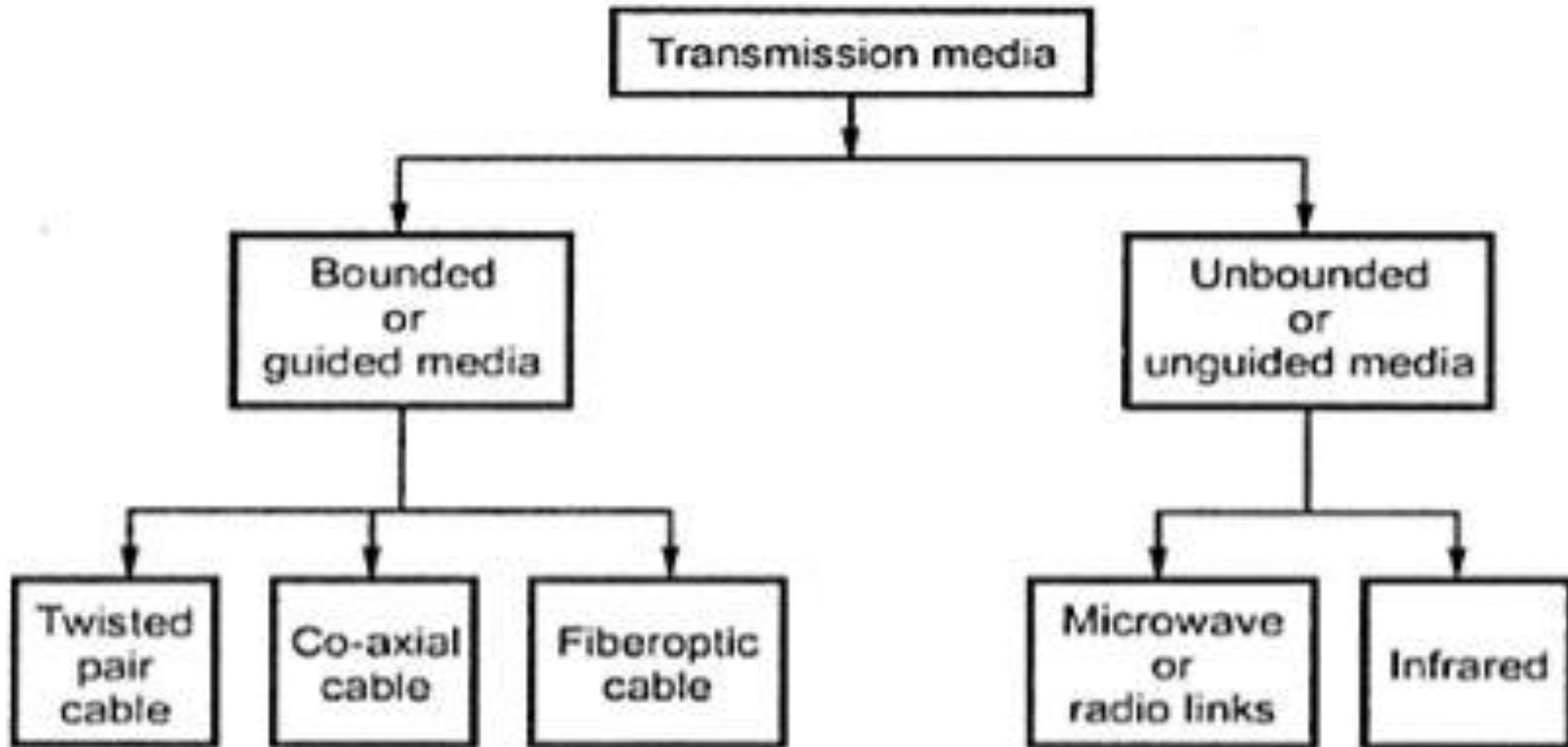
Transmission Media

Fig1: Classification of Transmission Media

Transmission Media

- **Two main categories:**
  - Guided — wires, cables
  - Unguided — wireless transmission, e.g. radio, microwave, infrared, Bluetooth …
- **Guided media:**
  - Twisted-Pair cables:
    - Unshielded Twisted-Pair (UTP) cables
    - Shielded Twisted-Pair (STP) cables
  - Coaxial cables
  - Fiber-optic cables

Twisted Pair Cables

Shielded twisted pair (STP)
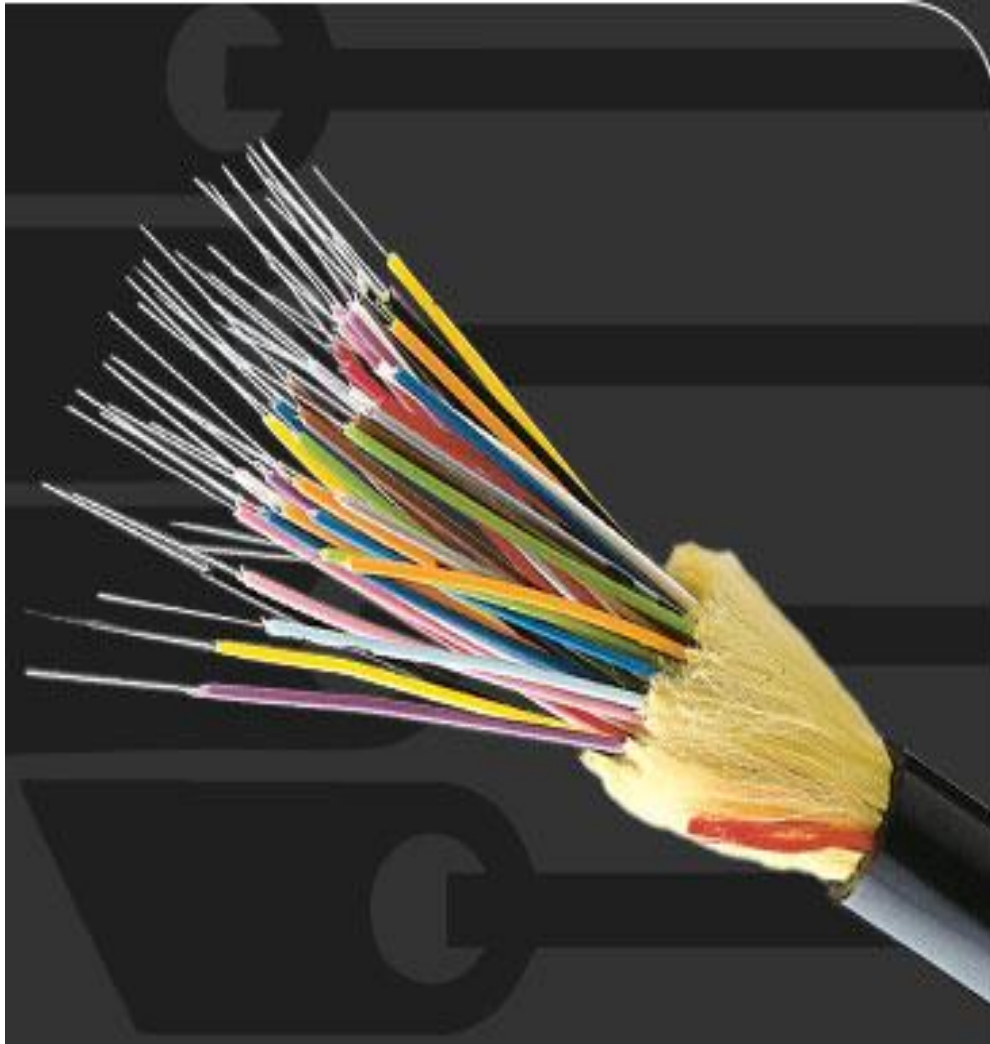
Unshielded twisted pair (UTP)

Coaxial Cable Networks
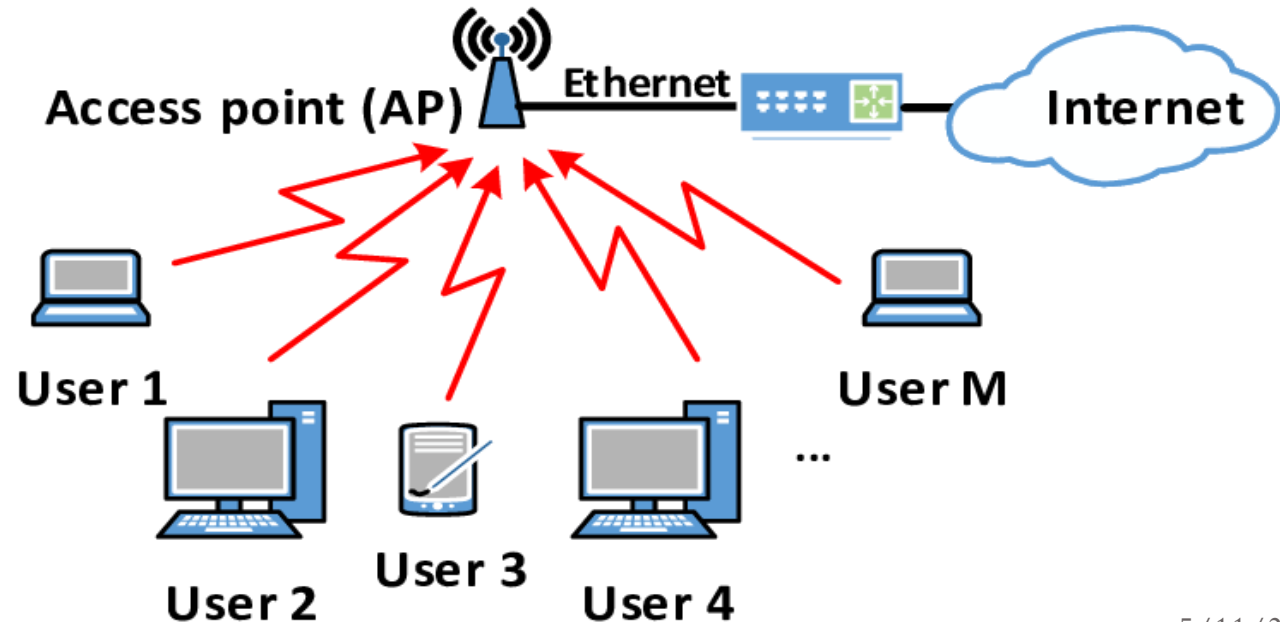

ThinNet and ThickNet Cables

Fiber Optic Cable

©2000 Belkin Components

- Wireless Transmission Media is a form of unguided media.
- Wireless communication involves no physical link established between two or more devices, communicating wirelessly.
- Wireless signals are spread over in the air and are received and interpreted by appropriate antennas.

Categories of UTP Cables

- *Category 1* — the lowest quality, only good for voice, mainly found in very old buildings, not recommended now

- *Category 2* — good for voice and low data rates (up to 4Mbps for low-speed token ring networks)

- *Category 3* — at least 3 twists per foot, for up to 10 Mbps (common in phone networks in residential buildings)

- *Category 4* — up to 16 Mbps (mainly for token rings)

- *Category 5* (or *5e*) — up to 100 Mbps (common for networks targeted for high-speed data communications)

- *Category 6* — more twists than Cat 5, up to 1 Gbps

Type	Distance	Speed	Cost	Advantages	Disadvantages
UTP	100 m	10 Mbps to 1000 Mbps	Least expensive	Easy to install; widely available and widely used	Susceptible to interference; can cover only a limited distance
STP	100 m	10 Mbps to 100 Mbps	More expensive than UTP	Reduced crosstalk; more resistant to EMI than Thinnet or UTP	Difficult to work with; can cover only a limited distance
Coaxial	500 m (Thicknet) 185 m (Thinnet)	10 Mbps to 100 Mbps	Relatively inexpensive, but more costly than UTP	Less susceptible to EMI interference than other types of copper media	Difficult to work with (Thicknet); limited bandwidth; limited application (Thinnet); damage to cable can bring down entire network
Fiber-Optic	10 km and above single 2 km and farther multi	100 Mb to 100 Gb single mode 100 Mbps to 9.92 Gb multi	Expensive	Cannot be tapped, so security is better; can be used over great distances; is not susceptible to EMI; has a higher data rate than coaxial and twisted-pair cable	Difficult to terminate

81

The INTERNET

What is the INTERNET?

- The internet is the global network of networks, which interconnects millions of computer systems and billions of people around the world.

- The networks that are interconnected to the internet are owned and operated by various organizations around the world.
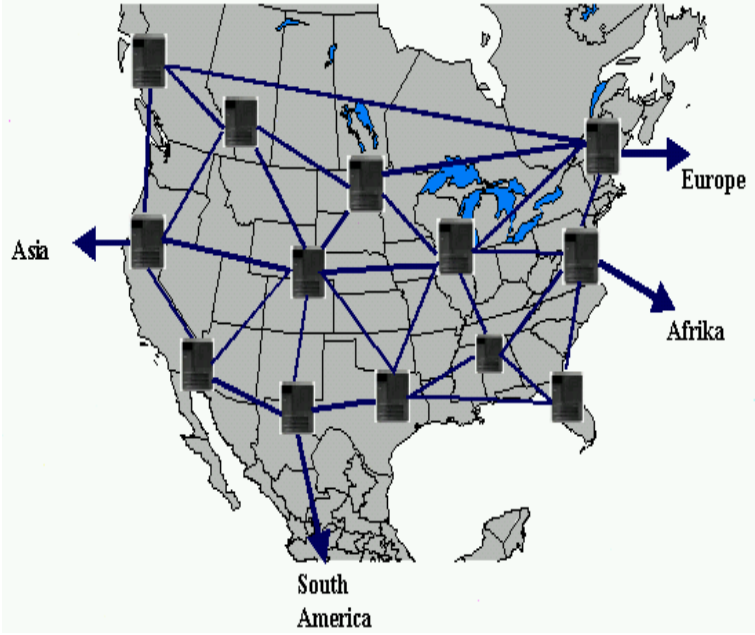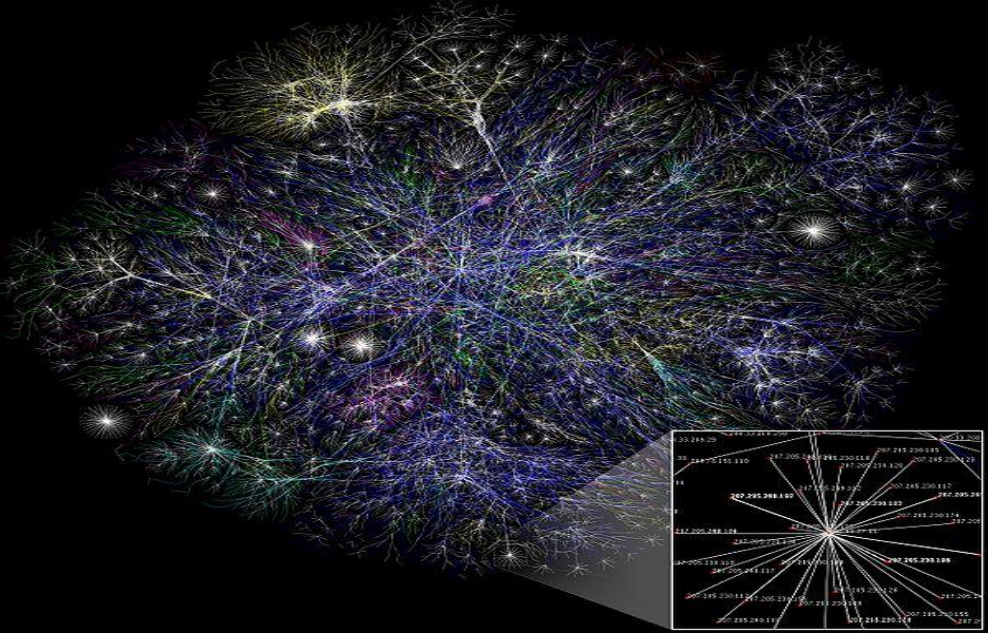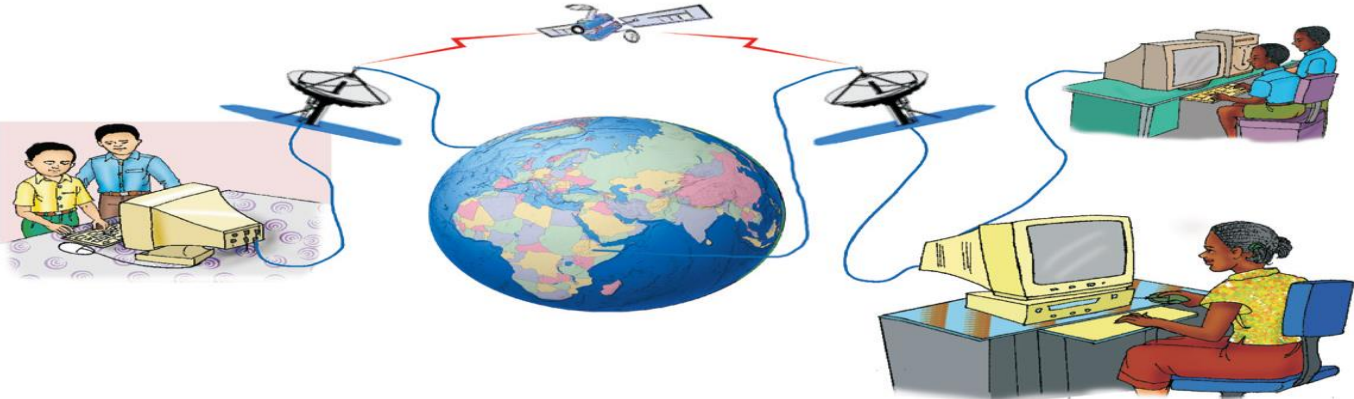
INTERNET

- The Internet is consisted of academic, business, government networks, which together carry various

- The internet provides services such as e-mail, online chat, file transfer and the interlinked Web pages and other documents of the World (WWW).

- An Internet service provider (ISP) is an organization that provides services for accessing, using, or participating in the Internet.

Internet

- The Internet is not a closely controlled by 'single' system, but an grouping of independent networks united by the common use of TCP/IP protocol.

- Internet grew out of an experiment begun in the 1960's by the U.S. Department of Defense , ARPANET (The Advanced Research Projects Agency Network).

Internet

Internet

To connect to the Internet, the following are needed:

1. Computer

2. Telephone line (cable)

3. Modem and/or router

4. ISP (Internet Service Provider)

5. Web browser, *e.g.*, *Internet Explorer*, *Mozilla Firefox*, *Google Chrome*, *Safari*, *Opera*, etc.

Internet- Intranet and Extranet

- **Intranet**
  - An intranet is a network that works like the Internet but is only available *within* a particular organization, not to the public.
- **Extranet:**
  - Extranet provides selected users from outside the organization to access data from the internal network. Extranets are commonly used by suppliers to provide data to company clients

Internet Connections

Dial-up Connection

- This provides connection to Internet through a dial-up terminal connection to the ISP.

- The computer, which provides Internet access is known as 'Host or Server' and the computer that receives the access, is 'Client' or 'Terminal'.

- The client computer uses modem to access a "host" and acts as if it is a terminal directly connected to that host.

5/11/2019

Dial-up Connection

Internet Connections

- **Leased Connection**
  - It is the secure, dedicated and most expensive, level of Internet connection.
  - With leased connection, your computer is dedicatedly and directly connected to the Internet using high-speed transmission lines.
  - It is on-line twenty-four hours a day, seven days a week.
  - Leased Internet connections are limited to large corporations and universities who could afford the cost

Internet Services

- Internet is best characterized by the services it provides.
- The following are some of the services of Internet:
  - WWW
  - E-mail
  - FTP
  - Internet Telephony
  - Telnet
  - RFC/Chat

WWW (World Wide Web)

- WWW is the most important service provided by Internet.
- WWW is a set of sites that you can go for information.
- hyperlinks within WWW documents can take you quickly to other related documents.
- A worldwide collection of electronic documents
- Each electronic document is called a **Web page**
- Can contain text, graphics, audio, video, and built-in connections
- A **Web site is a collection of related Web pages**
- Also called the **Web**

Tim Berners-Lee

- Father of W .W .W
- The inventor of HTML.
- Invented WWW while working at CERN, the European Particle Physics Laboratory.

Web browser

- **Program that allows you to view Web pages**
  - Netscape
  - Internet Explorer
  - AltaVista
  - Firefox
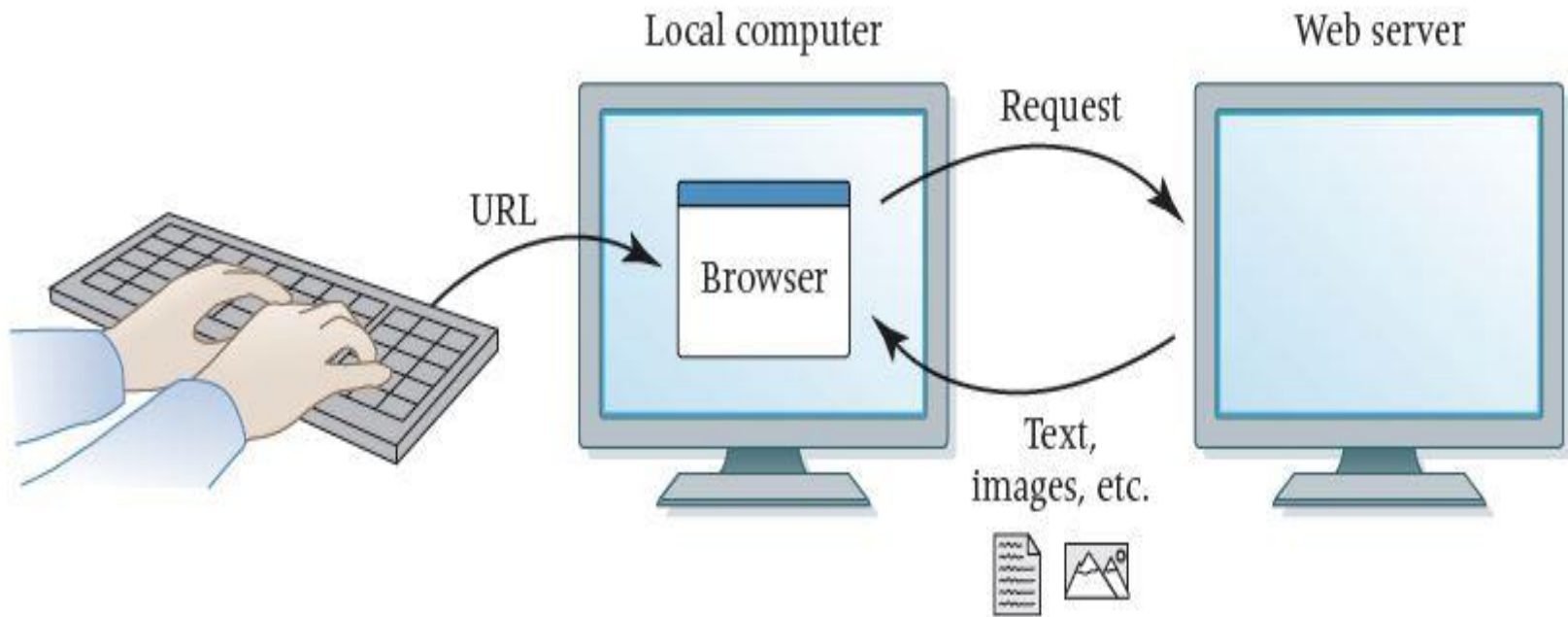 - Opera
  - Safari
  - Google Chrome

Web browser

FIGURE 16.1 A browser retrieving a web page

Universal Resource Locator

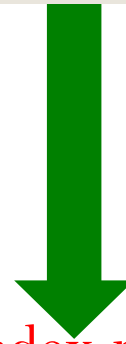http://www.aau.edu.et/index.php/home-newcs/index.html

http
Protocol
Identifier

www.aau.edu.et
Server's Name

index.php/home-ewcs/index.html
Directory & File Name

Email

- Electronic Mail (email) is the most frequently used application of the Internet which is used for sending a message electronically over the internet, from the sender to the receiver.

- The message first goes to your **Internet Service Provider's mail server**, which in turn sends it to the **recipient's mail server**. On the way your message may go through several servers, each reading the domain name in order to route it to the appropriate server.

Email

- To send and receive e-mail messages, you need to create an e-mail account on an Internet mail server with a unique domain name.

- Email Service providers: Yahoo, Gmail, Hotmail,

- E-mail address is a Unique name that consists of a user name and domain name that identifies the user: abebe@gmail.com

   selam@yahoo.com

File Transfer Protocol (FTP)

- **File Transfer Protocol—Internet standard that allows you to upload and download files with other computers on the Internet.** to do this, there should be an admission from the remote computer.

  - There are two computers involved in an FTP transfer: a server and a client.

  - The **FTP server**, running FTP server software, listens on the network for connection requests from other computers. The client computer, running FTP client software, initiates a connection to the server

Internet Telephony (Voice over IP)

- Voice over Internet Protocol (VoIP) is a methodology and group of technologies for the delivery of Voice communications and Multimedia sessions over Internet Protocol (IP) networks, such as the Internet.

- Other terms commonly associated with VoIP are *IP telephony*, *Internet telephony.*

- *E.g. Skype,VIBER*

Telnet (Remote Login)

- **Telnet:-** It is a program that allows you log in from your own computer to a remote computer directly through the Internet and you can work on that computer.

- The term "telnet" is a mashing together of "telephone" and "network"

- For example, if I travelled abroad and had use of machine with Internet access, I could use telnet to login to my account on SIS-Server at AAU provided I have an account on the machine.

Telnet Client

Telnet Server (telnetd)

"Username"
"Password"

Telnet Protocol

Internet Relay Chat-IRC

- Internet Relay Chat is one of the most popular and most interactive services on the Internet.

- Using an IRC client (program) you can exchange text messages interactively with other people all over the world