Chapter Six

Data Communications and Computer Networks

CS211 ICT Fundamentals

Agenda

- Data Communications
- Data transmission
  - Communication channels
  - Types of transmission mode
  - Components of Data communications
  - Applications of Data Comm.
- Computer Networks
  - Classification of networks
  - Networking components (devices, software, …)
  - Distributed systems

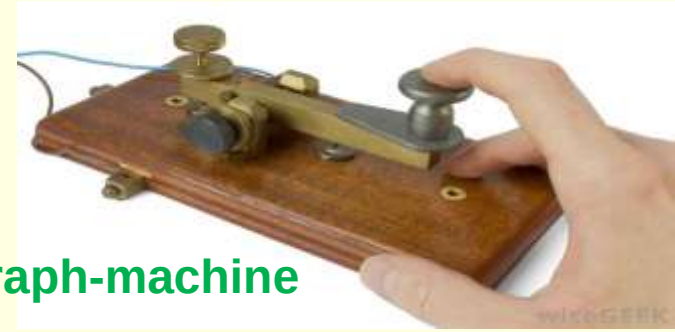
Data Communications

- Communications, also called telecommunications, refers to the transfer of data from a transmitter (sender or source) to a receiver across a distance. The term telecommunication means communication at a distance. The data transferred can be voice, sound, images, graphics, video, text, or a combination thereof (multimedia).

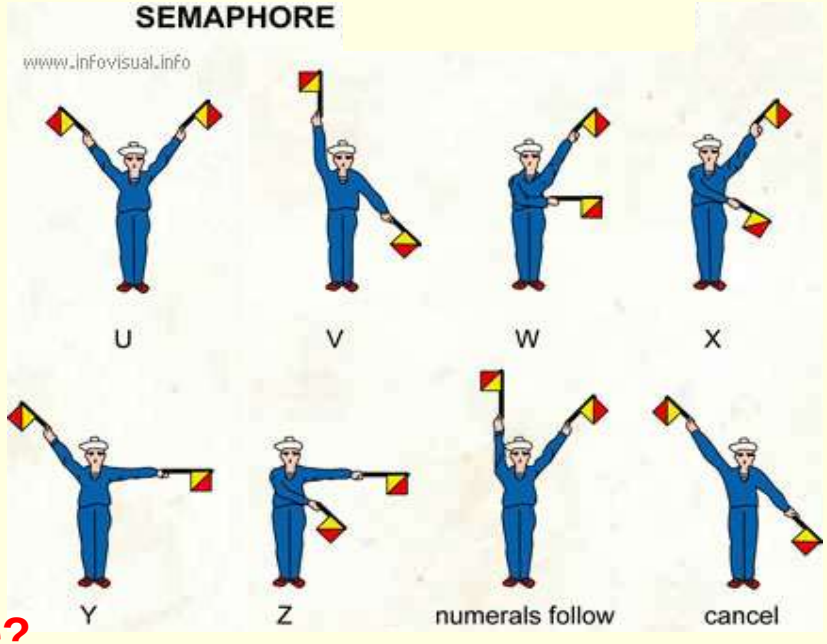
Telecommunications

A ·–	J ·–––	S ···	1 ·———–
B –···	K –·–	T –	2 ··–––
C –·–·	L ·–··	U ··–	3 ···––
D –··	M ––	V ···–	4 ····–
E ·	N –·	W ·––	5 ·····
F ··–·	O –––	X –··–	6 –····
G ––·	P ·––·	Y –·––	7 ––···
H ····	Q ––·–	Z ––··	8 –––··
I ··	R ·–·	0 –––––	9 ————·

- Tele (Far) + Communications
- Early telecommunications
  - smoke signals and drums
  - visual telegraphy
    (or semaphore in 1792)
- Telegram and telephone
  - Telegraph (1839)
  - Telephone (1876)
- Radio and television
- Telephony (VoIP)
  - Voice and Data



telegraph-machine



What is the medium here?

Data Communications

- The word data refers to information presented (encoded) 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.

Communications Cont…

- Data Communications
  - Transmission of signals
    - Encoding (conversion, encrypting, modulating…), interfacing (modulating,…), signal integrity, multiplexing, compression, etc.
- To be transmitted data must be converted to electrical or electromagnetic signals.
- The methods include electrical signals carried along a conductor, optical signals along an optical fiber, and electromagnetic signals (waves) through space
- The two measure approaches to greater efficiency in using a shared medium for data communication are multiplexing and compression.

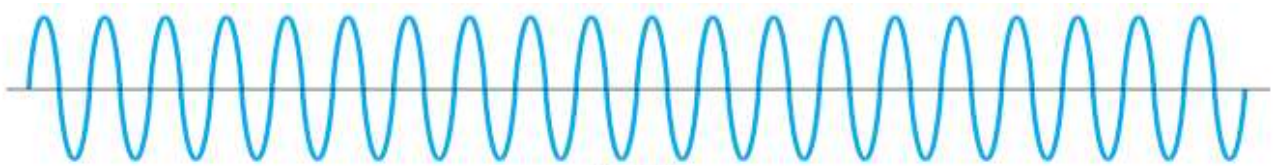
Data communication four basic terms

- **Data**: A collection of facts in raw forms that become information after processing.
- **Signals**: Electric or electromagnetic (radio and light waves) encoding of data.
- **Signaling**: Propagation of signals across a communication medium.
- **Transmission**: Communication of data achieved by the processing of signals.

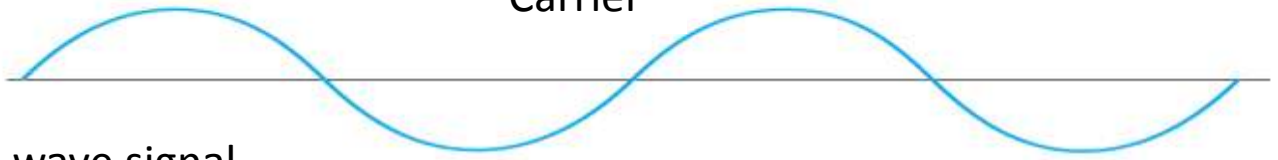
Analogue & Digital Signals

- Telephones, radios, and televisions – The older forms of communications technology – were designed to work with an analog signal.
- An analog signal is a continuous electrical signal in the form of a wave. The wave is called a carrier wave.
- Two characteristics of analog carrier waves that can be altered are frequency and amplitude.
- **Examples of analog values: Sound, Temperature, Pressure, Light, Video**

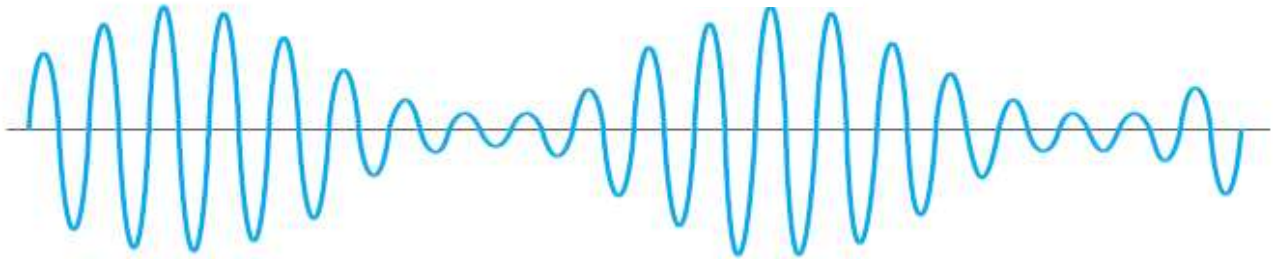
Analogue & Digital Signals Cont.



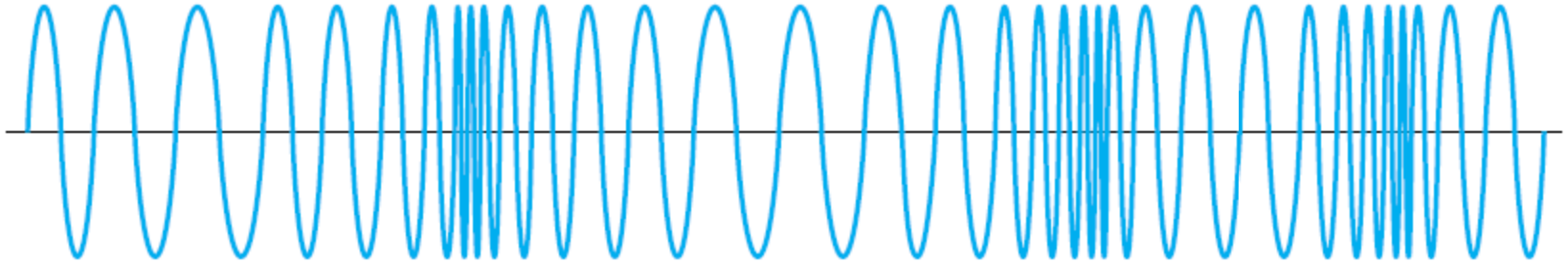
Carrier



Modulating sine-wave signal



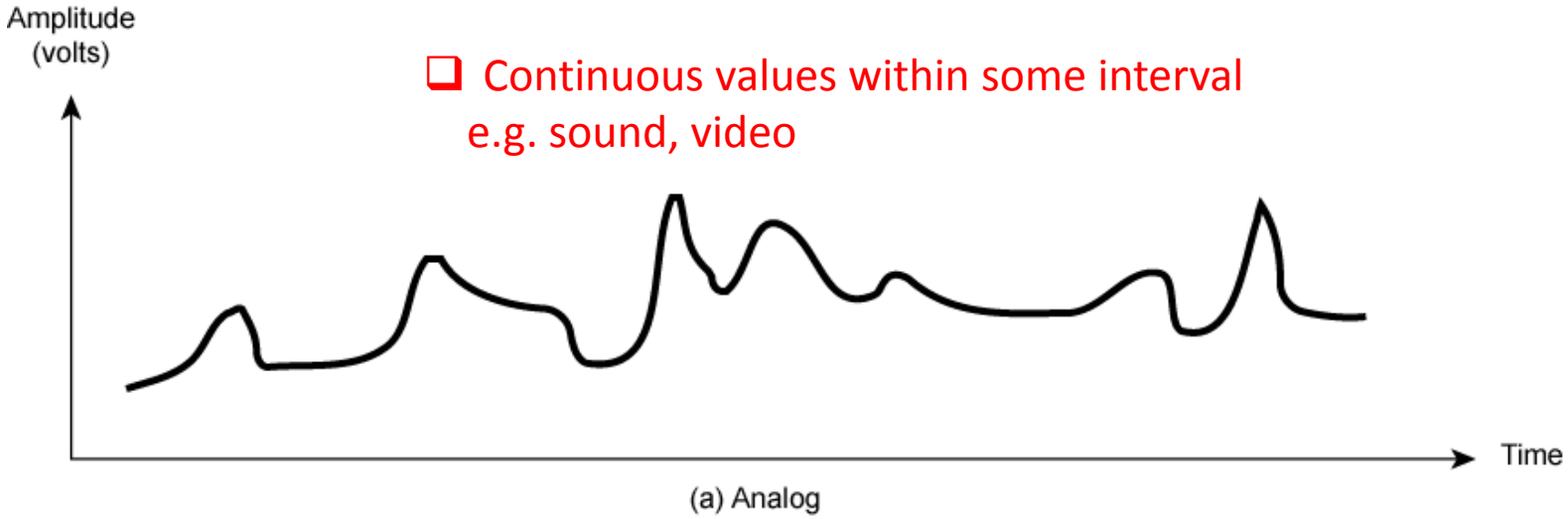
Amplitude-modulated wave



Frequency-modulated wave

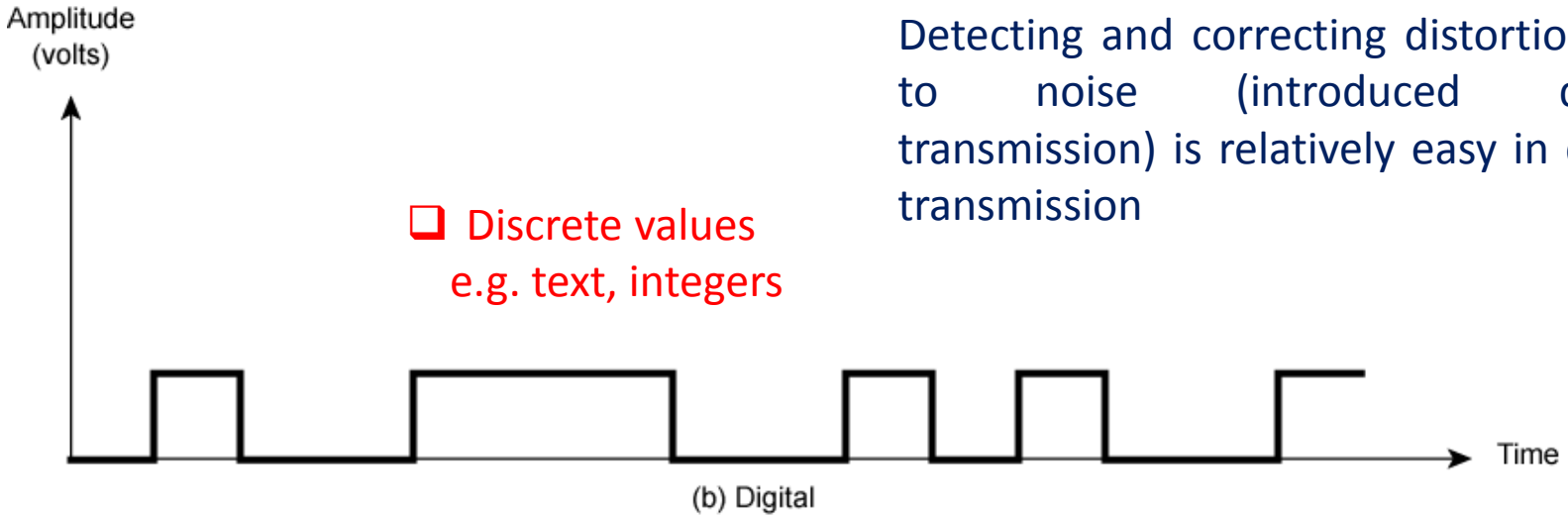
Processing of signals for transmission

Analogue & Digital Signals



(a) Analog

- Continuous values within some interval
  e.g. sound, video



(b) Digital

- Discrete values
  e.g. text, integers

Detecting and correcting distortion due to noise (introduced during transmission) is relatively easy in digital transmission

The principal advantages of digital signaling are that it is generally cheaper than analog signaling and is less susceptible to noise interference.

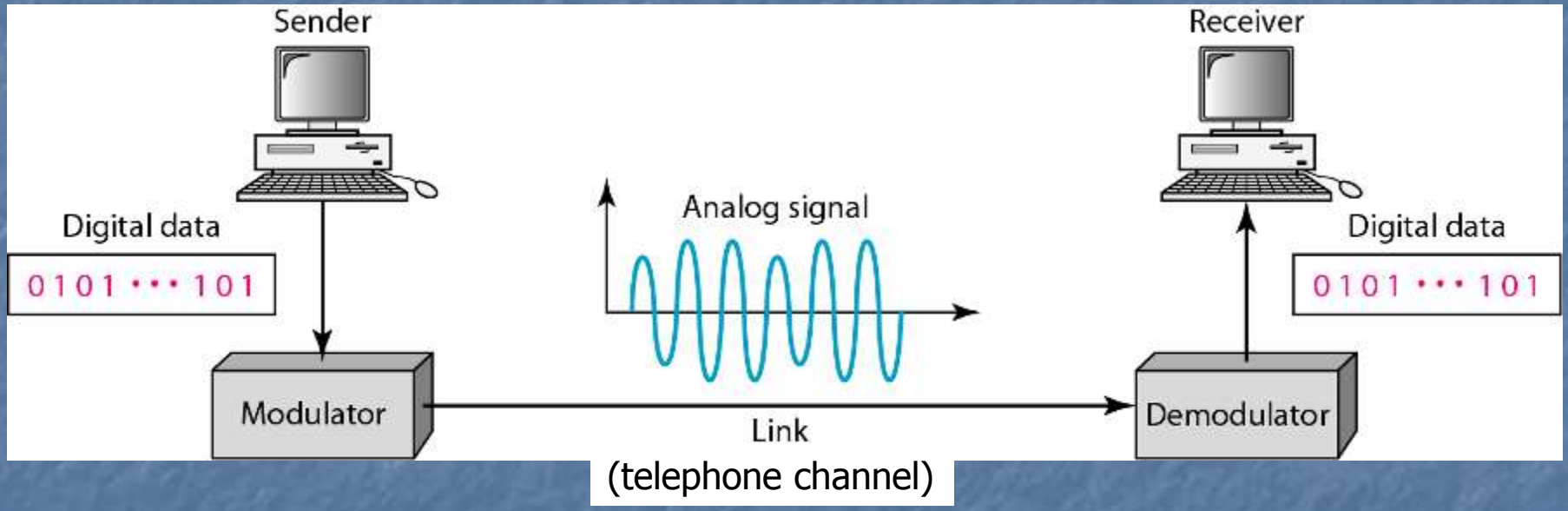
Bandwidth of transmission

1. telecommunications: **range of radio frequencies:** a range of radio frequencies (hertz) 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 (bps).
3. a data **transmission rate**; the maximum amount of information (bits/second) that can be transmitted along a channel. Higher frequency and/or wider bandwidth results in transmission of more data per unit time. (bus speed, serial & parallel ports)

Bandwidth is limited by the type of transmission medium

Digital-to-Analog Conversion

- Required to send digital data over a public telephone channel
  - Also known as *modulation*



What are telecommuting and virtual offices?

"Move the work instead of the workers"

Devices of Data Communication

- **Video Display Terminals and printing terminals**
  - **I/O devices (microphones, speakers, cameras, etc.)**
- **Modem – transmission of data over telephone lines**
- **Interface units (modems, multiplexers, codecs) - Coordinates various types (aspects) of data transmission and receptions. Thereby greatly increasing the efficiency of data communication.**

- ❑ **An analog communication device always distorts the input and adds noise.**
- ❑ **Digital information doesn't become distorted while being stored, copied, or communicated.**

Data transmission

- **A basic communication system consists of :**

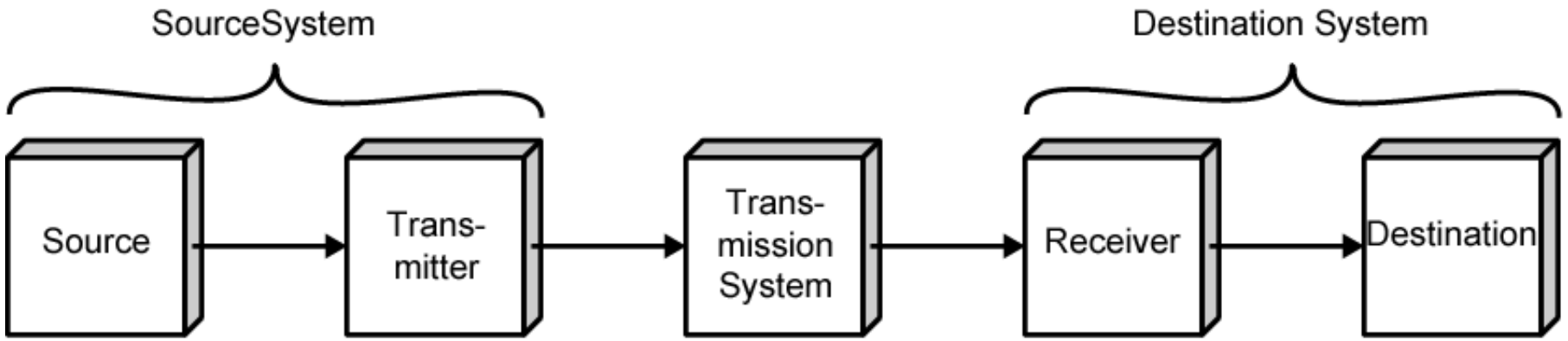
Example - consider a radio broadcast.

- **In this case**
  - **the broadcast tower (antenna) is the transmitter,**
  - **the radio is the receiver and**
  - **the transmission medium is free space.**

A Communications Model

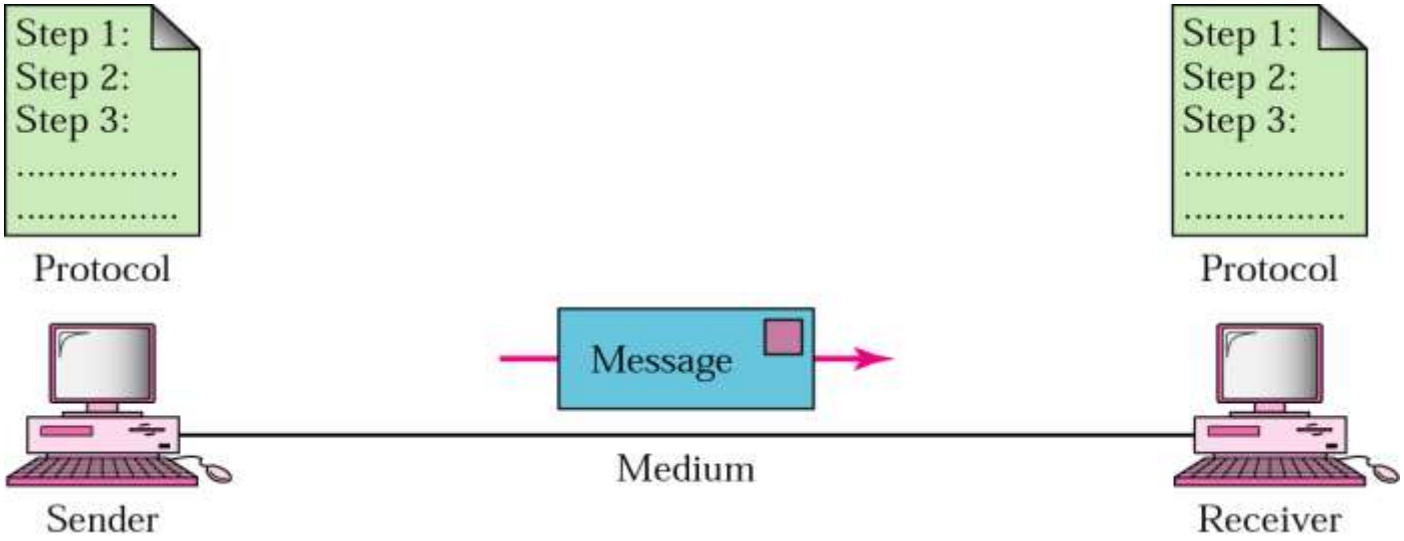
- Source
  - —generates data to be transmitted
- Transmitter (some encoding is done here)
  - —Converts data into transmittable signals
- Transmission System
  - —Carries data
- Receiver (decoding…)
  - —Converts received signal into data
- Destination
  - —Takes incoming data

Simplified Communications Model - Diagram



(a) General block diagram

Five Components of Data Communication



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

Communication Protocols

- The procedure of data transmission in the form of software is commonly called *protocol*.
- *Data communication software* is the software that enables us to communicate with other systems.
- The data communication software instructs computer systems and devices as to how exactly data is to be transferred from one place to another.

Data transmission software or protocols (functions)

- The data transmission software or protocols performs the following functions for the efficient and error free transmission of data
  - **Data sequencing**: A long message to be transmitted is broken into smaller packets of fixed size and a unique sequence number is given for every packet.
  - **Data Routing**: It is the process of finding the most efficient route between source and destination before sending the data.

Cont…

- **Flow control:** enables a receiver to regulate the flow of data from a sender so that the receiver's buffers do not overflow. Regulates the process of sending data between fast sender and slow receiver.
- **Error Control**: Error detecting and recovering is one of the main function of communication software. It ensures that data is transmitted without any error and loss. (retransmit if not ack.)
- **Opening/closing comm. Lines**, message switching, circuit switching, multiple use of comm. lines, …

Transmission upon agreed encoding rules and protocols . Example is TCP/IP; TCP/IP means Transmission Control Protocol/Internet Protocol

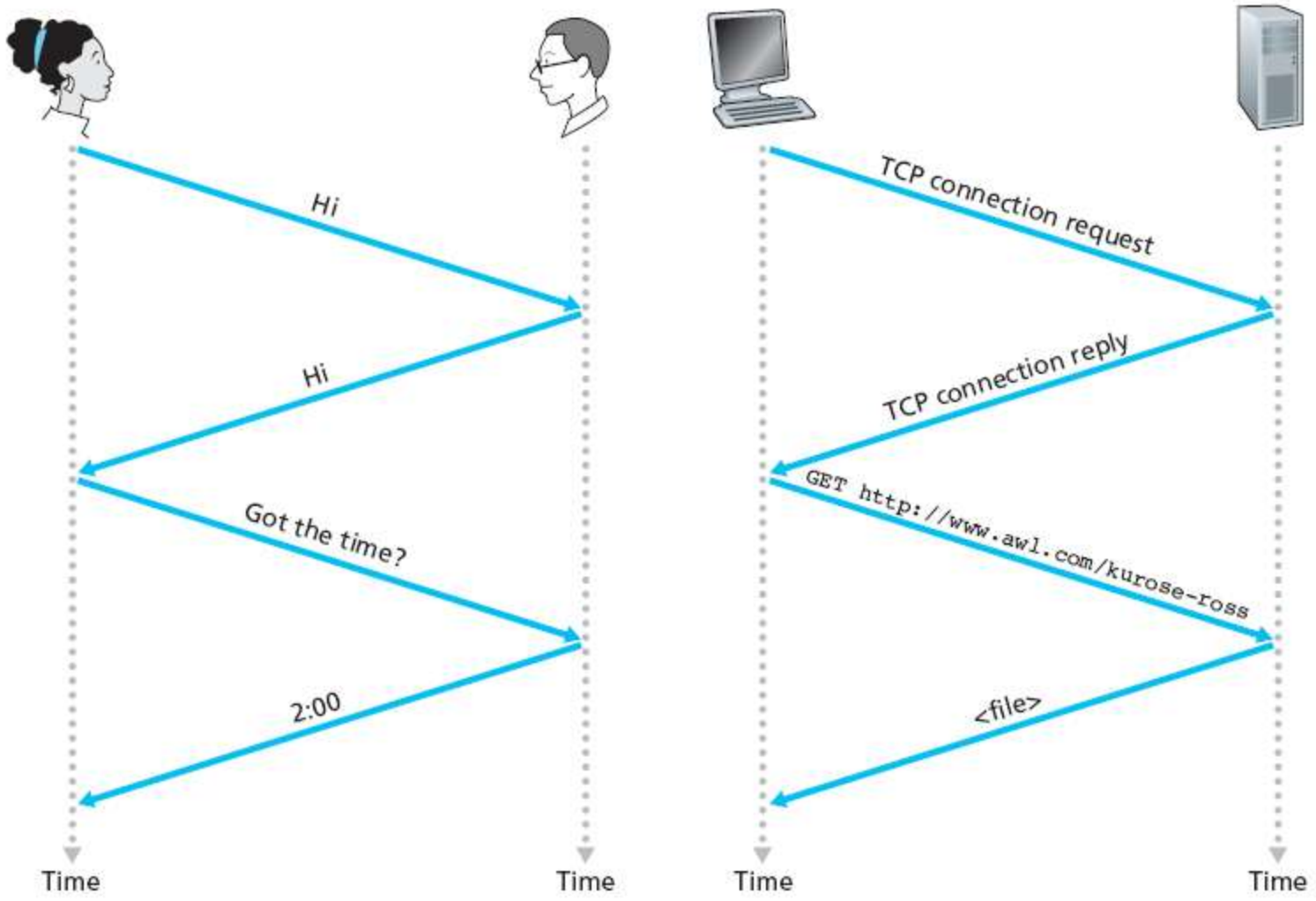
Elements of a Protocol (Communications Software)

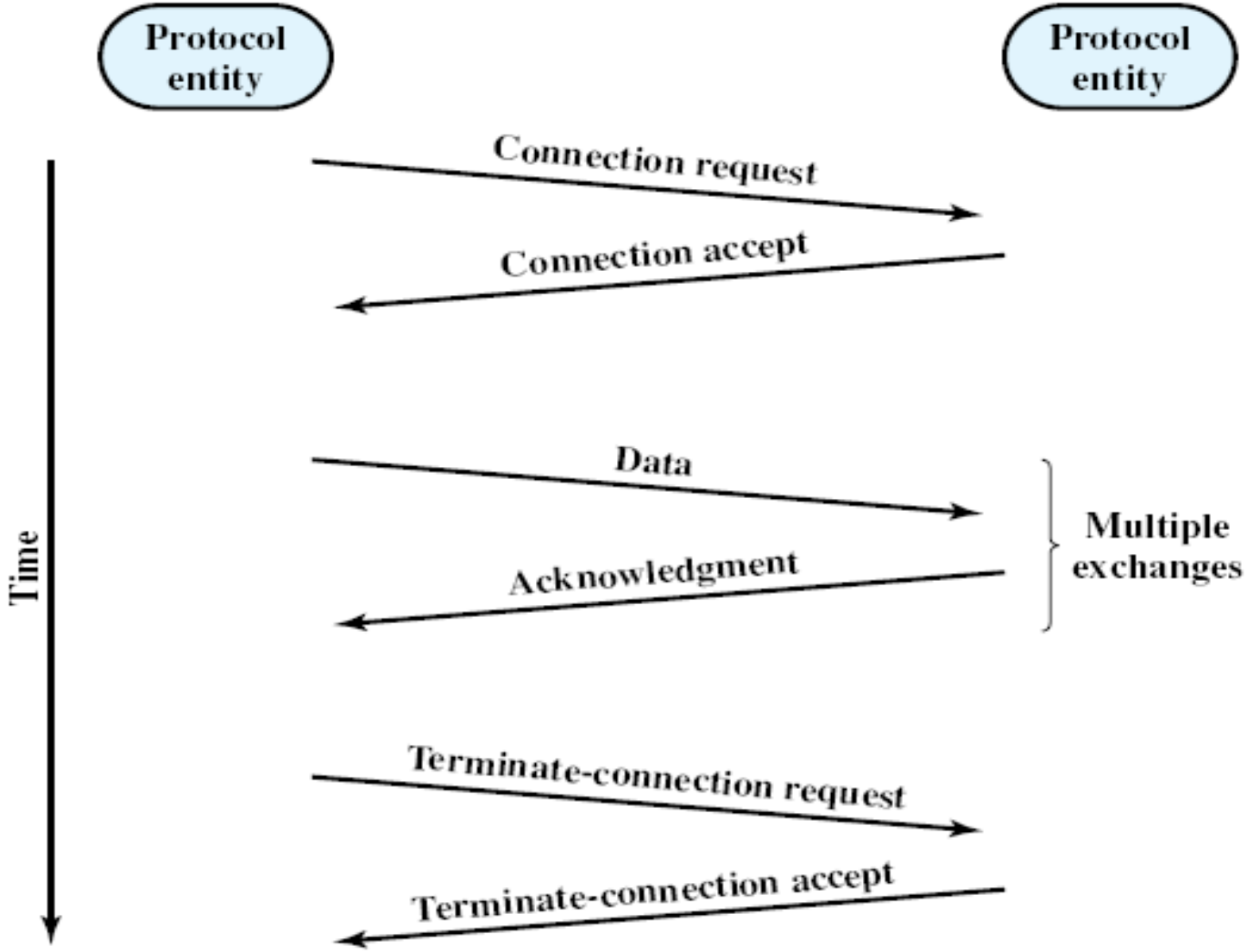
- **Syntax**
  - **Structure or format of the data blocks**
  - **Indicates how to read the bits - field delineation**
- **Semantics**
  - **Interprets the meaning of the bits**
  - **Knows which fields define what action**
  - **Control information for coordination and error handling**
- **Timing**
  - **When data should be sent and what**
  - **Speed at which data should be sent or speed at which it is being received.**

We can group protocol functions into the following categories:

- Encapsulation (data + control information)
- Fragmentation and reassembly
- Connection control
- Ordered delivery
- Flow control
- Error control
- Addressing
- Multiplexing
- Transmission services (encryption, compression,…)

A human protocol and a computer network protocol





The Parts of a Connection-Oriented Data Transfer

Connection control function of a protocol

Data Transmission Modes

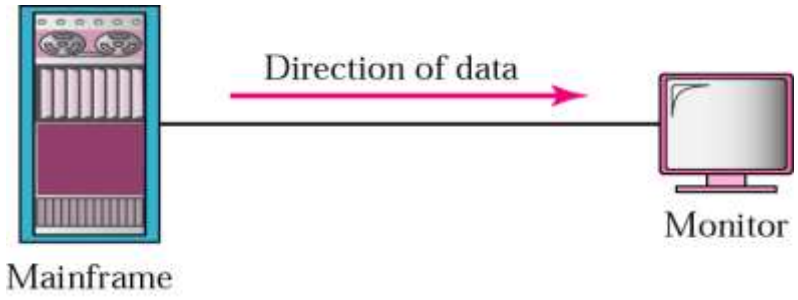
- **Simplex System**
  - **You can only send data from one location to another but you cannot receive. It is one way communication.**

    Ex. Telemetry, Broadcast radio
- **Half Duplex**
  - **You can send/receive but not simultaneously.**

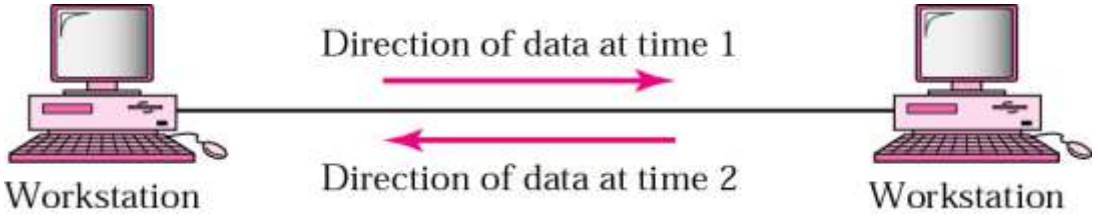
    Ex. Marine Radio, Walky-talky (Police Radio)
- **Full Duplex**
  - **A system that allows communication in both directions simultaneously and synchronously. Use of full-duplex line improves efficiency.**
  - **The medium is carrying signals in both directions at the same time.**

    Ex. Telephone

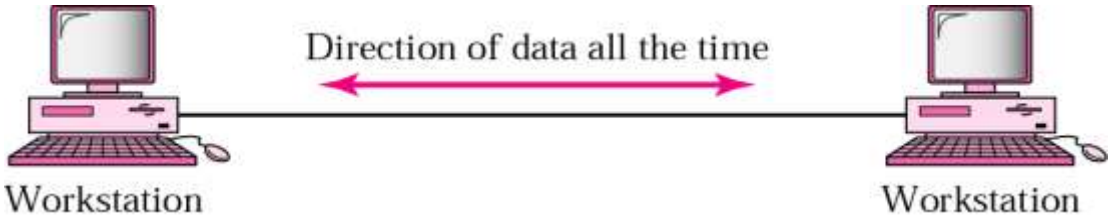
Direction of data flow



Simplex



Half Duplex



Full Duplex

Communication Channels

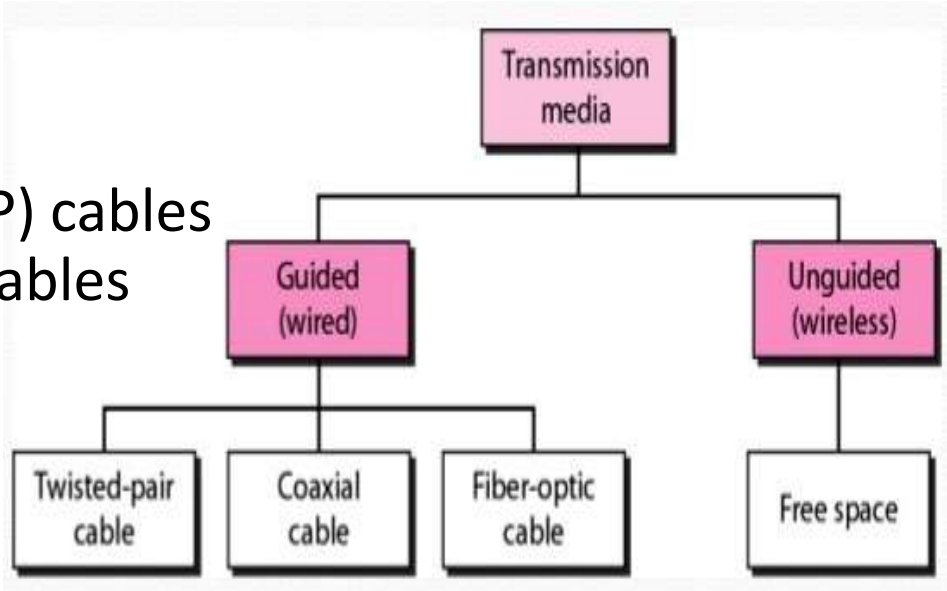
- A **channel** is a path between two communication devices
- **Channel capacity**: How much data can be passed through the channel (bits/sec or hz(frequency-range))
  - Also called **channel bandwidth (range of frequencies)**
  - The smaller the pipe the slower the data transfer!
  - **Analog bandwidth of a medium is expressed in hertz;**
  - **Digital bandwidth of a medium is expressed in bits per second.**
- Consists of one or more **transmission media**
  - Materials carrying the signal
  - Two types:
    - Physical: wire or cable (Guided)
    - Wireless: air (or space) (Unguided)

Transmission Channel (Media)

- Two main categories:

1.Guided (Physical)

- Twisted-Pair cables:
  - Unshielded Twisted-Pair (UTP) cables
  - Shielded Twisted-Pair (STP) cables
- Coaxial cables
- Fiber-optic cables

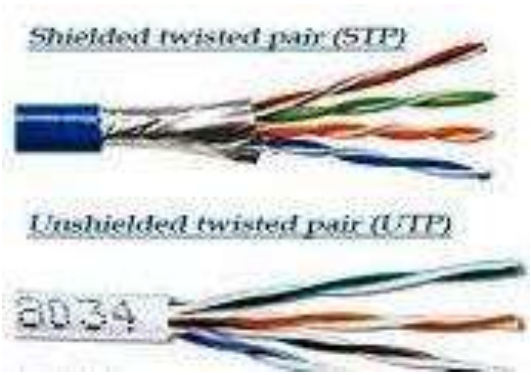


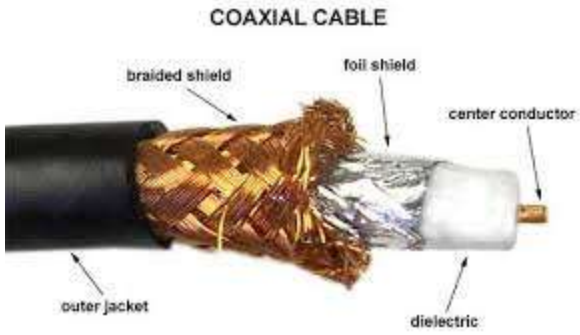
2.Unguided (Wireless)

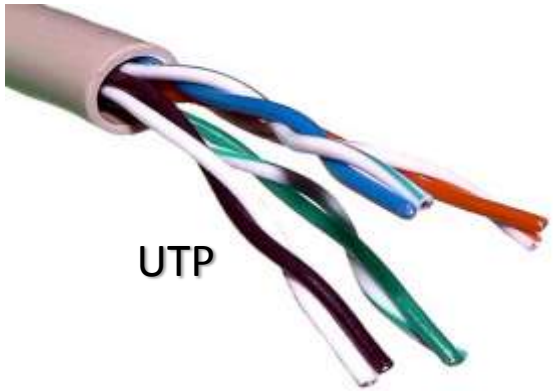
- Wireless transmission, e.g. radio, microwave, infrared, sound, sonar (echolocation finding in air and water)

Physical Media (Guided Channel)

- **A tangible media**
- **Twisted-pair cable:**
  - One or more twisted wires bundled together (why twist?)
  - Made of copper
- **Coax-Cable:**
  - Consists of single copper wire surrounded by three layers of insulating and metal materials
  - Typically used for cable TV
- **Fiber-optics:**
  - Strands of glass or plastic used to transmit light
  - Very high capacity, low noise, small size, less suitable to natural disturbances

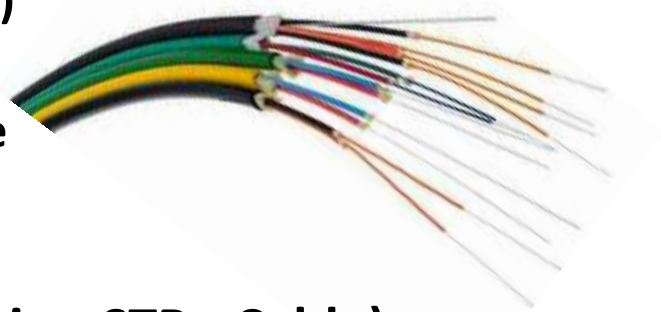






Information channel Cont'd …

- **Guided**
  - **Cable transmission (Attenuation, Distortion & noise) (reduce the strength & change the form during transmission) (*AC at very high voltage to overcome loss due to resistance of wire)**
    - **Fibre-optics**
      - **10GBPS and greater, long distance**
    - **Coaxial**
      - **10MBPS, 200M - 1KM**
    - **Twisted pair (Shielded Twisted Pair – STP - Cable)**
      - **10 to 1000MBPS, 100M**
    - **Twisted pair (unshielded twisted pair-UTP)**
      - **less interference protection and lower data rate than STP**
      - **Cross talk problem**



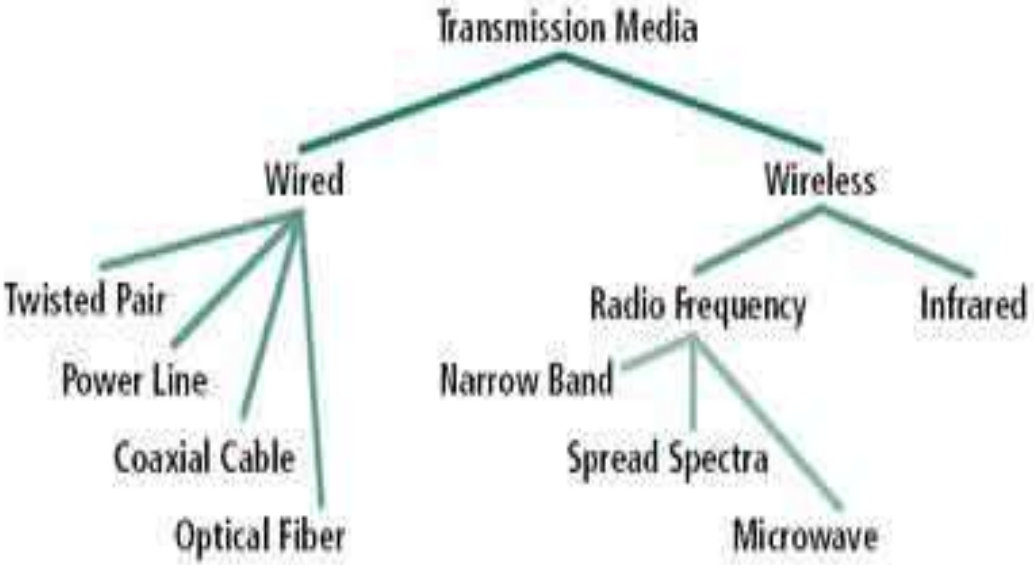
Coaxial cable connector

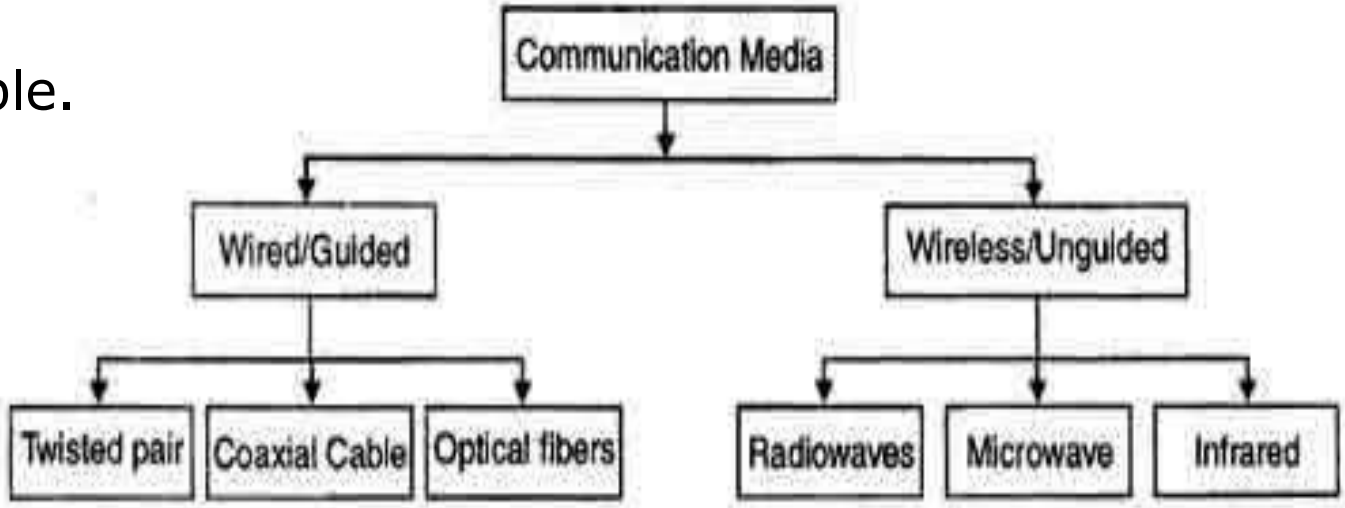
Fiber optic cables

Information channel or media Cont'd …

Coaxial Cable

A thinnet coaxial cable.





Fiber-Optic Cable

- Fiber-optic cables use light signals for data transmission.
- Either laser or other light producing mechanism, such as light emitting diodes (LEDs), are used as the source of light.
- Using a laser is more dependable, but more costly, so most fiber-optic networks use LEDs as the source of light.

Physical Transmission Media and wireless Infrared Characteristics Comparison

Twisted-Pair	Coaxial	Fiber-Optic	Infrared Light
			Wireless
Low Cost	Moderate Cost	High Cost	Moderate Cost
Best for short distances (330 ft.)	Moderate Distance (3300 ft. – thin) (8250 ft. – thick)	Long Distances (14,256 ft.)	Short distance (75 ft.)
Easy to Install	Professional Installation	Professional Installation	Easy to Install
Low Security	Average Security	High Security	Low Security
Low resistance to interference	Moderate resistance to interference	Very high resistance to interference	Very high resistance to interference

Transmission Media

Data Transmission Rate

Type of Cable and LAN	Transfer Rates
Twisted Pair	
• 10Base-T (Ethernet)	10 Mbps
• 100Base-T (Fast Ethernet)	100 Mbps
• 1000Base-T (Gigabit Ethernet)	1000 Mbps
• Token ring	4 - 16 Mbps
Coaxial Cable	
• 10Base2 (ThinWire Ethernet)	10 Mbps
• 10Base5 (ThickWire Ethernet)	10 Mbps
Fiber-Optic Cable	
• 10Base-F (Ethernet)	10 Mbps
• 100Base-FX (Fast Ethernet)	100 Mbps
• FDDI (Fiber Distributed-Data Interface) token ring	100 Mbps

Wireless channel capacity:

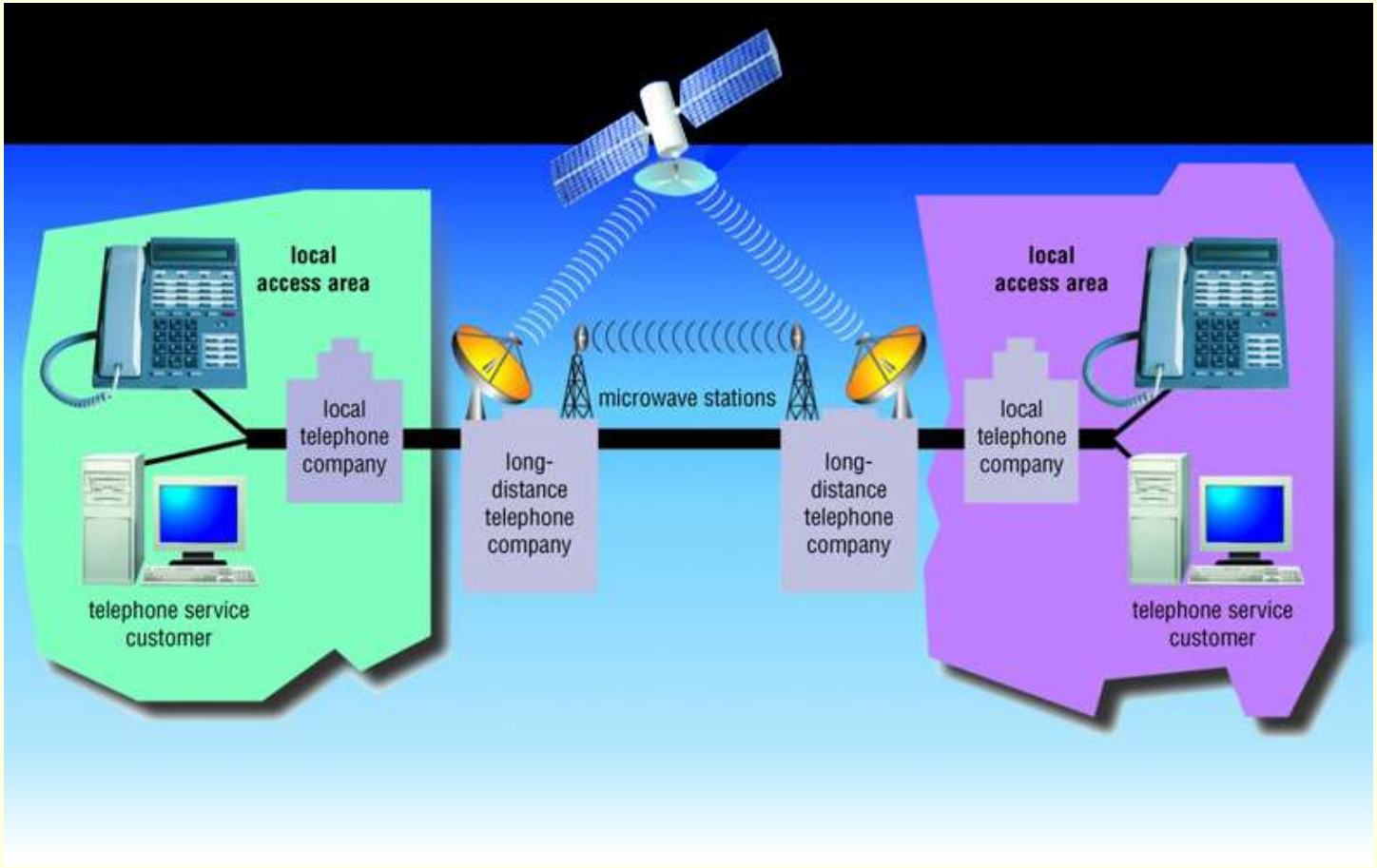
Channel	Transfer Rates
Broadcast radio	Up to 2 Mbps
Microwave radio	45 Mbps
Communications satellite	50 Mbps
Cellular radio	9,600 bps to 14.4 Kbps
Infrared	1 to 4 Mbps

Communication Satellite

- A communication satellite is a microwave relay station placed in outer space.
- In satellite communication, microwave signal is transmitted from a transmitter on earth to the satellite at space.
- The satellite amplifies the weak signal and transmits it back to the receiver.
- The main advantage of satellite communication is that it is a single microwave relay station visible from any point of a very large area.

Microwave Communications

Example: For Telephone Networks



Communication Satellite Cont.

- **Unguided or Wireless**
  - ❖ **Microwave**
  - ❖ **Satellite (Example; GEO or Geostationary)**
  - – **A man made spacecraft, about 23,000 miles (37,030 km) above the earth (speed about 10,000 km/hr?); GEO (geosynchronous earth orbiting); 3 of them are enough to cover the whole world.**
  - – **500 MHZ bandwidth (analog);**
  - – **The data transmission rate is 16 Giga bits per second. They are mostly used to link big metropolitan cities;**
  - – **Receives analog and digital signals, amplifies the signal and retransmits back to earth.**
  - ❑ **How are satellites put into orbit?**

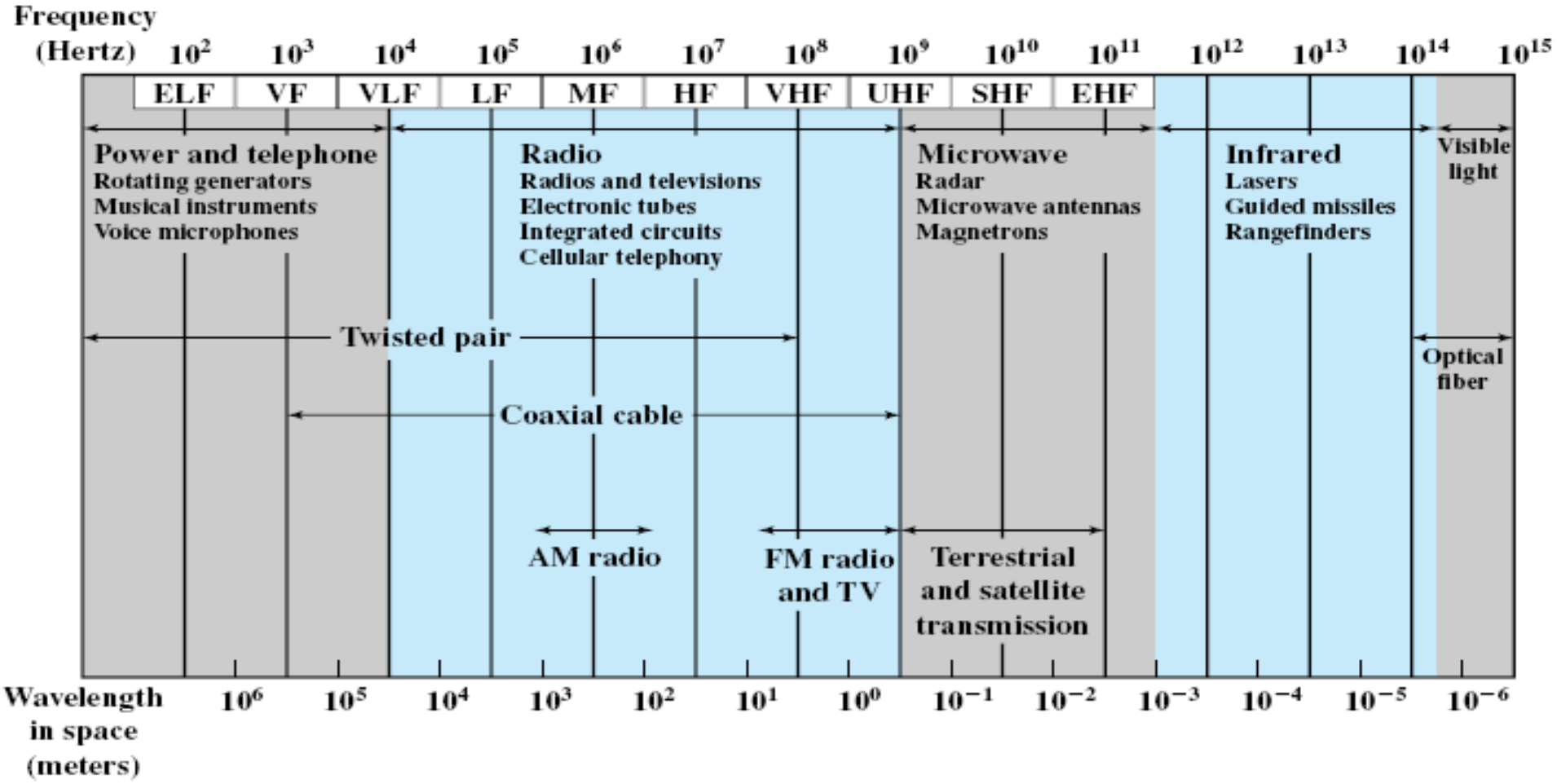
Microwave (Unguided)

- Microwave system uses very high frequency radio signals (10Ghz-1000Ghz) to transmit data through space.

  What is the speed of a radio signal?

- The transmitter and receiver of a microwave system should be in line-of-sight because the radio signal cannot bend.
- With microwave very long distance transmission is not possible without using repeaters (due to line of sight).
- In order to overcome the problem of line of sight and power amplification of weak signals (due to attenuation), repeaters are used at intervals of 25 to 30 kilometers between the transmitting and receiving end.

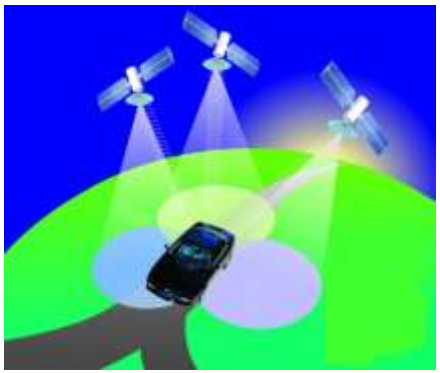
Electromagnetic Spectrum for Telecommunications

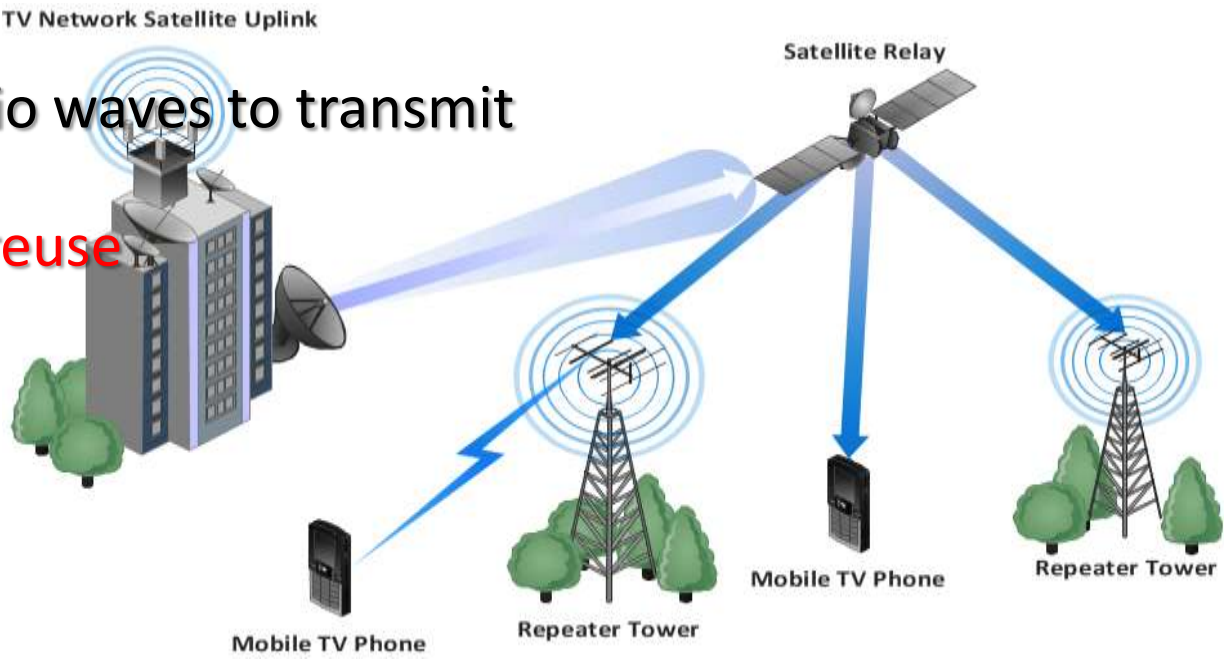


ELF = Extremely low frequency
VF = Voice frequency
VLF = Very low frequency
LF = Low frequency
MF = Medium frequency
HF = High frequency
VHF = Very high frequency
UHF = Ultra high frequency
SHF = Super high frequency
EHF = Extremely high frequency

Wireless Transmission Technologies

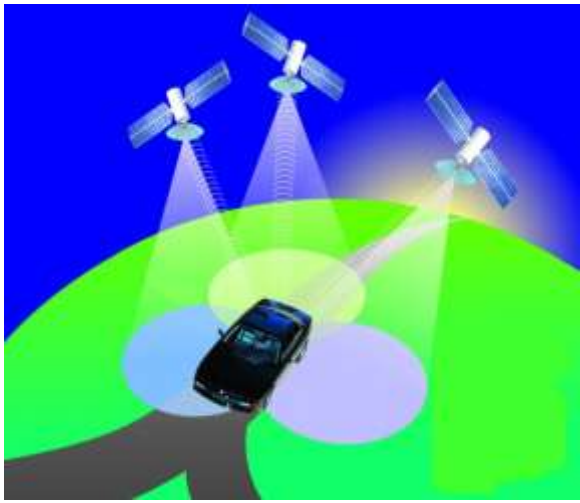
- Broadcast Radio (Example SW and AM)
  - Distribute signals through the air over long distance
  - Uses an antenna
  - Typically for stationary locations
  - Can be short range
- Cellular Radio
  - A form of broadcast radio used for mobile communication
  - High frequency radio waves to transmit voice or data
  - Utilizes frequency-reuse
  - Mobile TV phone





Wireless Transmission Cont'd…

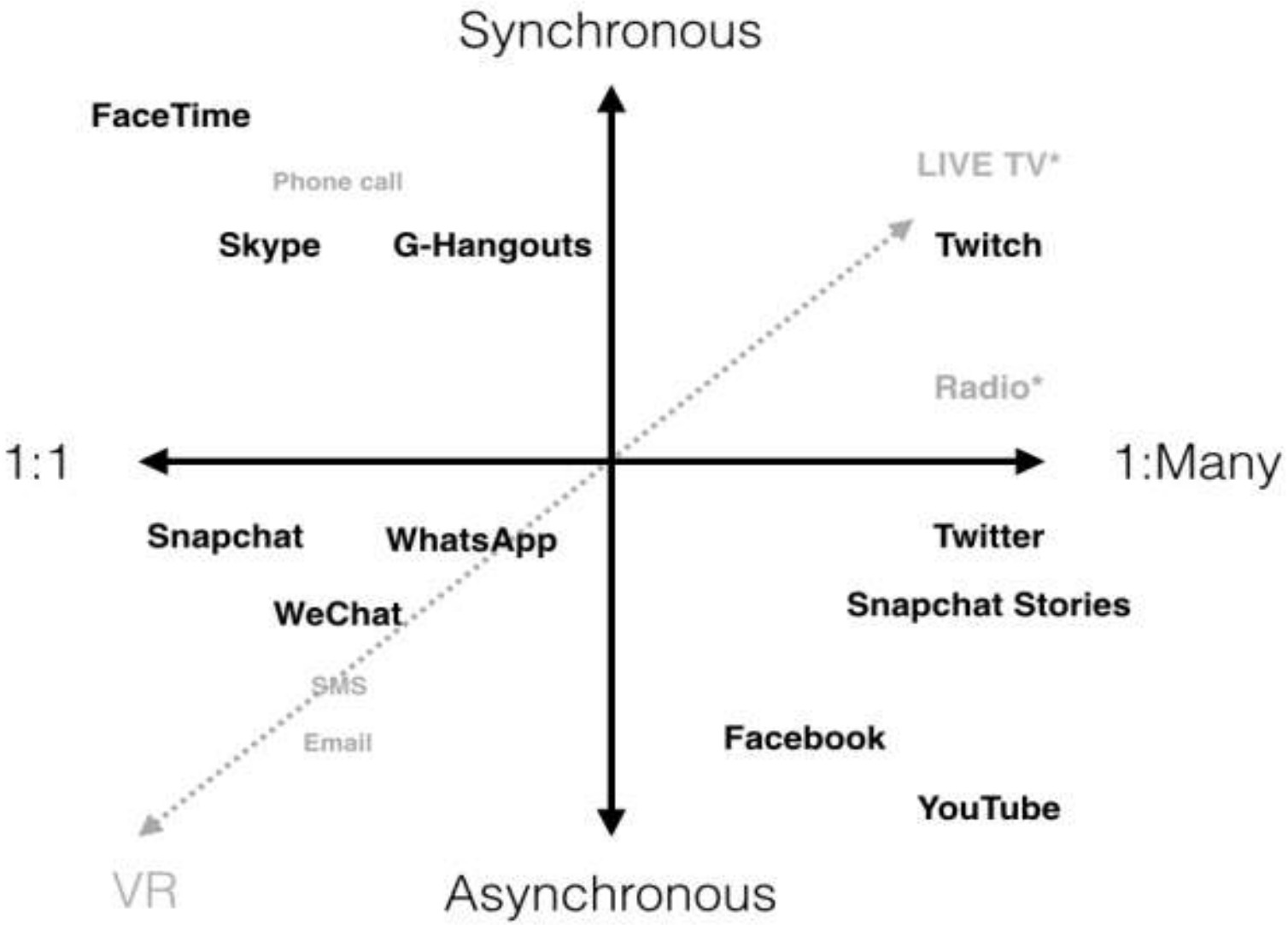
- Microwaves
  - Radio waves providing high speed transmission
  - They are point-to-point (can't be obstructed)
  - Used for satellite communication
- Infrared (IR)
  - Wireless transmission media that sends signals using infrared light- waves; 16Mbps; point-to-point
  - Example, electronic device remote controllers
- Bluetooth: **envisioned for a cable-free world**
  - Radio frequency technology; 2Mbps
  - Can pass over obstacles
  - Can detect other nearby Bluetooth devices
  - The recent Apple wireless earphones
  - Bluetooth operates over a short range, at low power, and at low cost.



Asynchronous Versus Synchronous Transmission

- **Asynchronous Transmission:** This method, used with most microcomputers, is also called start-stop transmission.
  - Data is sent one byte (or character/or packet) at a time.
  - Not used when very large amount of data must be sent rapidly.
  - Its advantage is that the data can be transmitted whenever and wherever it is convenient for the sender (store and forward delivery: message switching) **and (follow a convenient rout: packet switching**)
- **Synchronous Transmission:** This method, sends data in blocks.
  - Start and stop bit patterns, called sync bytes, are transmitted at the beginning and end of the blocks.
  - This method is rarely used with microcomputers because it is more complicated and more expensive than asynchronous transmission.
  - Appropriate for computer systems that need to transmit very large amount of data. (live transmission)(**circuit switching**)

Asynchronous Versus Synchronous Cont…



Applications of Data Communications

- E-mail
- Searchable Data (Web Sites)
- E-Commerce
- News Groups
- Internet Telephony (VoIP)
- Video Conferencing
- Chat Groups
- Instant Messengers
- Internet Radio
- Global Positioning System (GPS)
- Groupware
- Discussion Forums

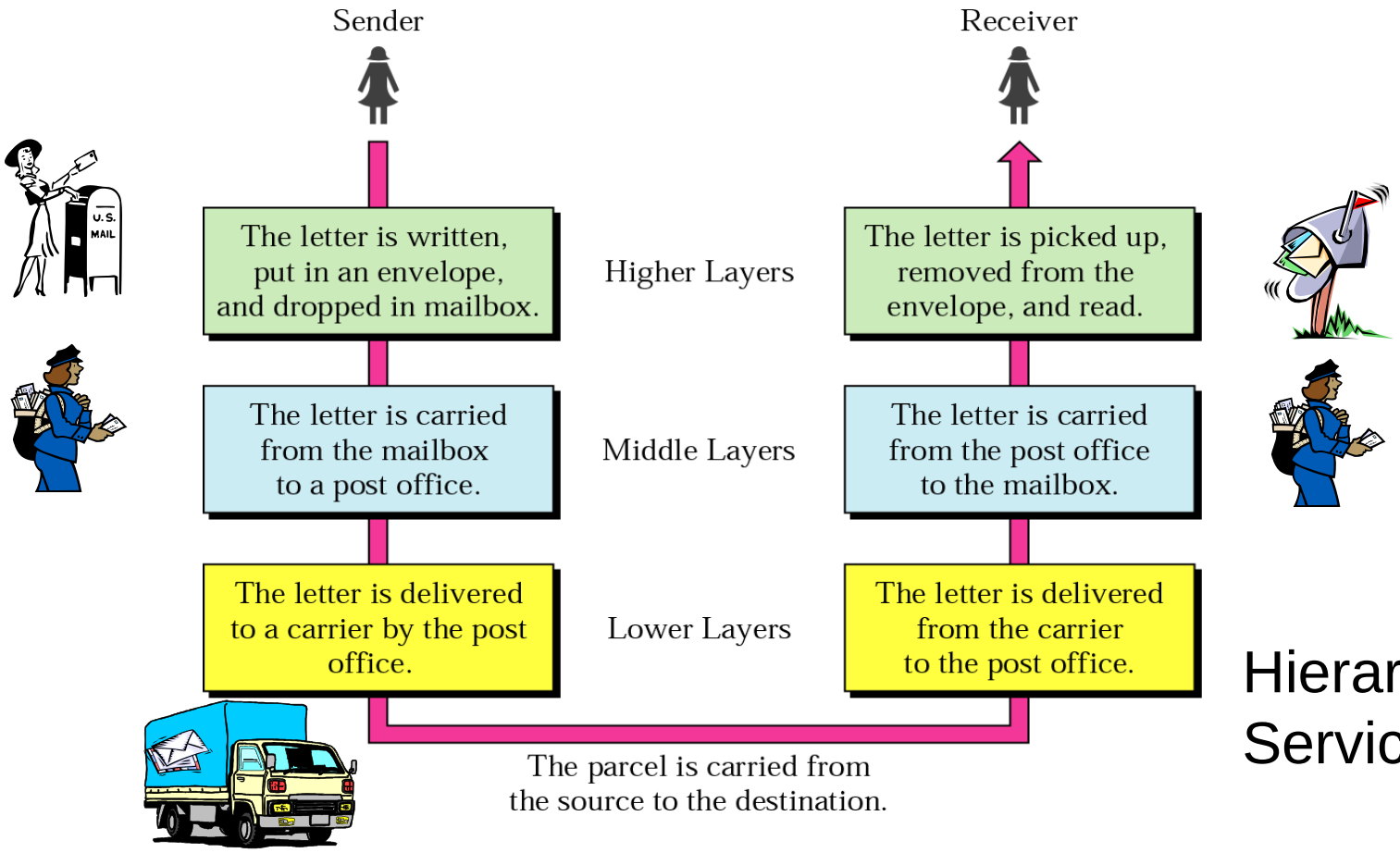
Electronic Fund Transfer, Internet banking; Online education, Telemedicine; Online Employment or job/vacancy; Internet browsing/search engines and so on.

More on Data Communications

- **Requirements of Data comm.**
  - **At least two devices ready to communicate**
  - **A transmission medium**
  - **A set of rules and procedures for proper communication (protocol)**
- **Data communications** refers to the study of **low-level** mechanisms and technologies used to send information across a physical communication medium
- Data communications provides a foundation of concepts on which the rest of networking is built

Layered Tasks in Communications

An example from the everyday life



Hierarchy of Services

Why layered communication?

- To reduce complexity of communication task by splitting it into several layered small tasks
- Functionality of the layers can be changed as long as the service provided to the layer above stays unchanged
  - makes easier maintenance & updating

- Each layer has its own task
- Each layer has its own protocol

Physical Layer

- What we call low level above
- Specifies
  - the characteristics of the transmission medium
  - Nature of the signals
  - Data rate

Groups of Layers	OSI Model	Early Internet Model
Application Layers	7. Application Layer	4. Application Layer
	6. Presentation Layer	
	5. Session Layer	
Internetwork Layers	4. Transport Layer	3. Transport Layer
	3. Network Layer	2. Network Layer
Hardware Layers	2. Data Link Layer	1. Hardware Layer
	1. Physical Layer	

Network Models: OSI is Developed by ISO

Each layer has its own protocol

OSI model

Layer	Name	Example protocols
7	Application Layer	HTTP, FTP, DNS, SNMP, Telnet
6	Presentation Layer	SSL, TLS
5	Session Layer	NetBIOS, PPTP
4	Transport Layer	TCP, UDP
3	Network Layer	IP, ARP, ICMP, IPSec
2	Data Link Layer	PPP, ATM, Ethernet
1	Physical Layer	Ethernet, USB, Bluetooth, IEEE802.11

Each layer provides service to a layer above it

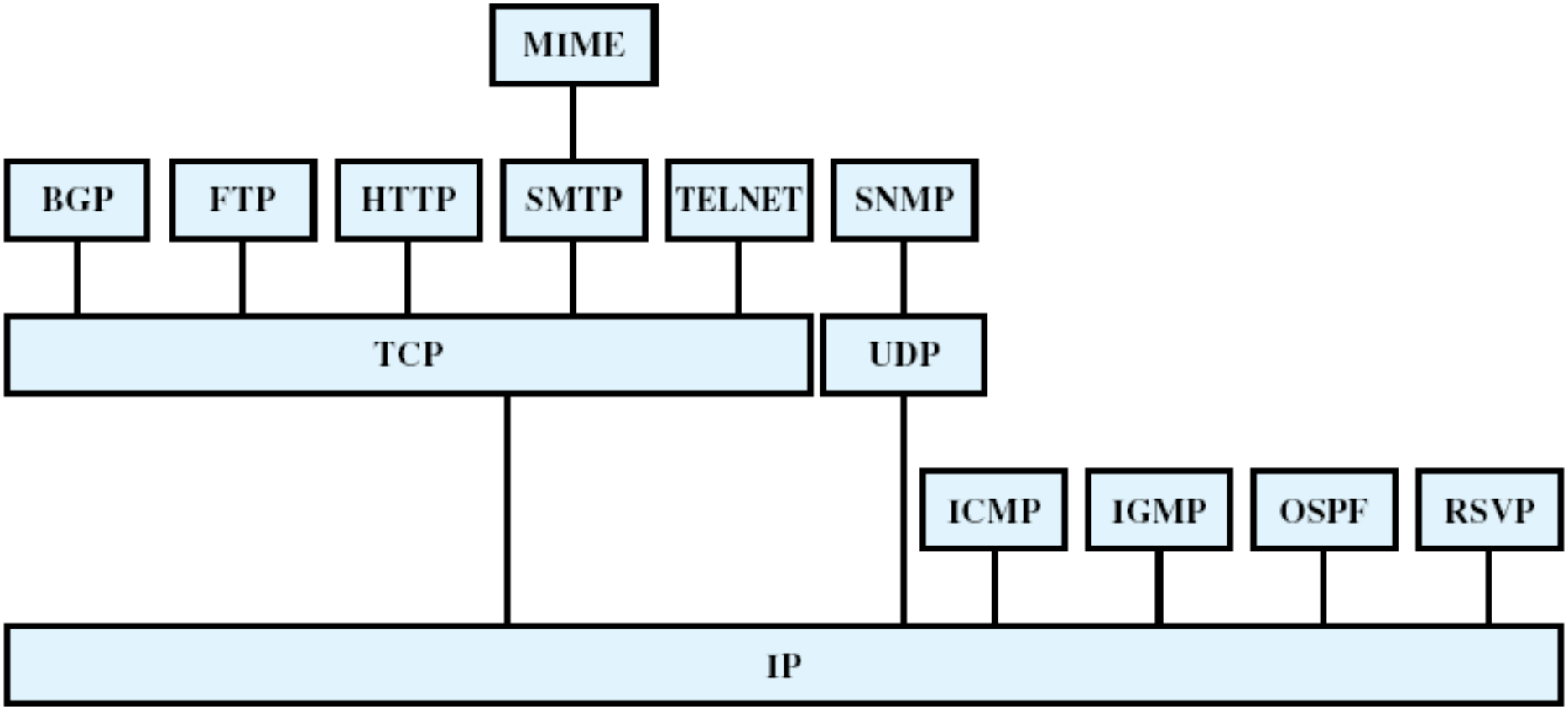
Ethernet (example network protocol) (Hardware Layer)

- CSMA/CD: Carrier Sense, Multiple Access, Collision Detect. Simple rules!

- Since Ethernet was designed to be on shared media, with 2 or more users, and the "more" part can be very big (that's the "Multiple Access" part) you have to listen to see if anyone else is talking before you talk (Carrier Sense) and if you and someone else start talking at the same time, notice it (Collision Detect), say "excuse me" stop and try again later. A polite free for all with rules.

Ethernet Protocol Main procedure

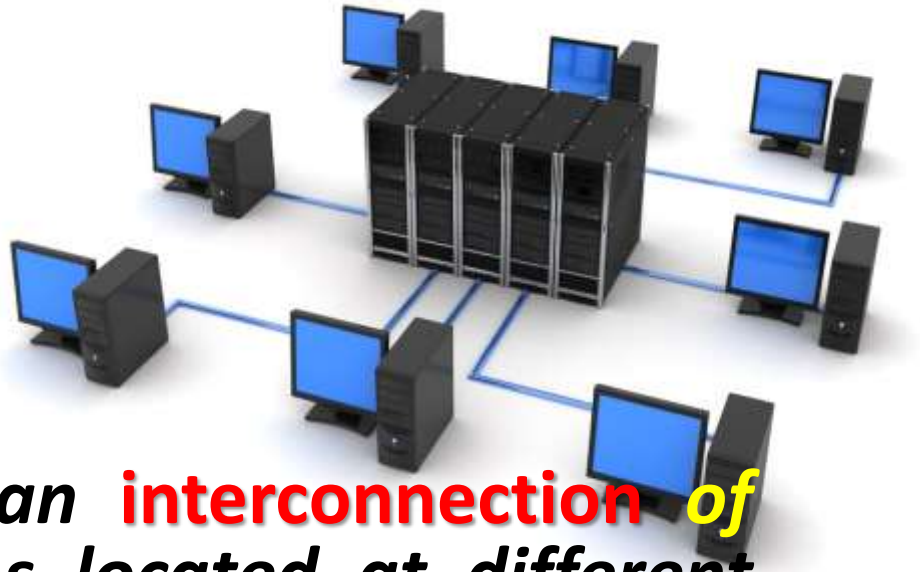
- When one computer wanted to send some information, it followed the following algorithm
  - **Make data ready for transmission.**
  - **Is medium idle? If not, wait for a period until it becomes ready.**
  - **Start transmitting.**
  - **Does a collision occur? If so, go to collision detected procedure (wait a couple of periods before retransmitting)**
  - **End successful transmission.**



BGP = Border Gateway Protocol
FTP = File Transfer Protocol
HTTP = Hypertext Transfer Protocol
ICMP = Internet Control Message Protocol
IGMP = Internet Group Management Protocol
IP = Internet Protocol
MIME = Multipurpose Internet Mail Extension
OSPF = Open Shortest Path First
RSVP = Resource ReSerVation Protocol
SMTP = Simple Mail Transfer Protocol
SNMP = Simple Network Management Protocol
TCP = Transmission Control Protocol
UDP = User Datagram Protocol

Some Protocols in the TCP/IP Protocol Suite

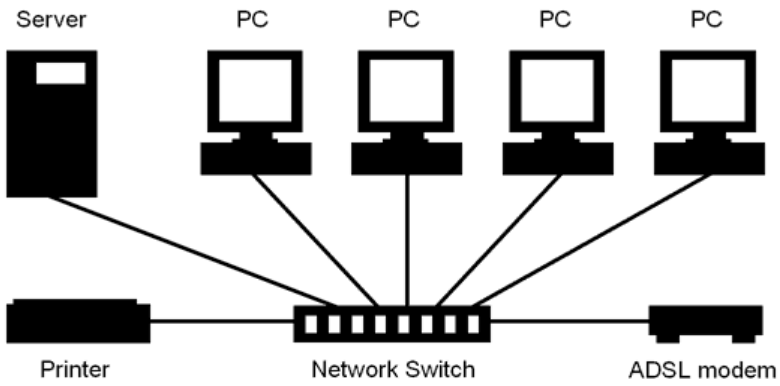
Computer Networks



- ***A computer network is an interconnection of various computer systems located at different places.***
- **Two or more computers and other peripheral or data communication devices linked together is called a Computer Network.**
- **The computer that provides resources to other computers on a network is known as *server*.**
- **In a network individual computers, which access shared network resources, are known as *workstations* or *terminals* or *clients.***

Computer Networks - Why networking?

- Remote access to resources – Efficiency through accessibility
- Reduction of data duplication – Data kept on a Server
- Communication (Collaboration)- people can work together in ways not previously possible (ARPANET)



Networks for, Cont'd …

- **saving money**
  - ***Price / performance rate** of a number of linked small computers is better than few large ones.*
  - ***For example**: Mainframes which are only about ten times the power of a personal computer, cost about a thousand times more.*
  - ***Better to get cheaper machines and network them.***
- **scalability - ability to grow and shrink the computer set-up**
  - ***Easier to add a machine or device to a network than to add components to a mainframe.***

use of Computer Networks ….

- **resource sharing**
  - ***Make data, memory, programs and equipment available to everyone regardless of where they are physically. Example Printer, app server***
- **reliability - by having alternatives**
  - ***Having duplicate machines to do the processing in case one or more machine goes down, or having files mirrored on different servers so we don't depend on one machine for those files - (multiple Servers)***

Networks for, Cont'd …

- **People use networks for**
  - **Access to remote information - for fun or information.**
    - **Banking services, marketing, online digital libraries, …**
  - **Person-to-person communication**
    - **Email, video conferencing**
  - **Interactive entertainment**
    - **Audio (music, radio, etc) and Video (movies, events, etc) on demand**
  - **Internet Access Sharing** (resource sharing)

The Costs (Drawbacks) of Networking

- **Network Hardware, Software and Setup Costs**
- **Hardware and Software Management and Administration Costs**
- **Undesirable Sharing**
- **Illegal or Undesirable Behavior**
- **Data Security Concerns**

Different ways of classifying networks

- *There is no generally accepted taxonomy into which all computer networks fit, but the following dimensions standout as important*:
  - By Network Topologies
  - By Transmission Technologies
  - By Scale
  - By management Method

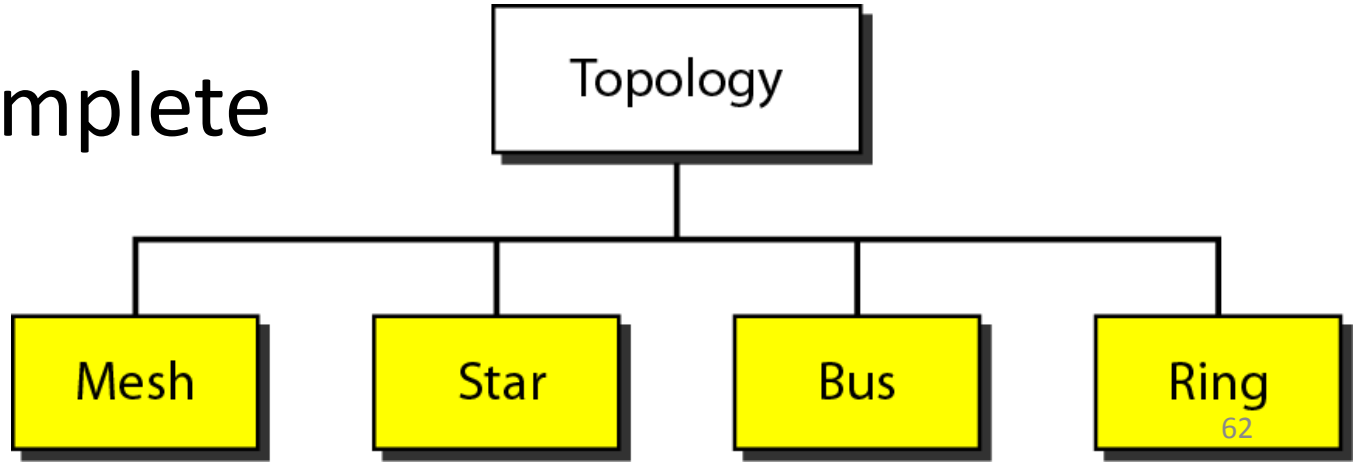
Ways of classifying networks Cont'd …

- **Depending on one's perspective, we can classify networks in different ways**
  - **Based on transmission media: Wired (UTP, coaxial cables, fiber-optic cables) and Wireless**
  - **Based on network size: LAN and WAN (and MAN)**
  - **Based on management method: Peer-to-peer or Client/Server**
  - **Based on topology (connectivity): Bus, Star, Ring …**

Topology of Networks

The logical layout, or shape, of a network is called topology.

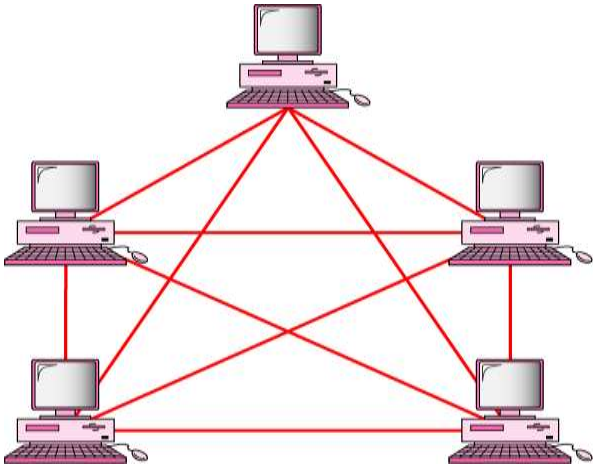
- Some of the basic topologies:
  - Star
  - Ring
  - Bus
  - Mesh/Complete



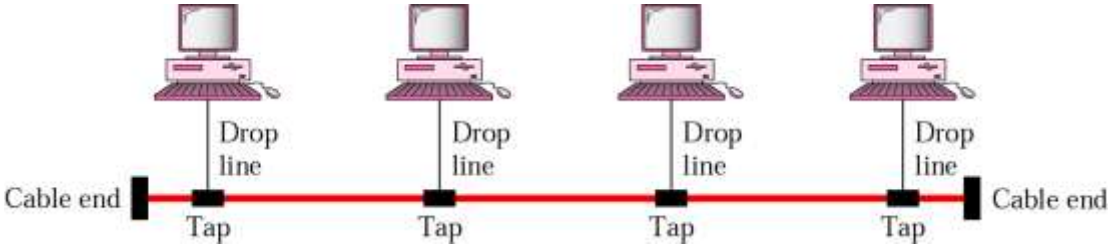
Topology Concerns

- Performance issues
  - Reliability, Ability to recover through/after failure of one or more nodes
- Physical constraints
  - Transmission speed, distance between nodes,
- Other issues
  - Susceptibility / Vulnerability to errors
  - Growth of the network
  - Capability and types of equipment the network needs
  - Cost, geographical area

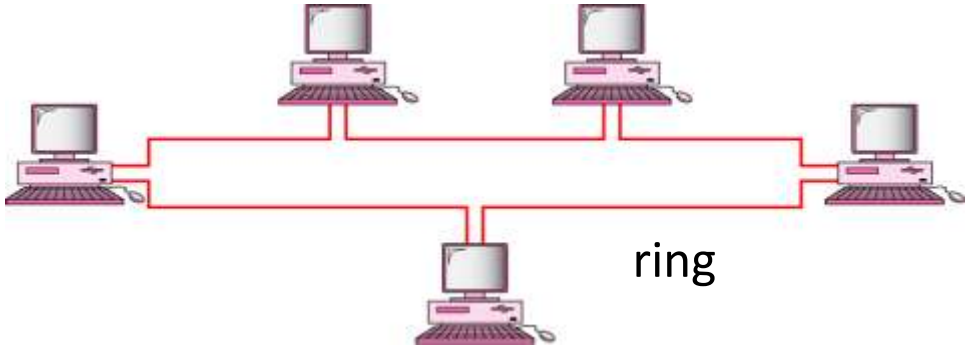
Mostly used network topologies



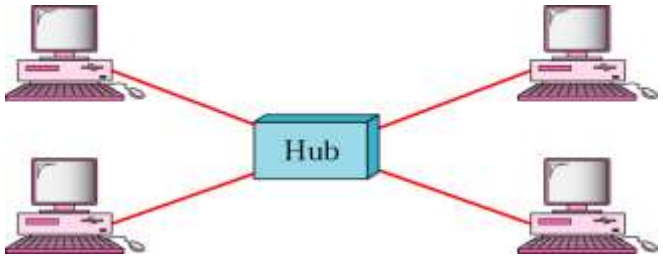
mesh



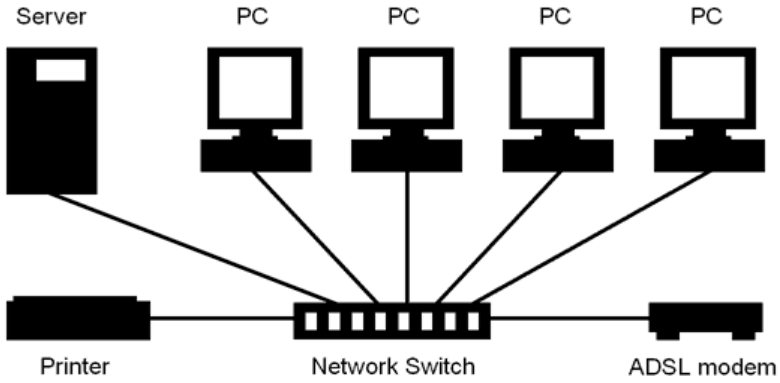
bus



ring



Star (Most Commonly Used Type)



Star *Topology*

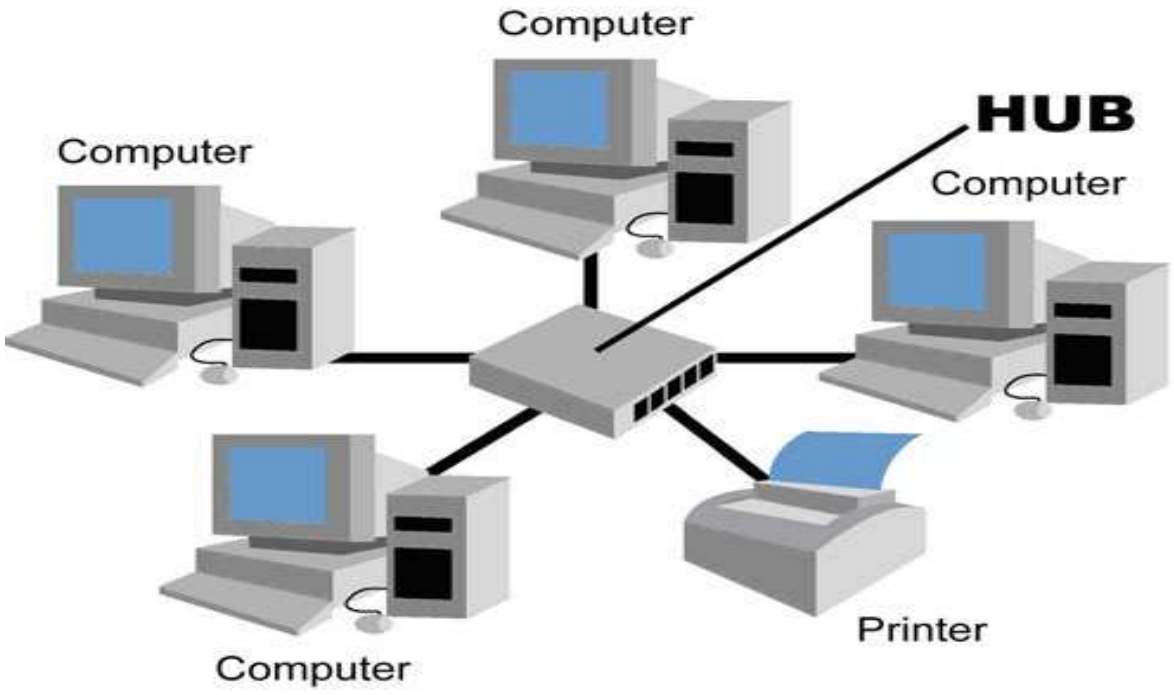
- A number of workstations (or nodes) are directly linked to a central node called a hub.
- Any communication between stations on a star LAN must pass through the central node.
- There is *bi-directional* communication between various nodes.
- The central node controls all the activities of the nodes.
- Cable segments from each computer are connected to a centralized component.

Cont…

- The advantages of the star topology are:
  - It offers flexibility of adding or removing of workstations from the network.
  - *Easy to add and remove machines, since we only need to hook them up to a central hub*
  - Breakdown of one station does not affect any other device on the network.
  - *It is robust since no machine depends on other machines.*

Cont…

- The major disadvantage of star topology is that
  - Failure of the central node disables communication throughout the whole network.
  - *It requires relatively more cabling than the Bus or Ring.*



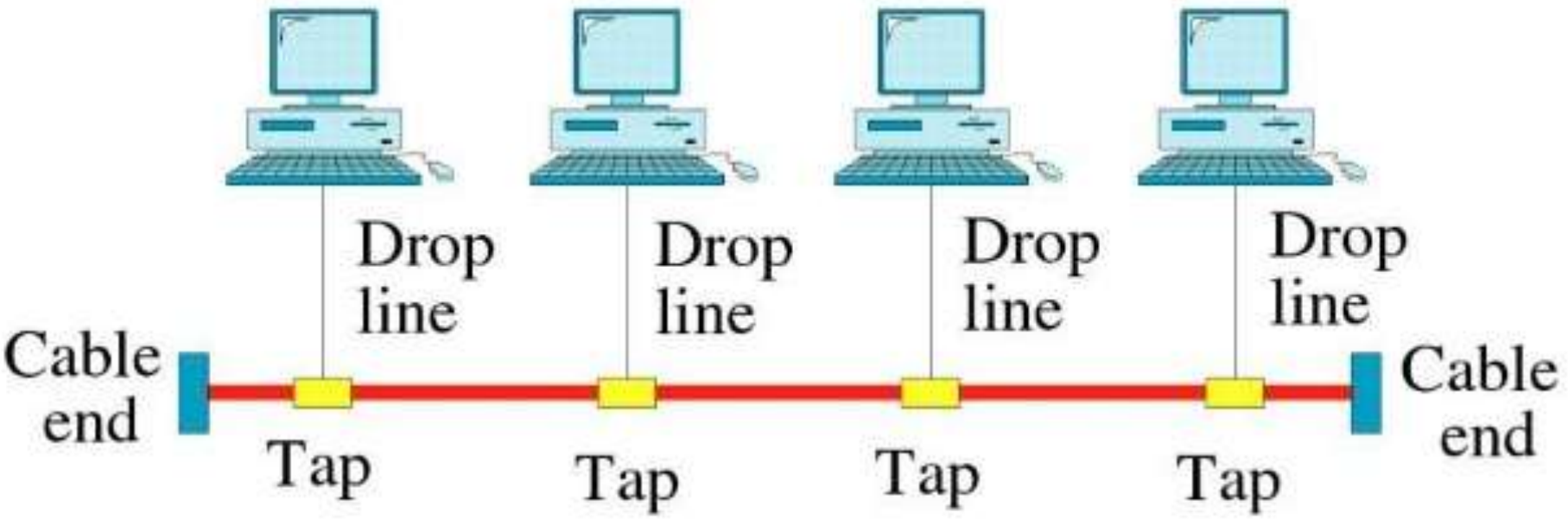
Ring Topology

- *Each station is attached to a nearby stations on a point to point basis so that the entire system is in the form of a Ring.*
- *Data is transmitted mostly in one direction only or in recent designs both directions.*
- *Thus the data packets circulate along the ring in either clockwise or anti-clockwise uni-direction in a closed loop and passes through each computer.*
- *The failure of one computer can take down the entire network.*
- *If a node goes down entire network goes down (single point of failure).*

Token Ring

- *A ring topology is easy to install, but uses expensive parts. It is easy to add a new machine.*
- **Token Ring Networks**
  - **Electronic token travels around the circuit**
  - **If Token is empty then data can be loaded and then offloaded at the destination node**
  - **Reduced or no chances of collision as compared to Star and Bus**
  - **An example is IBM's token ring network**

Bus Topology



Bus Topology

- *In bus topology all workstations are connected to a single communication line called bus.*
- *In this type of network topology there is no central node as in star topology.*
- *All nodes compete for the use of the BUS*

Bus Cont…

- *Transmission from any station travels the length of the bus in both directions and can be received by all workstations.*

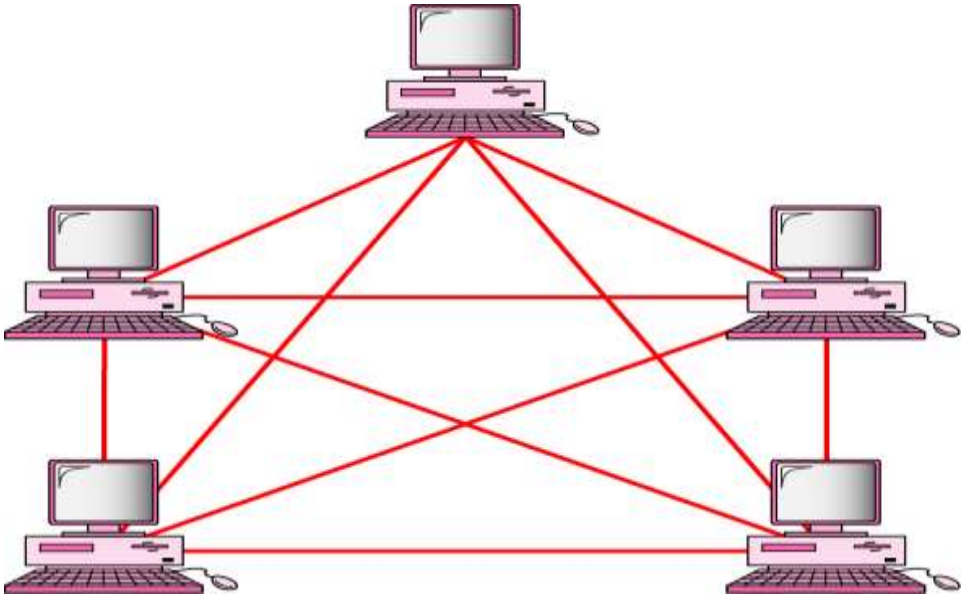
- *The advantage of the bus topology is that it is quite easy to set up.*

Bus Cont…

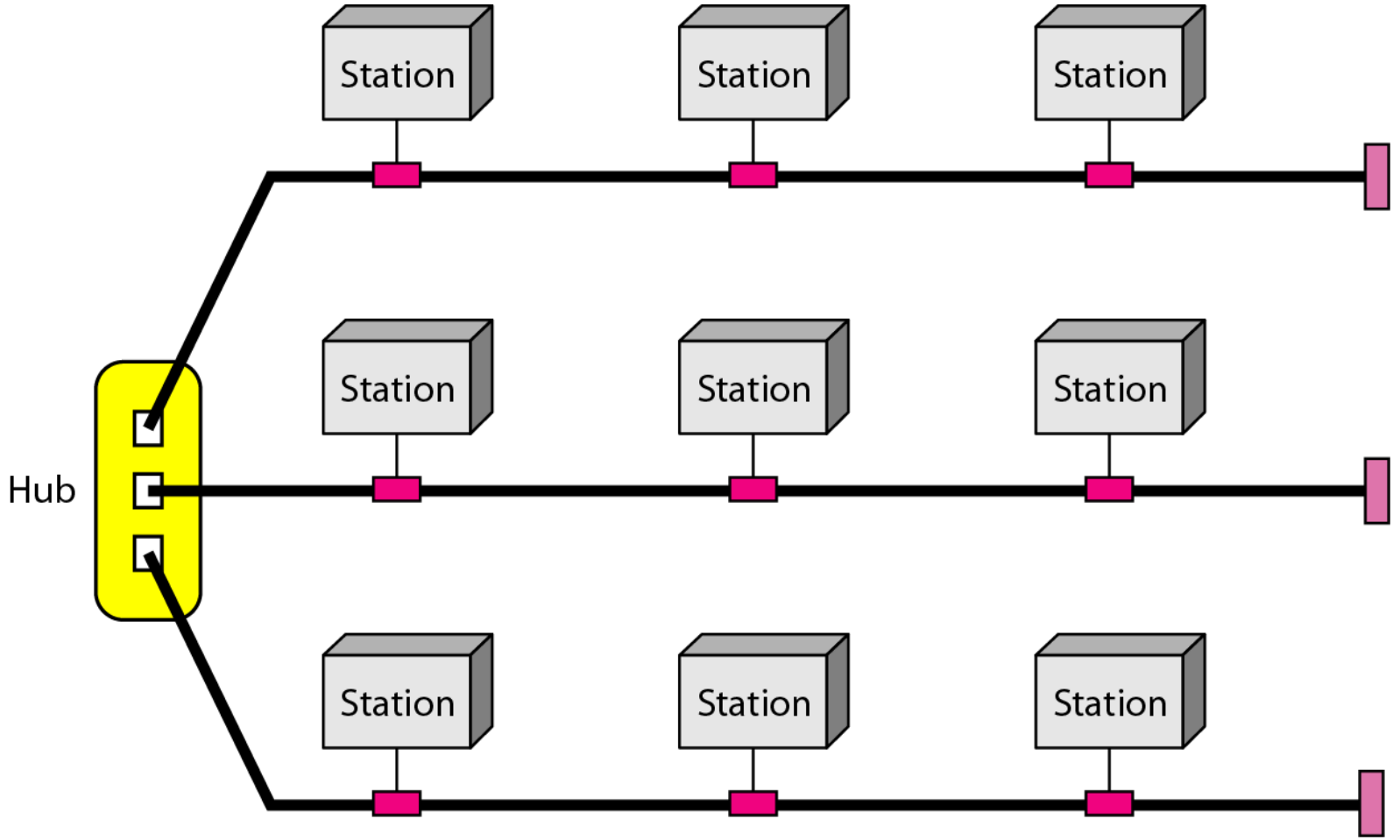
- *If one station of the topology fails it does not affect the entire system.*
- *The disadvantage of bus topology is that any break in the bus may break the entire network.*
- All messages are transmitted to the whole network
- *A **bus topology** is also easy and low cost to install.*

Complete/Mesh Topology

- *A **complete topology** is very robust, since every machine has connection to every other machine, so doesn't depend on other machines.*
- *It is more secure since we don't have to send data through intermediate machines. But the drawback is the amount of cabling that it needs.*
- *Also, adding and configuring a new machine is very cumbersome.*



A hybrid topology: a star backbone with three bus networks



Comparison of Network topologies

- **Advantages and Disadvantages of Network Topologies**

Topology	Advantages	Disadvantages
Bus	**Cheap. Easy to install.** **Takes less cable**	**Difficult to reconfigure.** **Break in bus disables entire network.**
Star	**Cheap. Easy to install.** **Easy to reconfigure.** **Fault tolerant. Most common.**	**More expensive than bus.**
Ring	**Efficient. Easy to install.**	**Reconfiguration difficult.** **Very expensive.**
Mesh	**Most fault tolerant.**	**Reconfiguration extremely difficult.** **Extremely expensive.** **Very complex.**

Network Types Based on Management Method

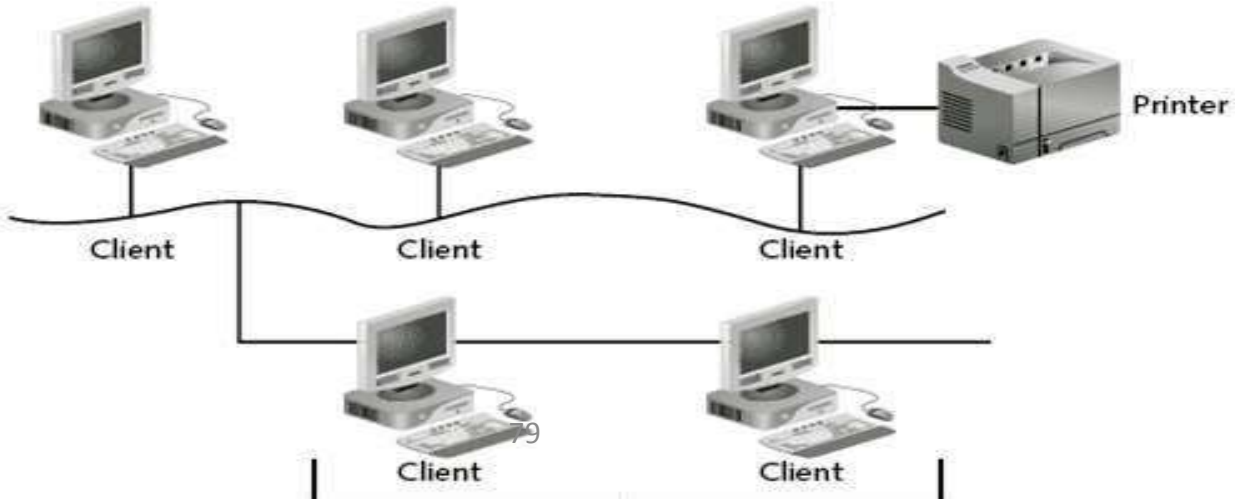
- Two major types of networks
  - **Peer-to-peer**
  - **Client/Server** (also called server-based)

A Networking Lexicon

- Must understand specialized networking vocabulary, including
  - **Server** — shares resources across network, typically with more central processing unit (CPU) power and storage capacity than other computers
  - **Client** — accesses shared resources
  - **Request-response** — client requests information; server responds by providing information
  - **Client-server relationship** — client makes a request to the server, and the server responds with providing requested data
  - **Peer-to-peer** — computers share and request resources from one another

Peer-to-Peer Networking

- Peers with no centralized control over shared resources
- Can share resources with any other computer on network
- No computer has higher access priority
- No computer has more responsibility to provide or share resources



Peer-to-Peer Networking Advantages

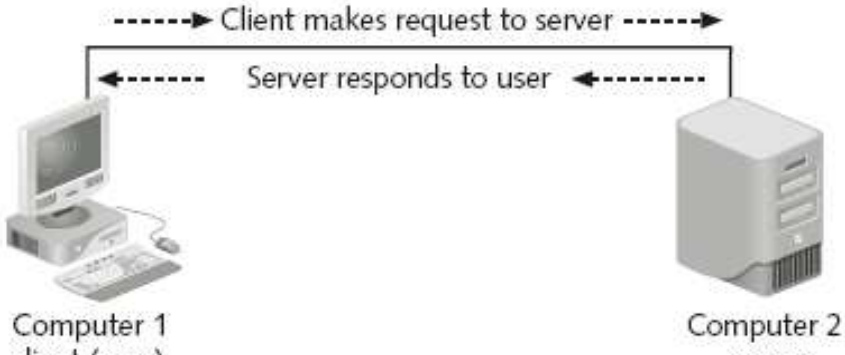
- Easy to install and configure
- No dedicated server
- Users control own shared resources
- Inexpensive to purchase and operate
- No additional equipment or software
- No dedicated administrators
- Works best with 10 or fewer peers

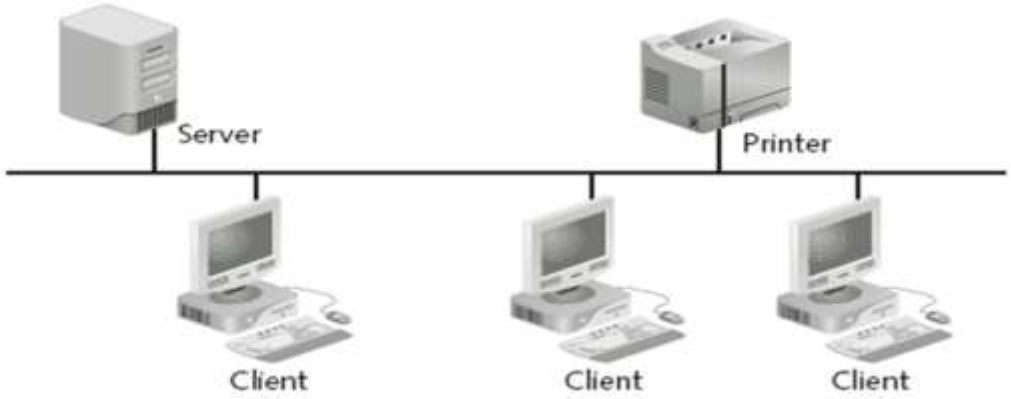
Peer-to-Peer Networking Disadvantages

- Security applies to single resource at a time
- Users may have many different passwords
- Must back up each machine individually
- Machine sharing resources may suffers reduced performance
- No centralized organization scheme to locate or control access to data
- Does not usually work well with more than 10 peers (users)

Server-Based Networks

- Server responds to client requests
- Provide centralized control over resources
- Servers require faster CPUs, more memory, larger disk drives, and extra peripherals such as external backup storages
- May be dedicated, handling only requests from client communities (file server, web server, app. server)





Server-Based Networks (continued)

- One or more servers may do centralized verification of user accounts and passwords
- Novell and Windows servers use a directory service
  - Checks account names and passwords against database
  - Manage shared resources
  - Windows 2000/2003/2008 calls it **Active Directory**
  - Novell NetWare calls it **Novell Directory Services** (NDS)
- Easier to scale
- May handle thousands of users

Server-Based Networking Advantages

- Simplifies network administration
- Centralizes user accounts, security, and access controls
- More powerful equipment
- More efficient access to network resources
- Single password for network logon
- Best choice for networks with 10 or more users or network with heavily-used resources

Server-Based Networking Disadvantages

- At worst, server failure renders network unusable
- At least, server failure causes loss of network resources
- More expensive
- Requires expert staff to handle complex server software
- Requires dedicated hardware and specialized software

Types of Servers

- File and print Servers
- Application Servers
- Web Servers
- Database Servers
- Directory Servers / Domain Controllers
  - Windows Servers combine computers, users, groups, and resources into logical domains
- Communication Servers
- Mail Servers
- DHCP Server
- DNS Server

Comparison of …

	Peer-to-peer	Client/Server
Type of user	Homes and small businesses	Large corporations, schools, and hospitals
Size of organization	Limited number of workstations	Large number of workstations
Administration	User	Central administrator
Security	Individual users	Network administrator
Network traffic	Limited number of users	Large number of users
Cost	Inexpensive to implement	Usually more expensive than peer-to-peer
Scalability	Limited growth	High growth projected

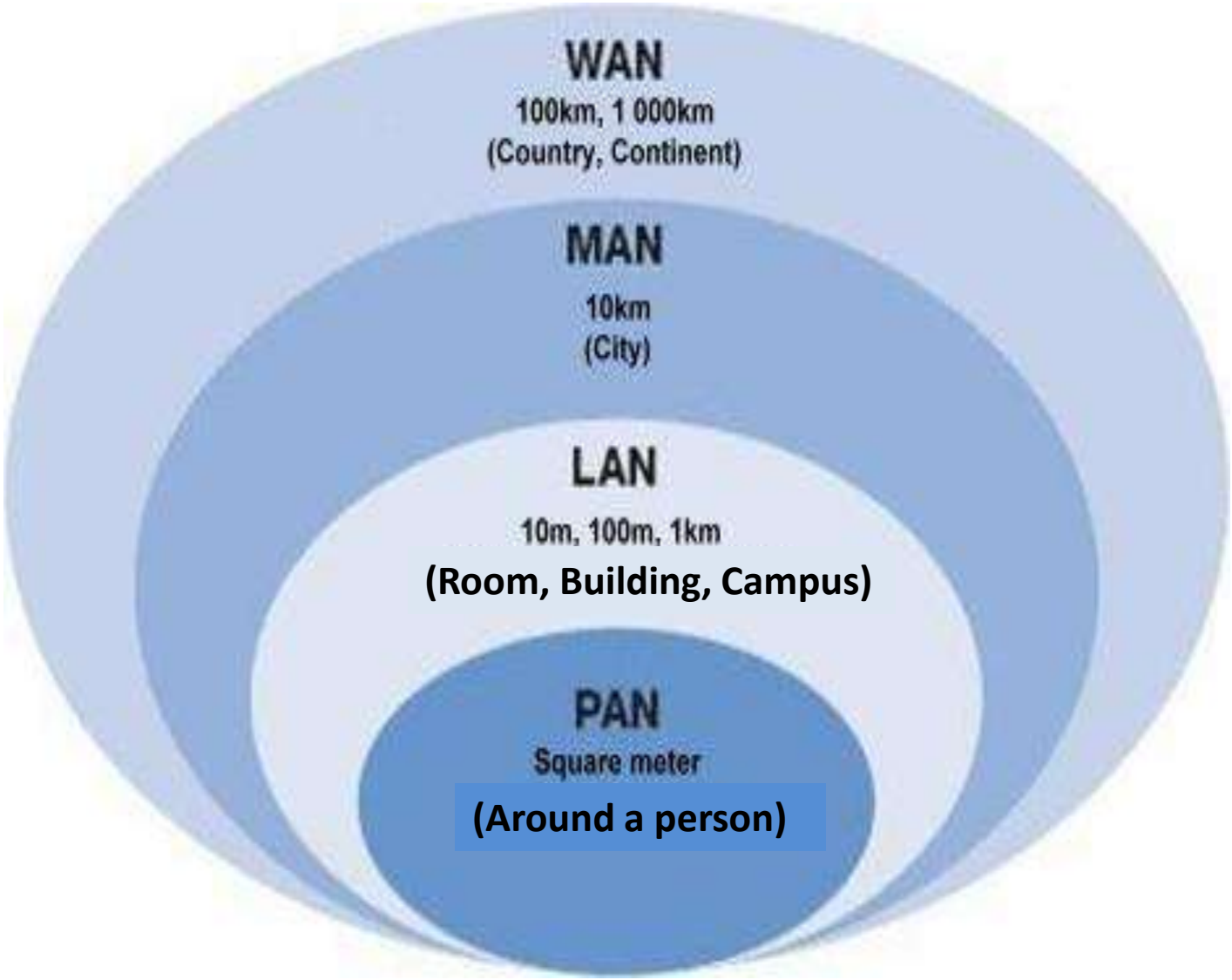
Network Classification based on Scale

- **Local Area Networks (LANs)**
- **Metropolitan Area Networks (MANs)**
- **Wide Area Networks (WANs)**
- **Internet – The World's Largest Network of Networks**

Network Classification based on Scale

- *There is no hard and fast rule on how big a network is before it becomes a LAN, MAN or WAN.*
- *E.g. a LAN is usually identified by either all machines using the same LAN protocol (e.g. IEEE 802.3 Ethernet), or they are machines communicating within the same organization or within 1KM area.*

Based on Scale (Network Size) Cont…



Local Area Networks (LANs)

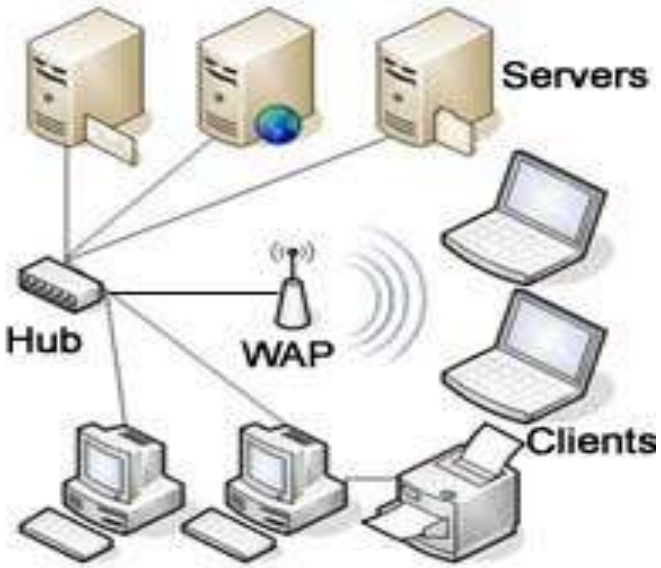
- Collection of interconnected computers that can share data, applications, and resources such as printers.
- Computers in a LAN are separated by distances of up to a few hundred meters and are typically used in offices or across nearby university campuses.
- A LAN enables the fast and effective transfer of information within a group of users and reduces operational costs.

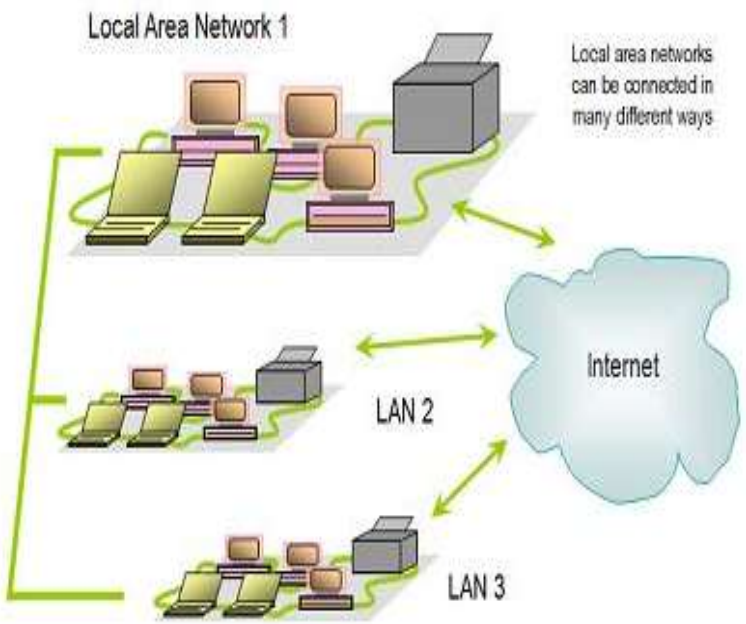
Cont…

- LANs are the basic building blocks of other types of larger networks.
- To establish a LAN you need the minimum of two computers.
- It covers the smallest geographic area next to PAN.
- You can have LAN in a room or a building or in a campus.

Local Area Network (LAN)

- Network of computers located in a single location, like a home, school, or office building
- Can share connection with other LANS and with the internet



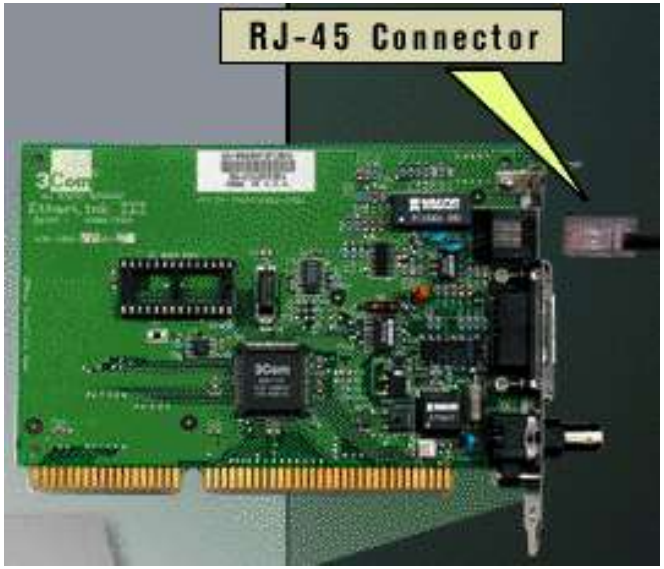


Setting up home networks

- Two or more computers (with NIC)
- Cable (UTP or STP)
- Connectors(RJ-45)
- Switch (or Hub)
- Network operating Systems
- An ISP (for Internet access)

Network adapter card or NIC

- Prepares data from computer for network and sends through the transmission medium
- Receives data from network and translates for computer



Securing a LAN

- Password
  - Most common tool for restricting access
  - Network Manager should consider the basic features of a typical password
- Setting Access Rights (For security and privacy)
  - Different level of access depending on the nature of the information stored
  - Common options are: Read only, Write, Create files, make directories, Delete files

This is one of the functions of the network operating system

Extending a LAN

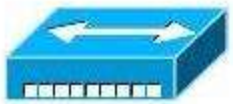
- **To alleviate the distance limitation of LAN**
  - **Methods Available**
    - **Repeaters**: (physical layer devices)
      - **tap into the network and boost the signal**
      - **Connect two LAN segments**
      - **Repeat and amplify all signals and forward noise and collision as well**

Repeater…

- **Hub**
  - Hubs are actually multiport repeaters.
  - Hubs are layer 1 devices (physical layer devices).
  - In many cases, the difference between the two devices is the number of ports that each provides.
  - While a typical repeater has just two ports, a hub generally has from four to twenty-four ports

Cont…

- The devices that are used to connect network segments include bridges, switches, routers, and gateways.



Hub

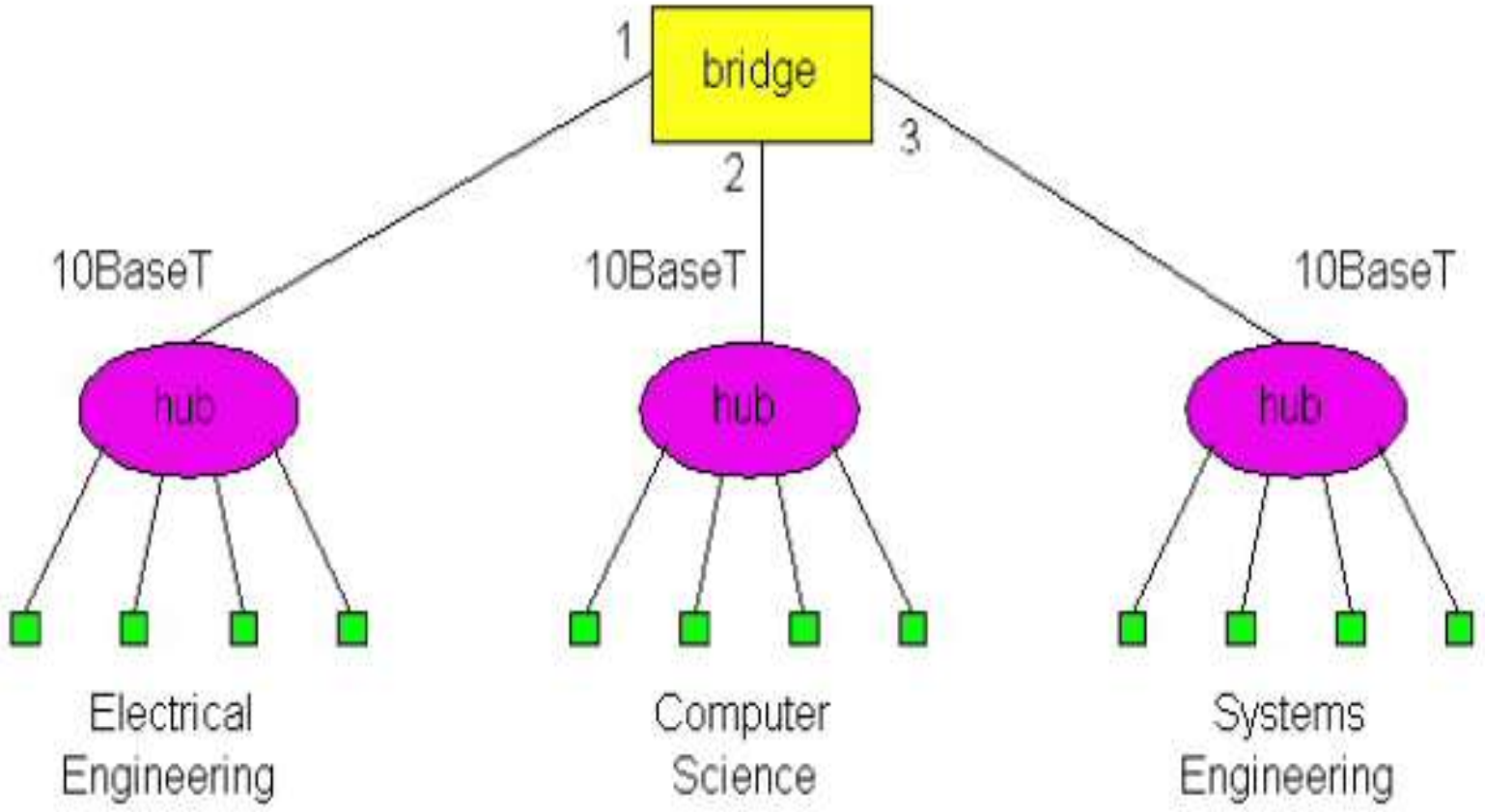
Switch

Bridge

Router

Cont…

- **Bridges:**
  - **Store frames from one LAN and sends to another.**
  - **The function of the bridge is to make intelligent decisions about whether or not to pass signals on to the next segment of a network**
  - **Slows down transmission speed and has potential for bottlenecks**
  - **Do not forward noise and collision**
  - **Uses computer MAC address (Physical address)**
  - Bridges are layer 2 devices (Data link layer devices).



Three departmental LANs interconnected with a bridge.

Three collision domains.

Cont…

- **Switch**
  - Is more intelligent than a hub
  - A switch is sometimes described as a multiport bridge
  - While a typical bridge may have just two ports linking two network segments, a switch can have multiple ports depending on how many network segments are to be linked
  - Bridges and Switches are PnP (plug and play devices) while Routers are Configurable.

Cont…

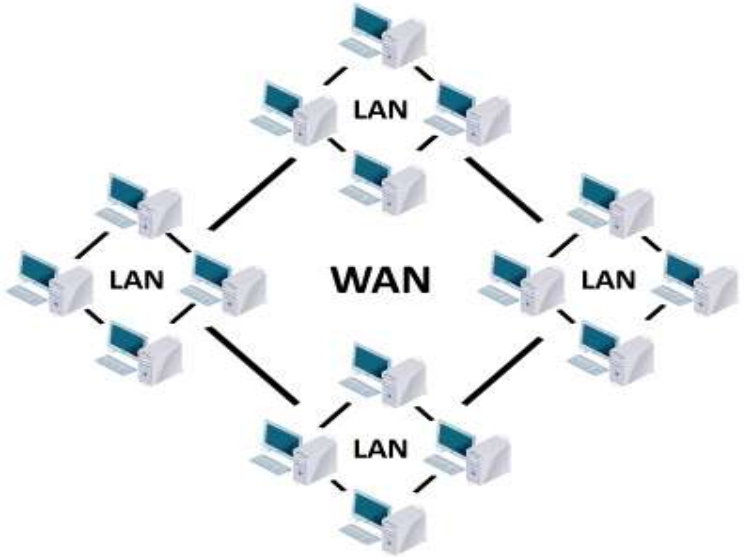
- **Gateway**
  - stores and sends **packets** to different networks. e.g. from a LAN to a Public network. It is located at network perimeters.
- **Router**
  - Routers are responsible for routing data packets from source to destination within the LAN, and for providing connectivity to the WAN.
  - In order to provide these services the router must be connected to the LAN and WAN.
  - A **router** at the perimeter of a network , connecting a LAN to a WAN, is essentially a **gateway**.
- **Both are Layer 3, network layer devices (uses IP address also called logical address)**

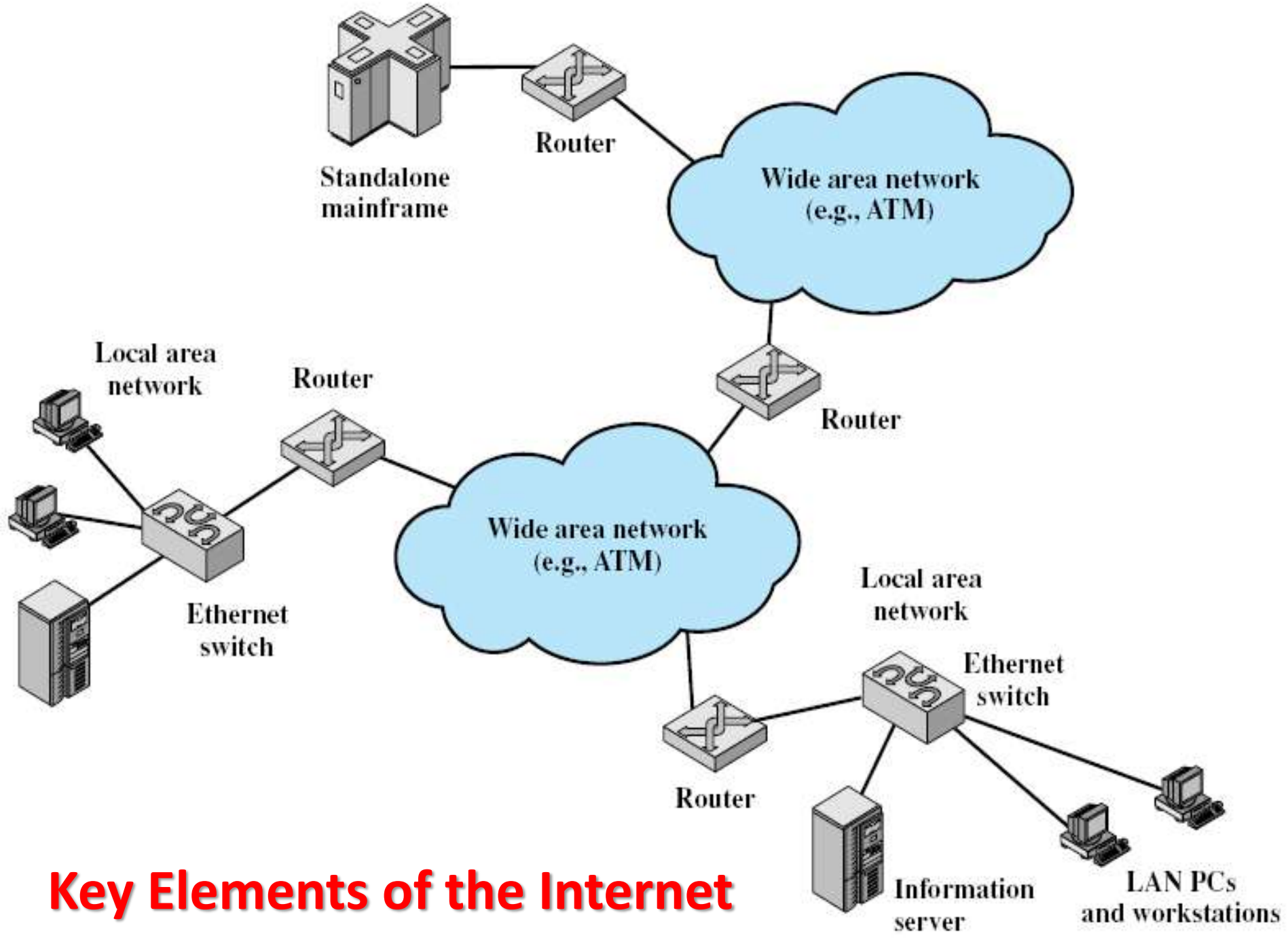
Metropolitan Area Networks (MANs)

- Similar technology to a LAN but over a wider area (e.g. city)
- Utilize microwave, optical fiber, other wires; Wired or wireless
- Different communicating LANs in a city can form MAN.
- MAN is a type of WAN

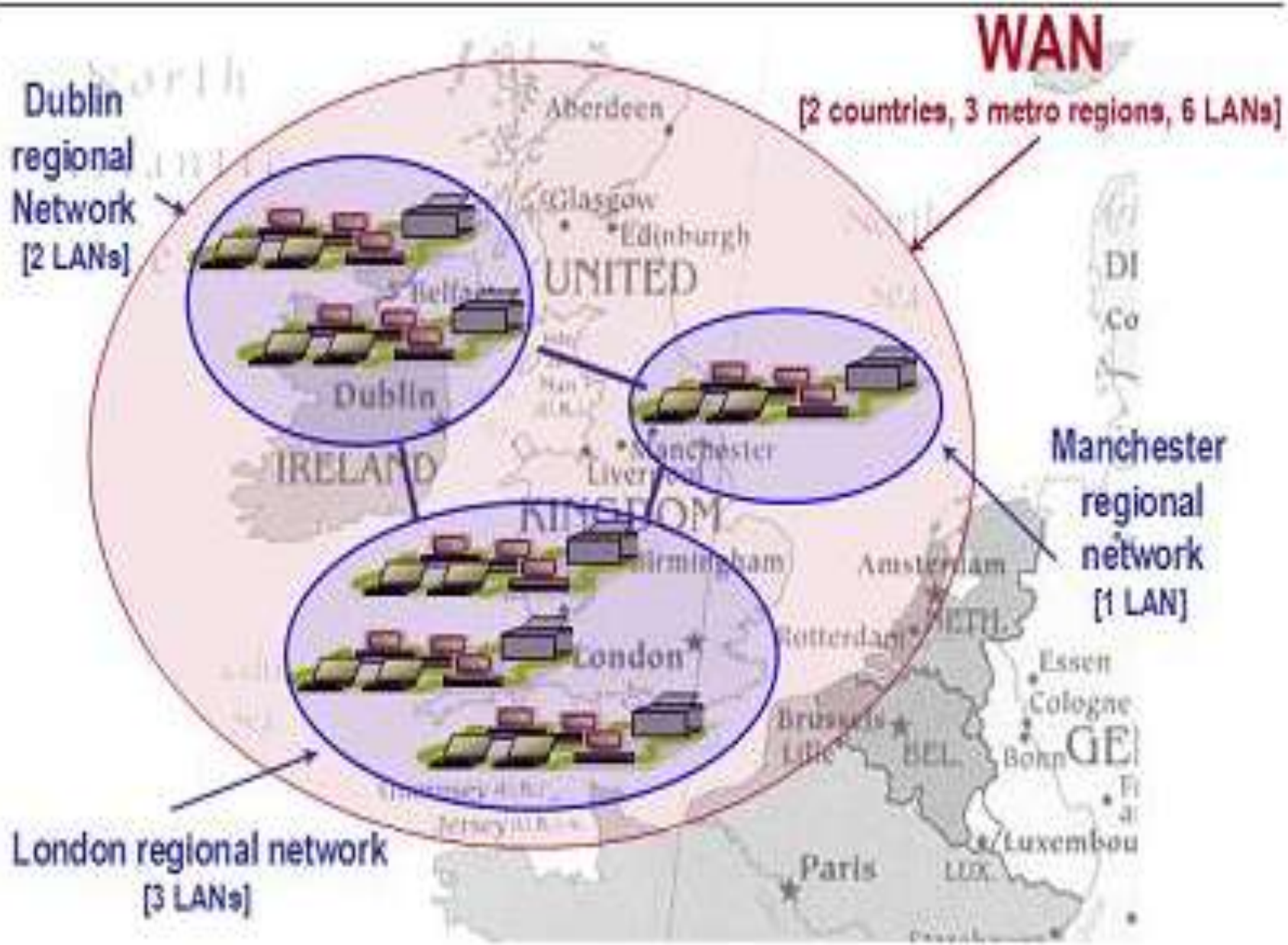
Wide Area Network (WAN)

- Network over a large area like a city, a country, or multiple countries
  - Connects multiple LANs together
- Generally utilizes different and much more expensive networking equipment than LANs
- The internet is the most popular WAN (Largest WAN)





Key Elements of the Internet


WAN
[2 countries, 3 metro regions, 6 LANs]
Dublin regional Network [2 LANs]
Manchester regional network [1 LAN]
London regional network [3 LANs]
Aberdeen
Glasgow
Edinburgh
UNITED
Dublin
IRELAND
Manchester
London
Amsterdam
Rotterdam
Essen
Cologne
Bonn
Brussels
Paris

Wide Area Networks (WANs) Cont…

- The largest WAN is the **Internet**, a global consortium of networks linked by common communication programs and protocols (a set of established standards that enable computers to communicate with each other).

A Wide Area Network

Comparing LAN, MAN, and WAN

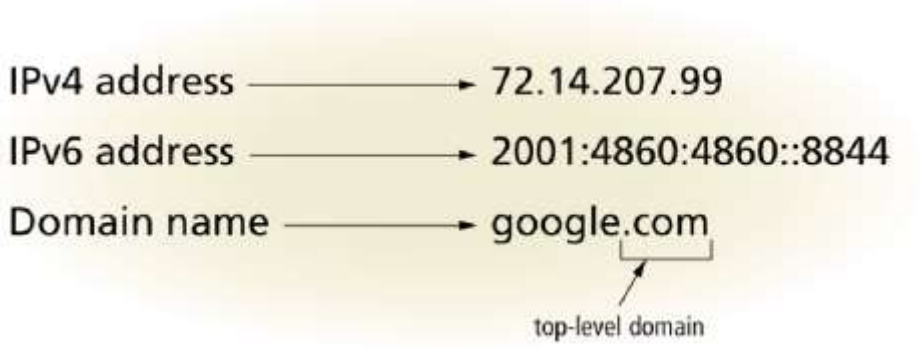
CRITERIA	LAN	MAN	WAN
Cost	Low	High	Higher
Network Size	Small	Larger	Largest
Speed	Fastest	Slower	Slowest
Transmission media type	Twisted-pair	Twisted-pair and fibre-optic cables	Fiber optic, radio wave and sattelite
Number of computers	Smallest	Large	Largest

Domain Name System

- The **domain name system** (DNS) is chiefly used to translate hostnames into numeric IP addresses
  - DNS is an example of a distributed database
  - If that server can resolve the hostname, it does so
  - If not, that server asks another domain name server

Connecting to the Internet

- An **IP address** is a sequence of numbers that uniquely identifies each computer or device connected to the Internet
- A **domain name** is a text-based name that corresponds to the IP address
- A **DNS server** translates the domain name into its associated IP address

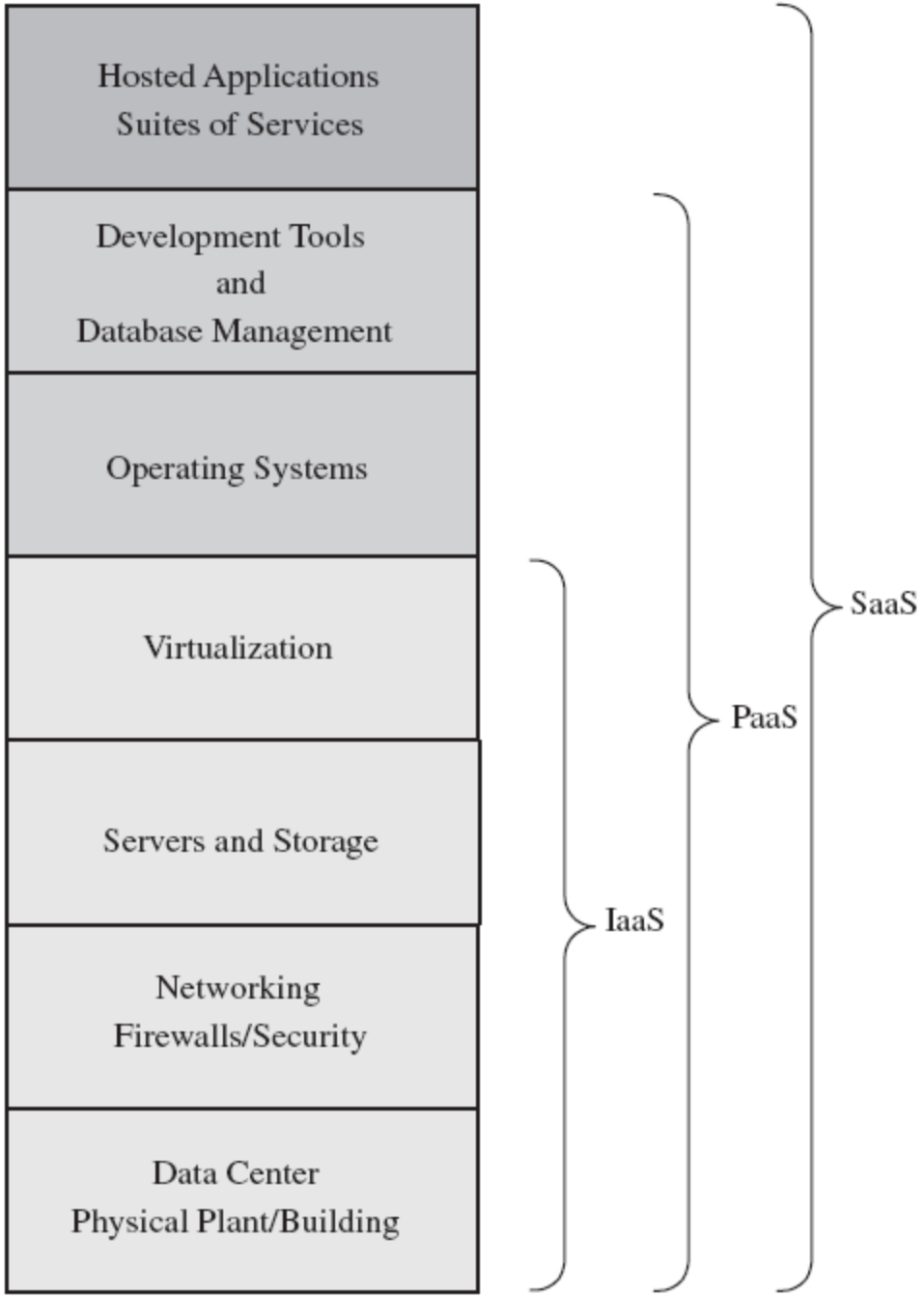


IPv4 address uses 32 bits
IPv6 address uses 128 bits

WWW - Internet

- Internet is a worldwide network of networks, linking computers to computers and other devices .
- It is publicly accessible network of interconnected computer networks that transmit data by packet switching using the standard Internet Protocol (IP).
- Some one can use one or all of the following Internet services:
  - mail (e-mail).
  - Telnet or remote login.
  - FTP or File Transfer Protocol.
  - The World Wide Web (WWW or "the Web")
    - The interlinked Web pages and other documents of WWW functions using HTML and other programming embedded within HTML that make possible hypertext. Linked by hyperlinks and URL.
  - Cloud computing

Cloud computing stack: IaaS, PaaS, and SaaS.



Intranet and Extranet

- Intranet
  - Is a private network that use Internet software and TCP/IP protocols
  - In essence it is a private internet
  - Important means of application delivery
  - Powered by internal web server

Cont…

- Extranet
  - Is a type of inter-organizational information system
  - Enables people who are located outside a company to work together with the company's internally located employees.
  - Aimed to connect business partners over the internet by allowing a part of their network
  - It comes from extended intranet
  - Closed to the general public, only for selected partners.

To do list (Reading Assignment)

- Read and take notes of
  - Internet 2, Internet 3
  - Next Generation Internet
  - Mobile Internet
  - Value Added Network
  - Semantic Web
  - Cloud Computing