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).

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.

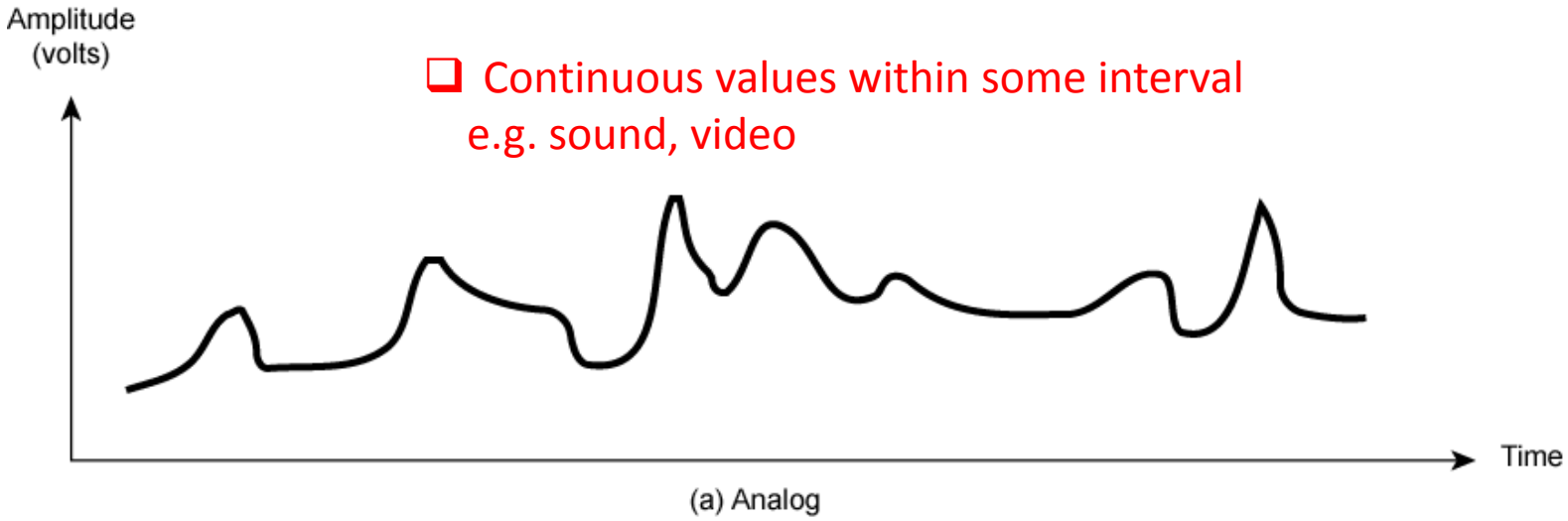
Communications Cont…

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

Data communication four basic terms

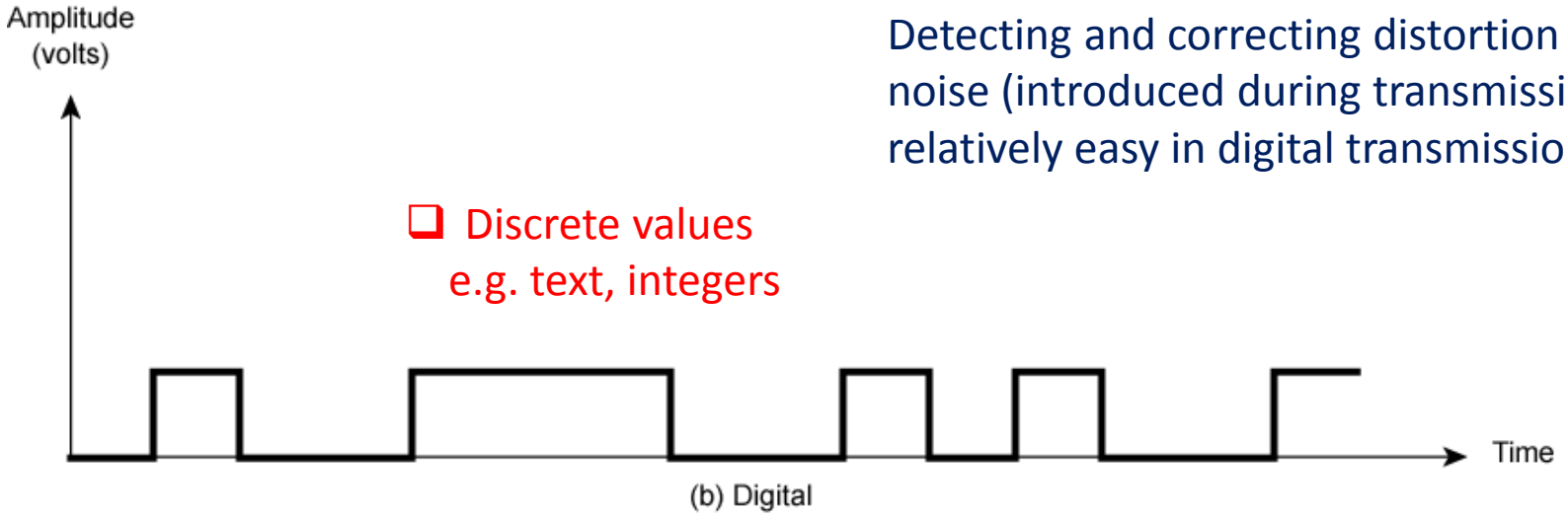
- **Data**: A collection of facts in raw forms that become information after processing.
- **Signals**: Electric or electromagnetic (radio and light waves) encoding of data.
- **Signaling**: Propagation of signals across a communication medium.
- **Transmission**: Communication of data achieved by the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

Analogue & Digital Signals



(a) Analog

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



(b) Digital

- Discrete values
  e.g. text, integers

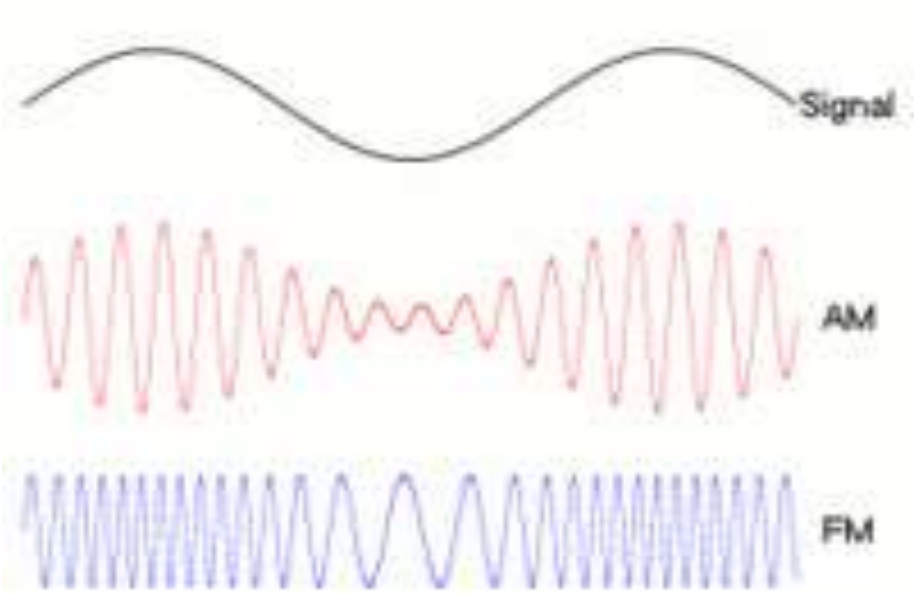
Detecting and correcting distortion due to noise (introduced during transmission) is relatively easy in digital transmission

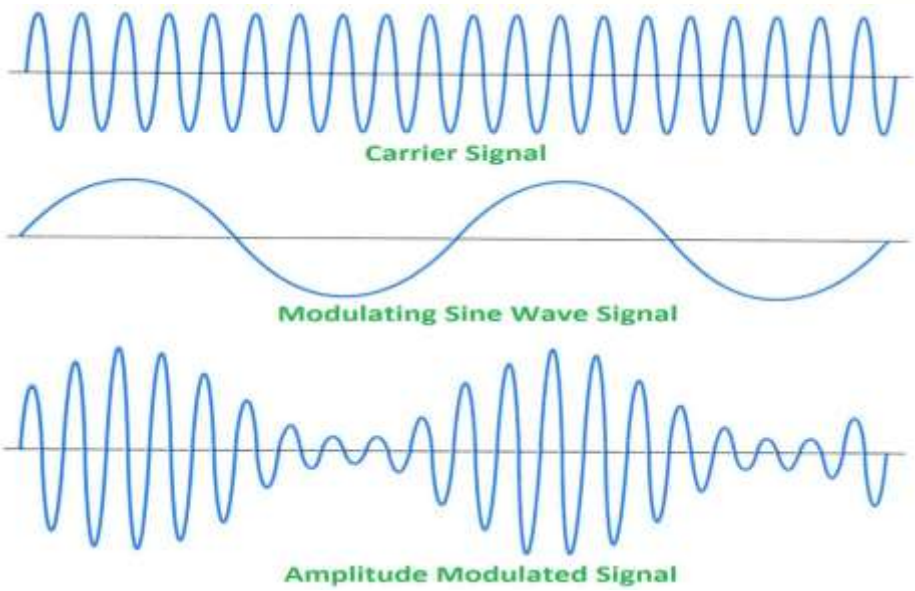
The principal advantages of digital signaling are that it is generally cheaper than analog signaling and is less susceptible to noise interference.

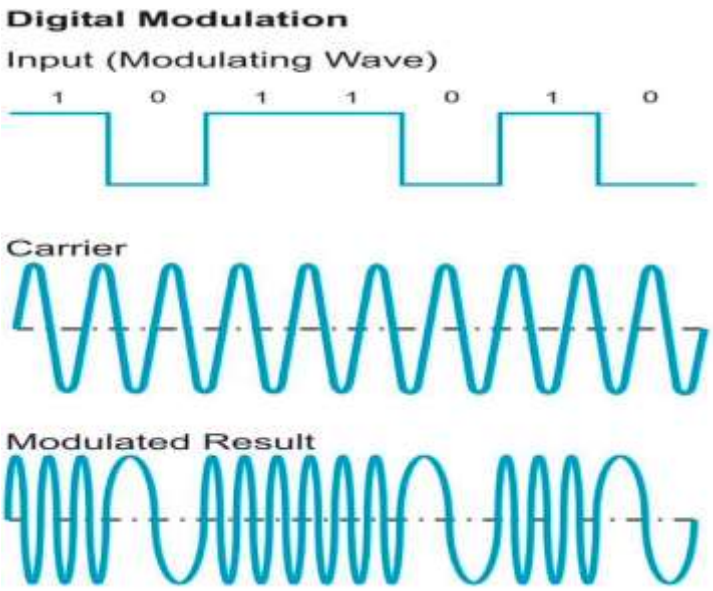
Analogue & Digital Signals

- **A modem converts sequences of binary voltage pulses into an analog signal by encoding the digital data onto a carrier wave through a process called modulation.**
- Three characteristics of analog carrier waves that can be altered are frequency, amplitude, and phase.
- **Examples of analog values: Sound, Temperature, Pressure, Light, Video**
- **Signals are electric or electromagnetic representations of data.**

Analogue & Digital Signals Cont.







Processing of signals for transmission

Bandwidth of transmission

1. telecommunications: **range of radio frequencies:** range of radio frequencies (in 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.

Bandwidth is limited by the type of transmission medium

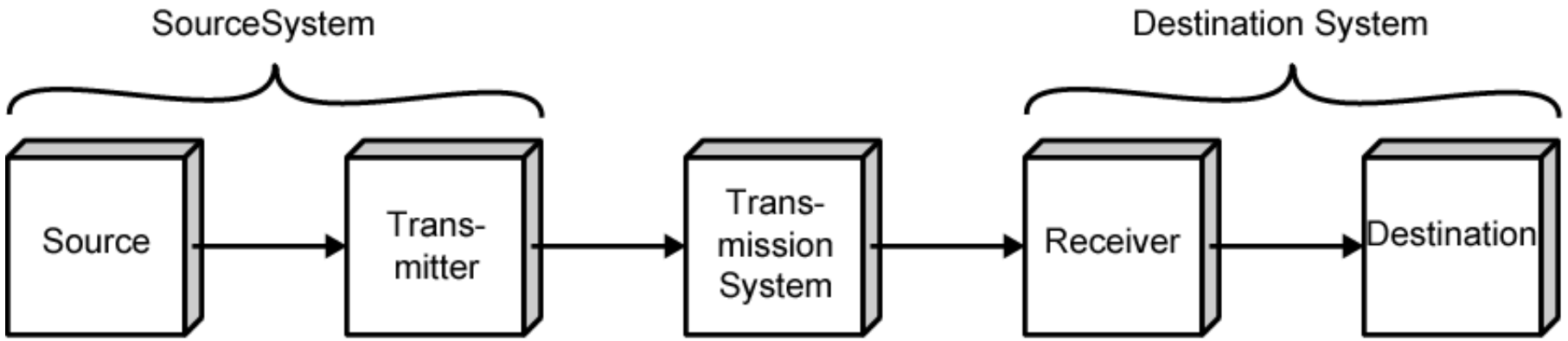
Data transmission

- **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.**

Simplified Communications Model - Diagram

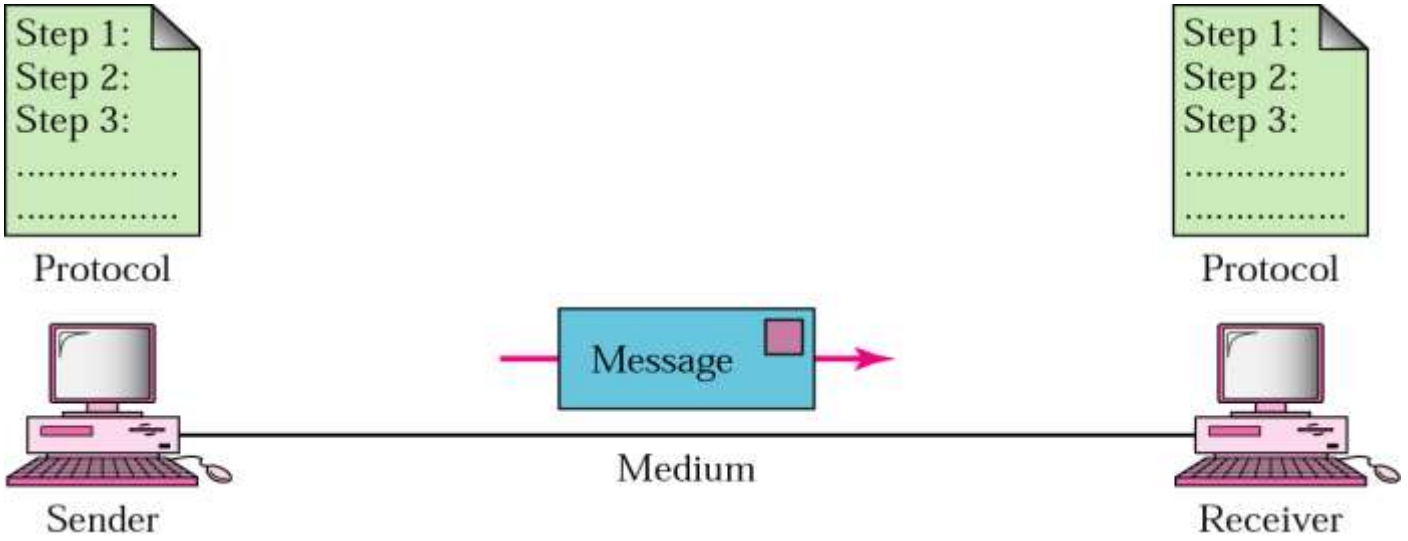


(a) General block diagram

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

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 each section of bits**
  - **Knows which fields define what action**
  - **Includes control information for coordination and error handling**
- **Timing**
  - **When data should be sent**
  - **Speed at which data should be sent or speed at which it is being received.**
  - **Includes speed matching and sequencing**

Protocol specification (precise syntax and semantics for interoperability)

Protocol Concepts

- Protocols are sets of rules.
- What do you want to do? (Application)
- Where are you going? (Addressing)
- How do you get there? (Media types, Routing)
- Did you get there? (Acknowledgments, Error checking)
- **A protocol defines what is communicated, how it is communicated, and when it is communicated.**

We can group protocol functions into the following categories:

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

Data Transmission Modes

- **Simplex System**
  - **Only one device on a link can transmit; the other can only receive. It is one way communication.** Use the entire capacity of the channel to send data

    Ex. Telemetry, Broadcast radio, keyboards
- **Half Duplex**
  - **Device 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 communication improves efficiency.**
  - **Signals going in either direction sharing the capacity of the link**
  - **The medium is carrying signals in both directions at the same time.**

    Ex. Telephone

Communication Channels

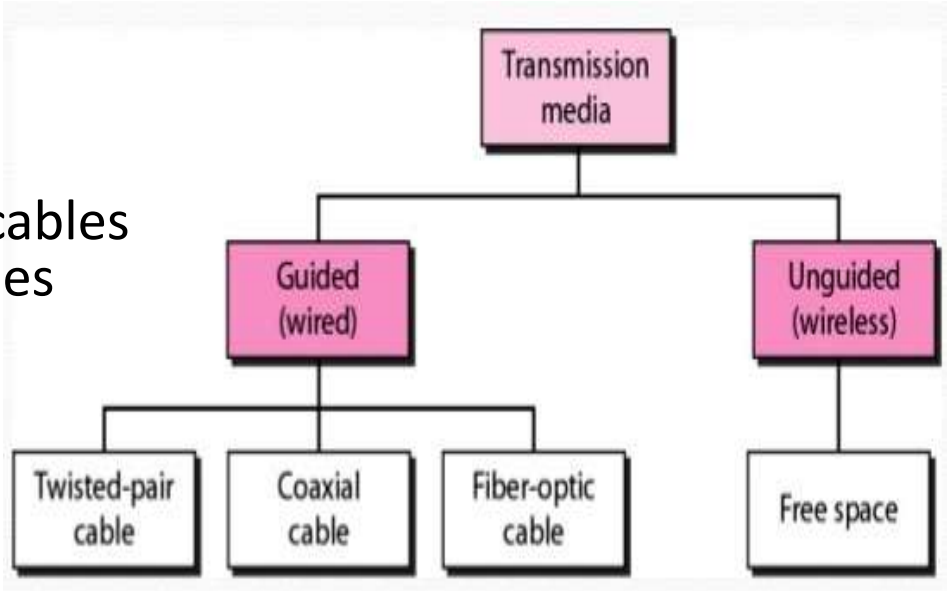
- A **channel** is a path between two communication devices
- **Channel capacity**: How much data can be passed through the channel, bits/sec or hz (frequency-range)
  - Also called **channel bandwidth (range of frequencies)**
  - The smaller the pipe the slower the data transfer!
  - **Analog bandwidth 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 or water) (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
- Power line



2.Unguided (Wireless)

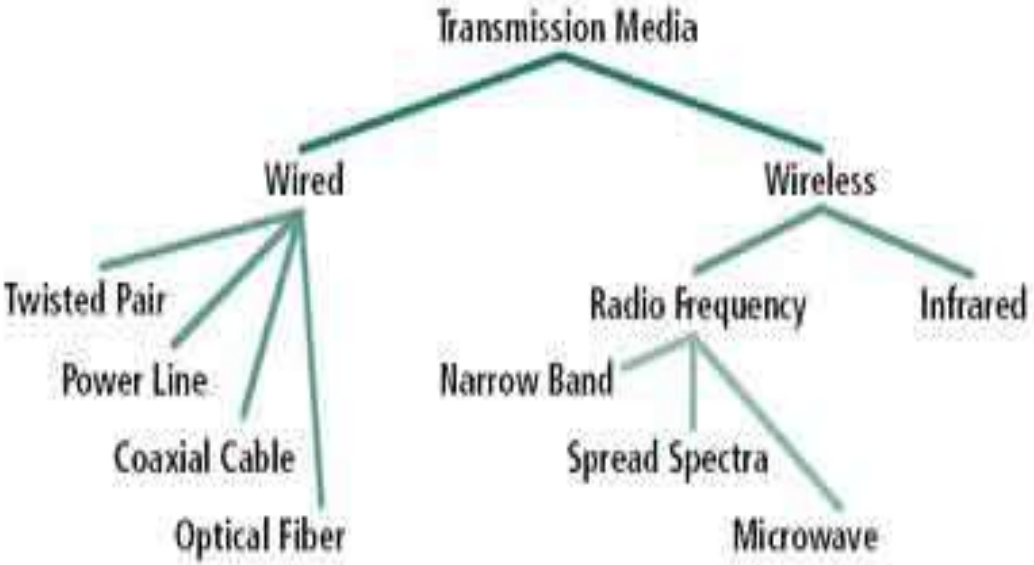
- Wireless transmission, e.g. radio, microwave, infrared (Can not be used outdoors at day time due to sunshine), sonar (echo-location finding system in water, using sound pulses)

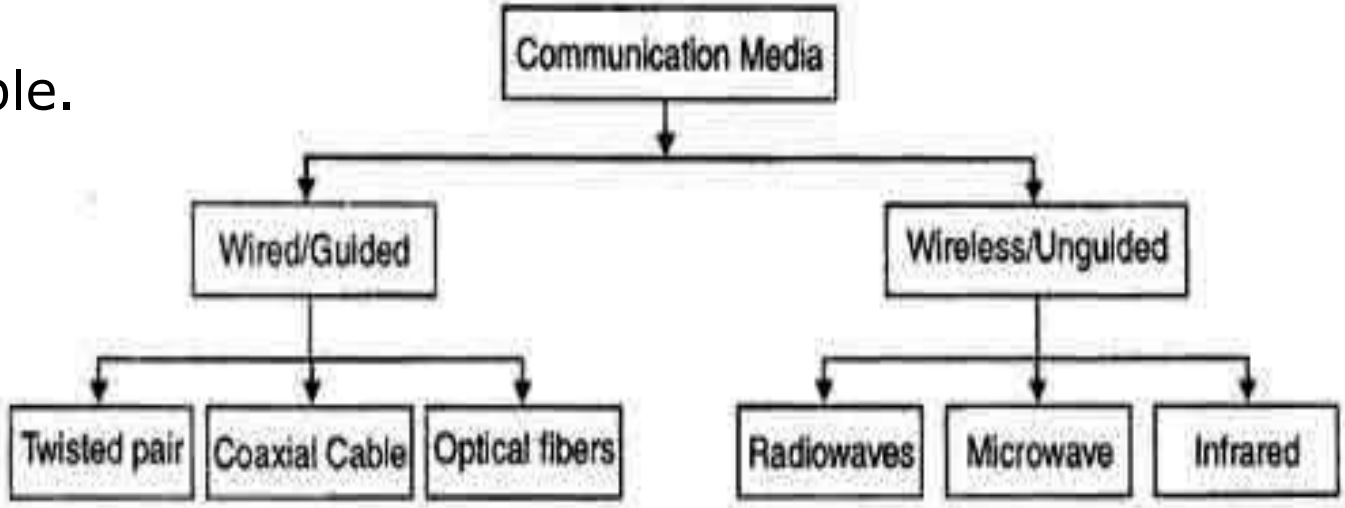
Each physical media has its own niche in terms of bandwidth, delay, cost, and ease of installation and maintenance

Information channel or media Cont'd …

Coaxial Cable

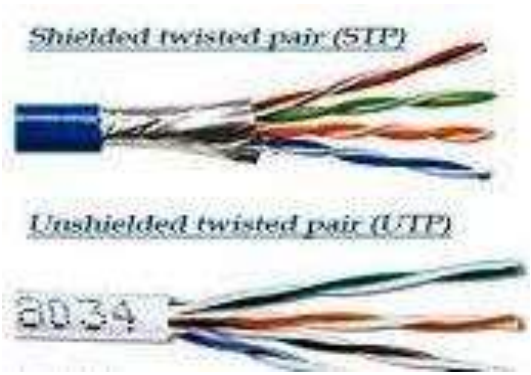
A thinnet coaxial cable.

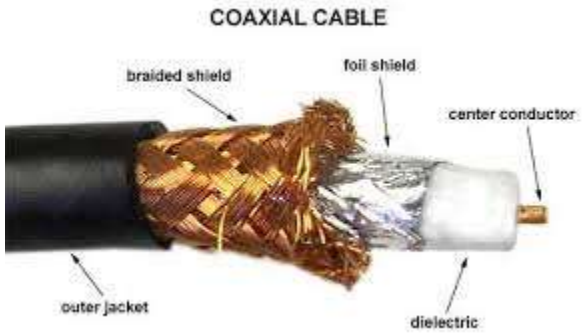


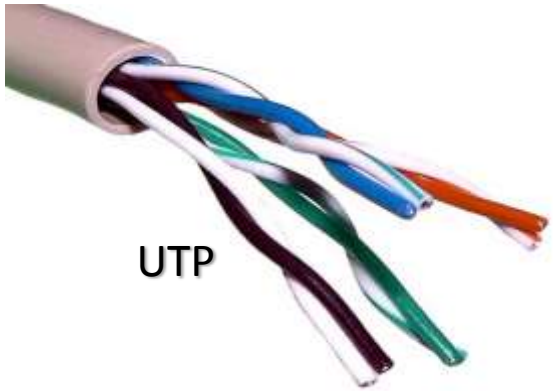


Physical Media (Guided Channel)

- **A tangible media**
- **Twisted-pair cable:**
  - One or more twisted wires bundled together (why twisted?)
  - 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, highly secure

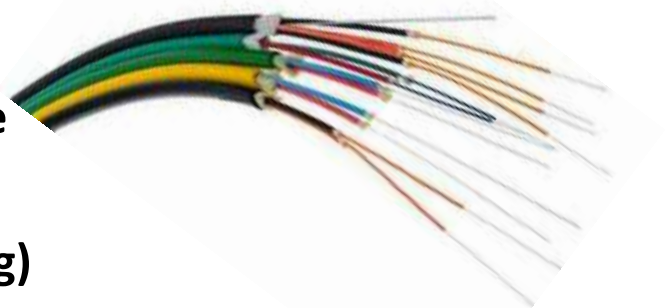






Information channel Cont'd …

- **Guided**
  - **Cable transmission (Attenuation, Distortion & noise) (reduce the strength & change the form during transmission)**
    - **Fibre-optics**
      - **10GBPS and greater, long distance**
    - **Coaxial**
      - **10MBPS and greater, 1Ghz (analog)**
    - **Twisted pair (Shielded Twisted Pair – STP - Cable)**
      - **10 to 1000MBPS, 100Meter (LAN)**
    - **Twisted pair (unshielded twisted pair-UTP)**
      - **less interference protection and lower data rate than STP**
      - **Cross talk problem**



Coaxial cable connector

Fiber optic cables

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.
- Photo diodes (photo detectors) are used as receiving devices
- 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

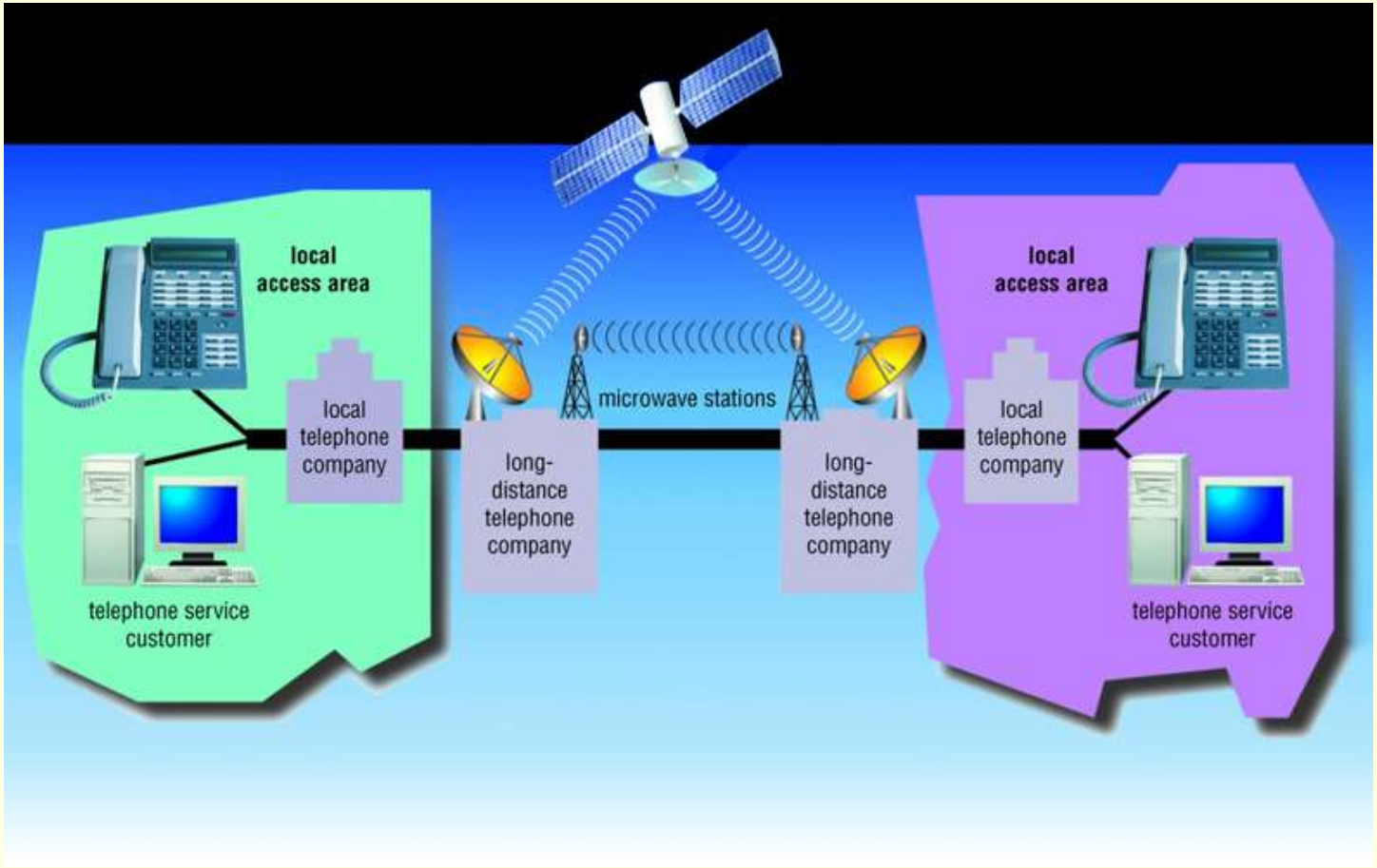
Twisted-Pair	Coaxial	Fiber-Optic	Infrared Light
			Wireless
Low Cost	Moderate Cost	High Cost	Moderate Cost
Best for short distances (330 ft.)	Moderate Distance (3300 ft. – thin) (8250 ft. – thick)	Long Distances (14,256 ft.)	Short distance (75 ft.)
Easy to Install	Professional Installation	Professional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

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



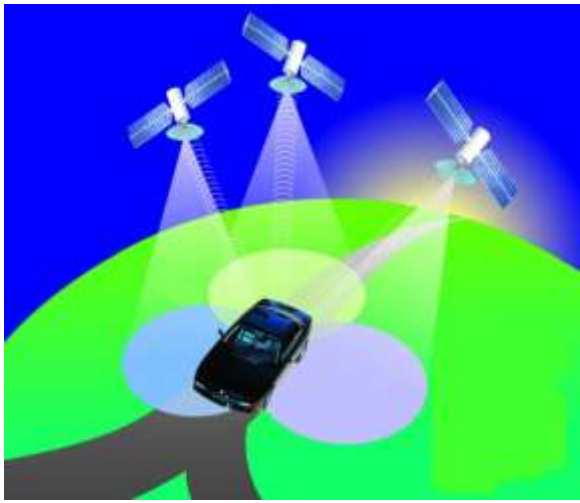
Microwave (Unguided)

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

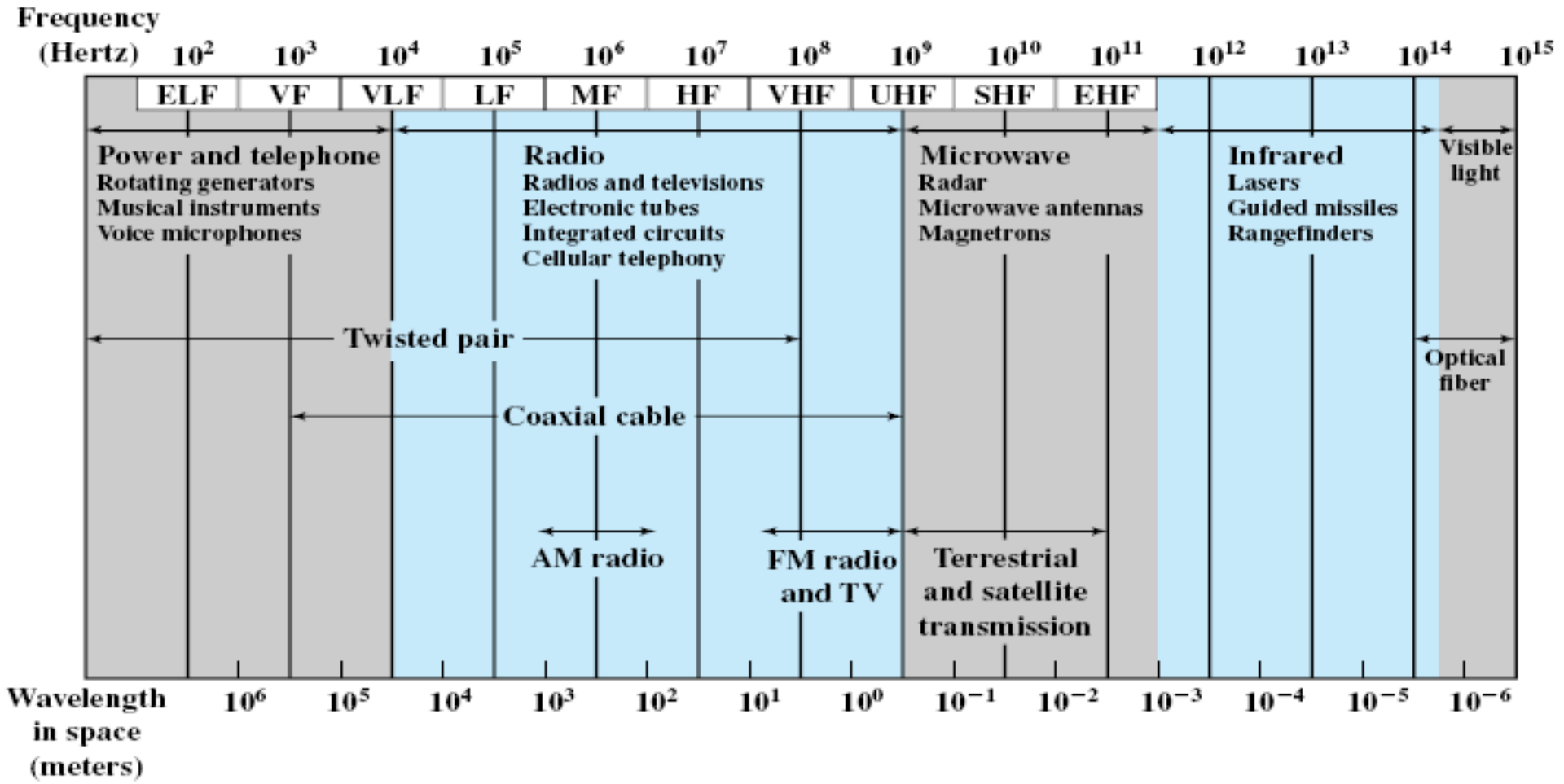
  What is the speed of a radio signal?
- The transmitter and receiver of a microwave system should be in line-of-sight because the radio signal cannot bend.
- Along the earth's surface very long distance transmission is not possible without using repeaters (due to line of sight and earth's curvature).
- 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.

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



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

Applications of Data Communications

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

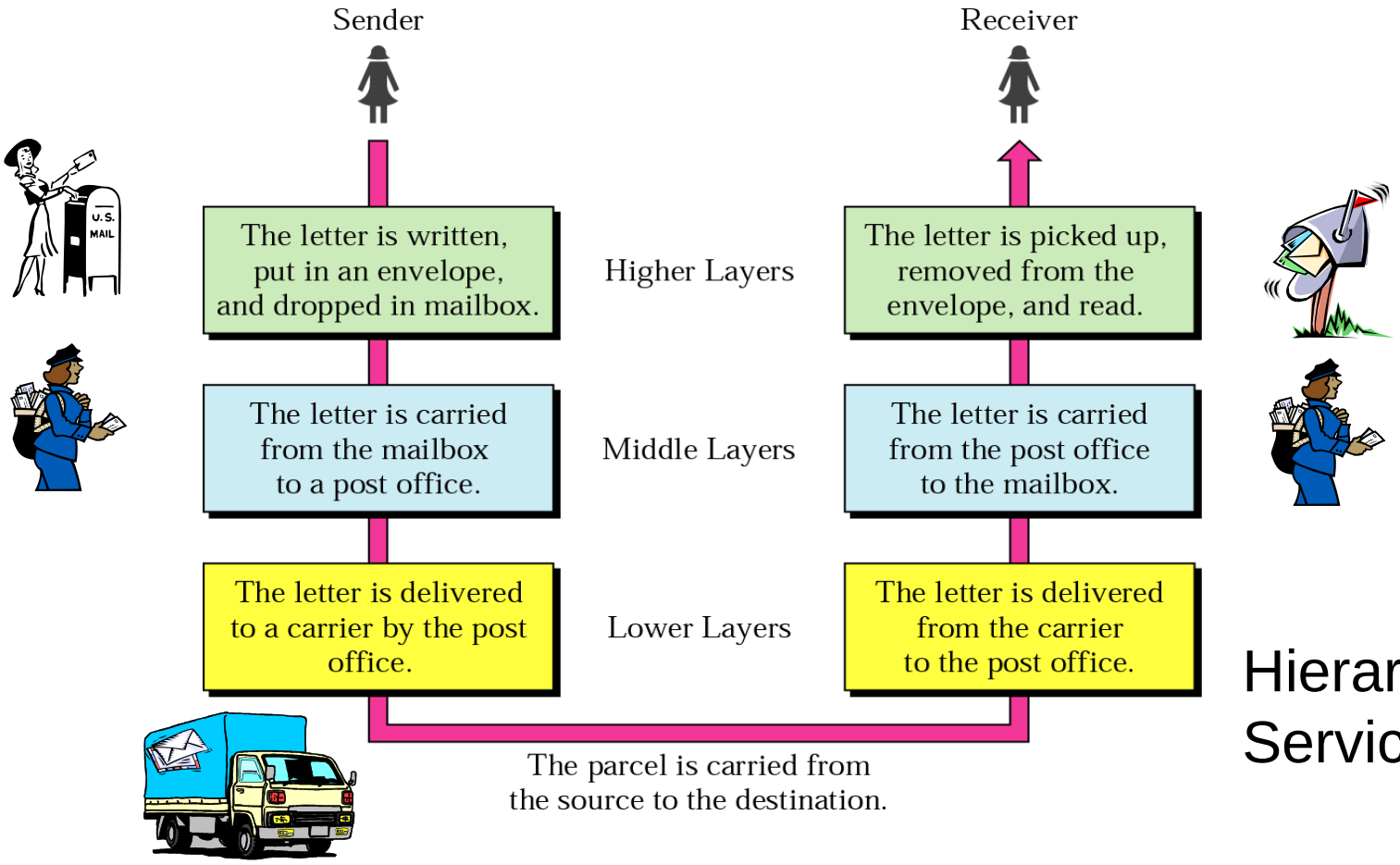
Electronic Fund Transfer, Internet banking; Online education, Telemedicine; Online Employment or job/vacancy; Internet browsing/search engines and so on.

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 manage (reduce) complexity of communication task by splitting it into layers of smaller tasks
- Functionality of the layers can be changed as long as the service provided to the layer above stays unchanged
  - makes easier maintenance & updating
- Simplifies teaching and learning

- Each layer has its own task (service)
- Each layer has its own protocol

Physical Layer

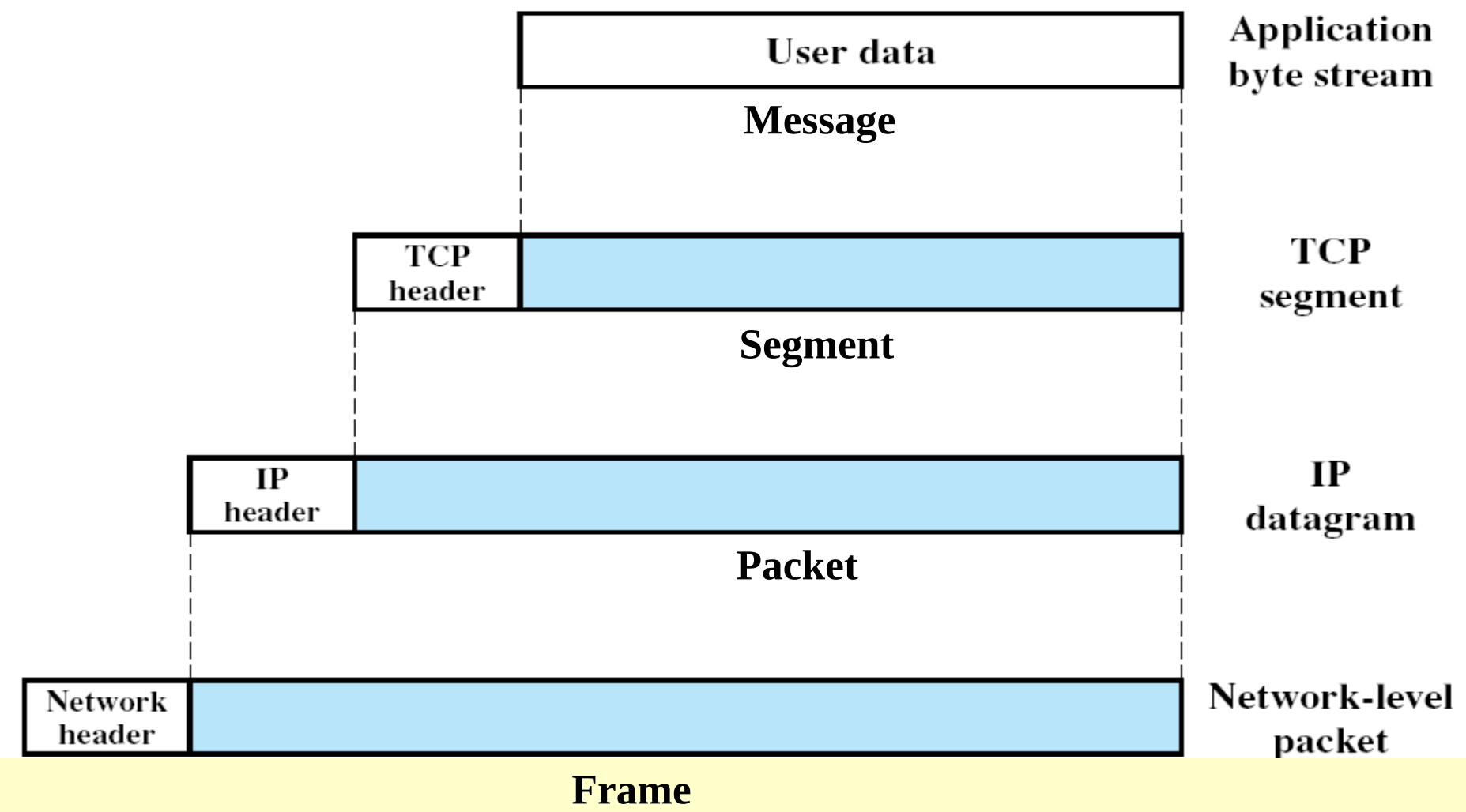
- lowest level layer
- Specifies
  - the characteristics of the transmission medium
  - Nature of the signals
  - Data rate

Groups of Layers	OSI Model	TCP/IP 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

*** standards are essential for interoperability**

Data + Control Information = Encapsulation



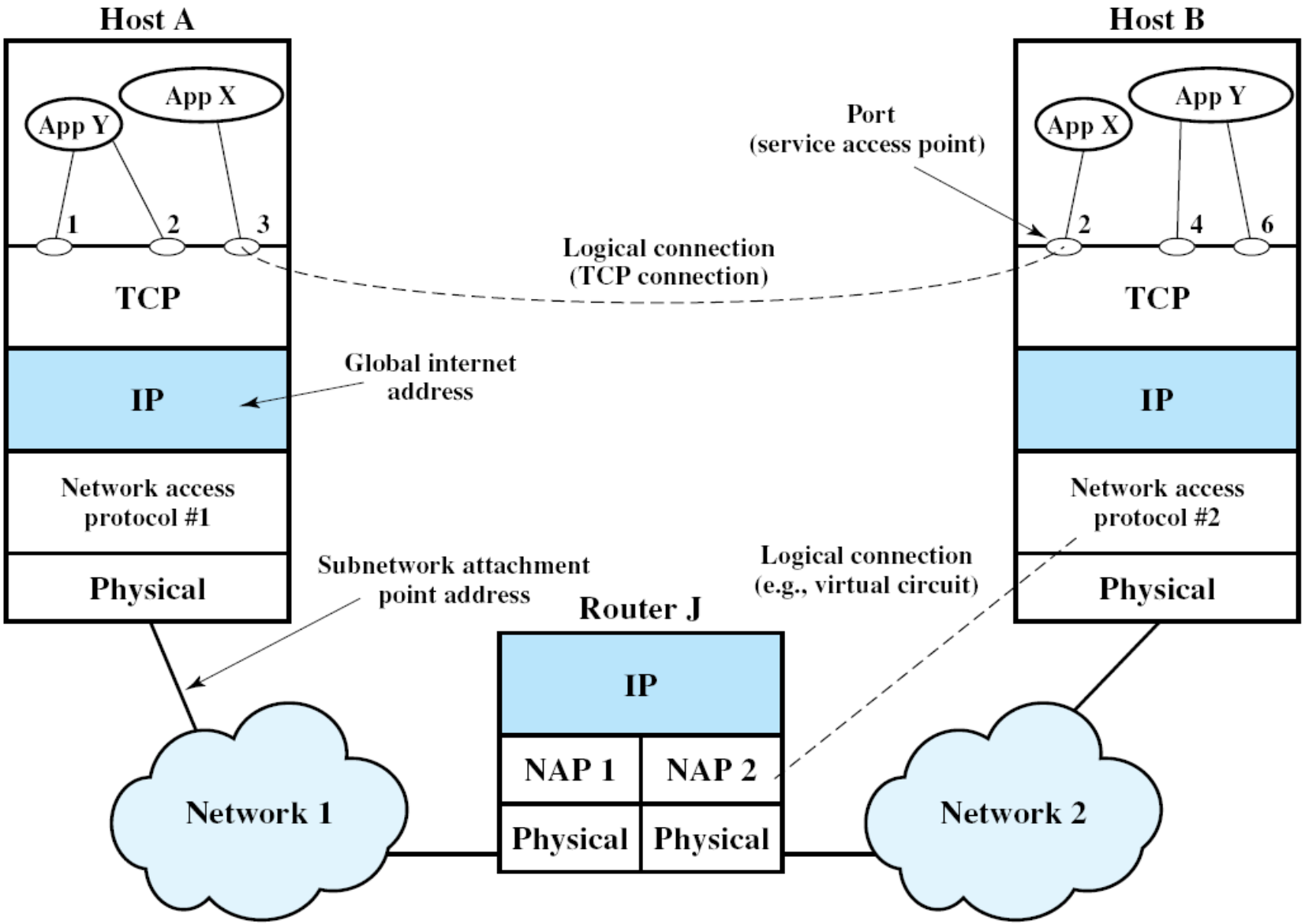
Protocol Data Units (PDUs) in the TCP/IP Architecture

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 , **DHCP**
2	Data Link Layer	PPP, ATM, Ethernet
1	Physical Layer	Ethernet, USB, Bluetooth, IEEE802.11

Each layer provides service to a layer above it



TCP/IP Concepts

From Stallings 8th edition page 36

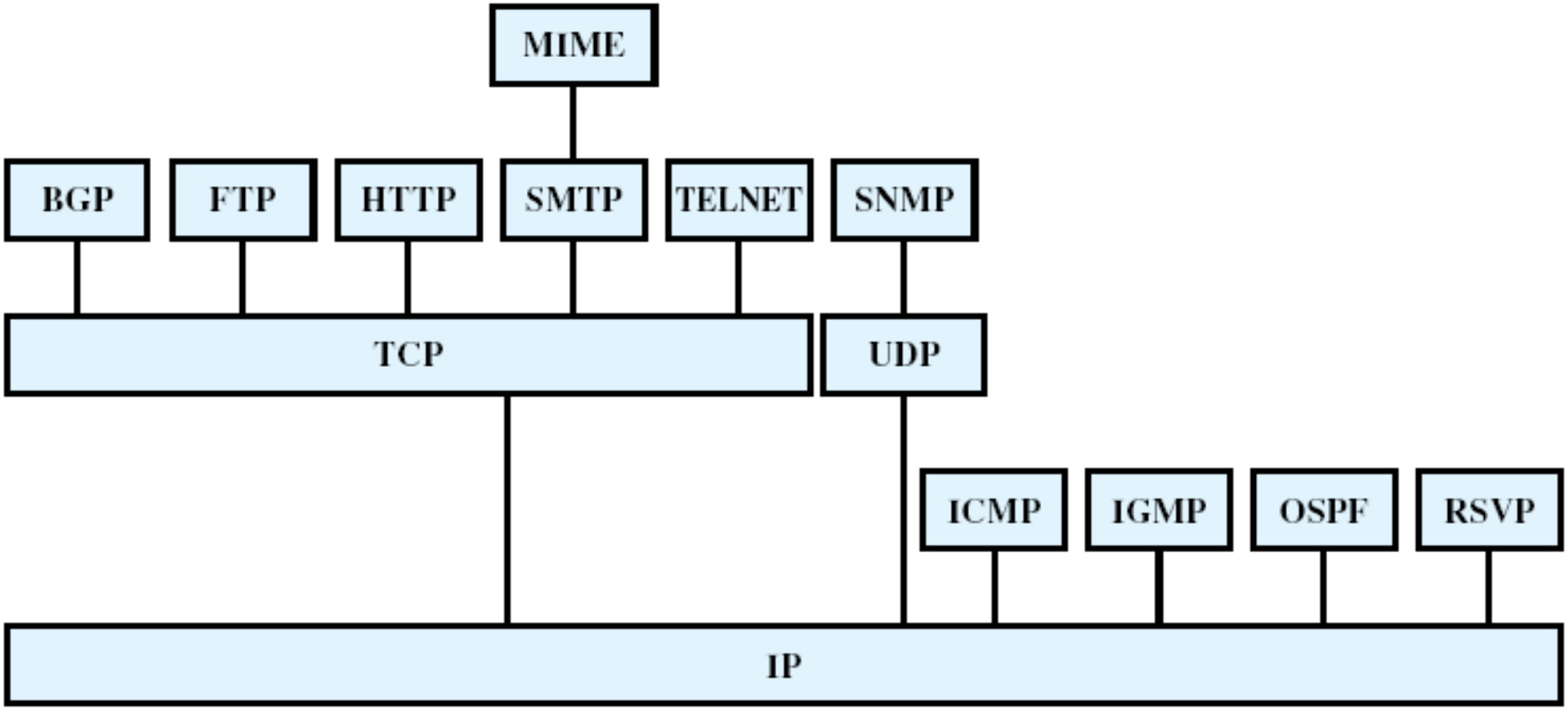
Ethernet (example network protocol) (Hardware Layer)

- 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

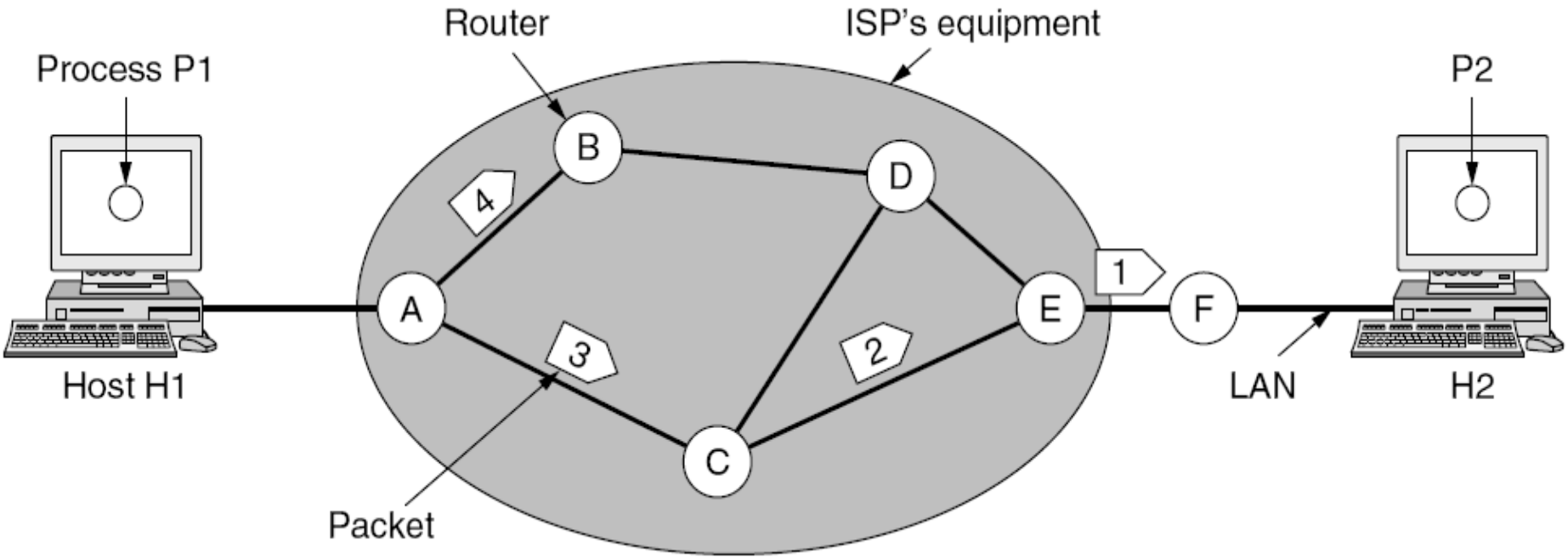
- When one computer wanted to send some information, it followed the following algorithm
  - **Make data ready for transmission.**
  - **Is medium idle? If not, wait for a period until it becomes ready.**
  - **Start transmitting.**
  - **Does a collision occur? If so, go to collision detected procedure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

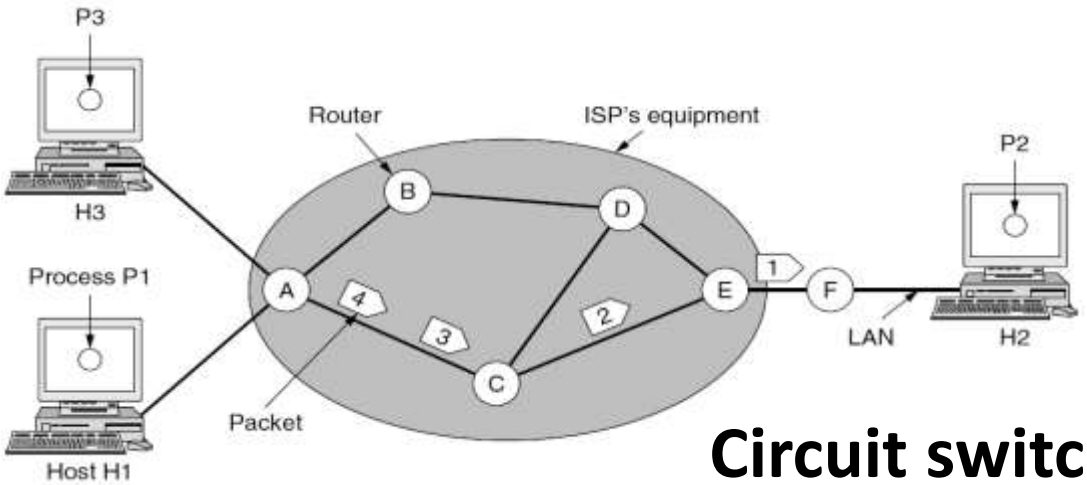


BGP = Border Gateway Protocol
FTP = File Transfer Protocol
HTTP = Hypertext Transfer Protocol
ICMP = Internet Control Message Protocol
IGMP = Internet Group Management Protocol
IP = Internet Protocol
MIME = Multipurpose Internet Mail Extension
OSPF = Open Shortest Path First
RSVP = Resource ReSerVation 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

Routing within a datagram (packet switched)network.





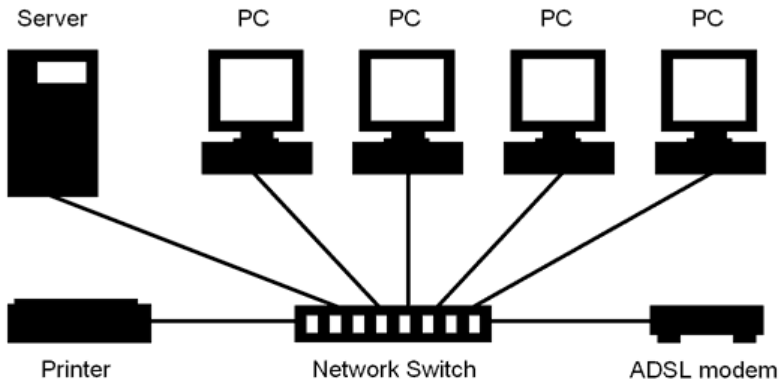
Circuit switched network.

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.
- 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.*
- Networks must meet certain criteria, the most important are: Performance, reliability, and security.

Computer Networks - Why networking?

- Remote access to resources – Efficiency through accessibility – Resource Sharing
- Reduction of data duplication – Data kept on a Server
- Communication (Collaboration)- people can work together in ways not previously possible (ARPANET)
- Saving money (peer to peer (distributed computing))
  - *Price / performance rate of a number of linked small computers is better than few large ones.*
  - *Better to get cheaper machines and network them.*
- scalability - ability to grow and shrink network capacity



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**
- **How can we be sure valuable information is safe in a networked environment?**

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 (Size)
  - By management Method

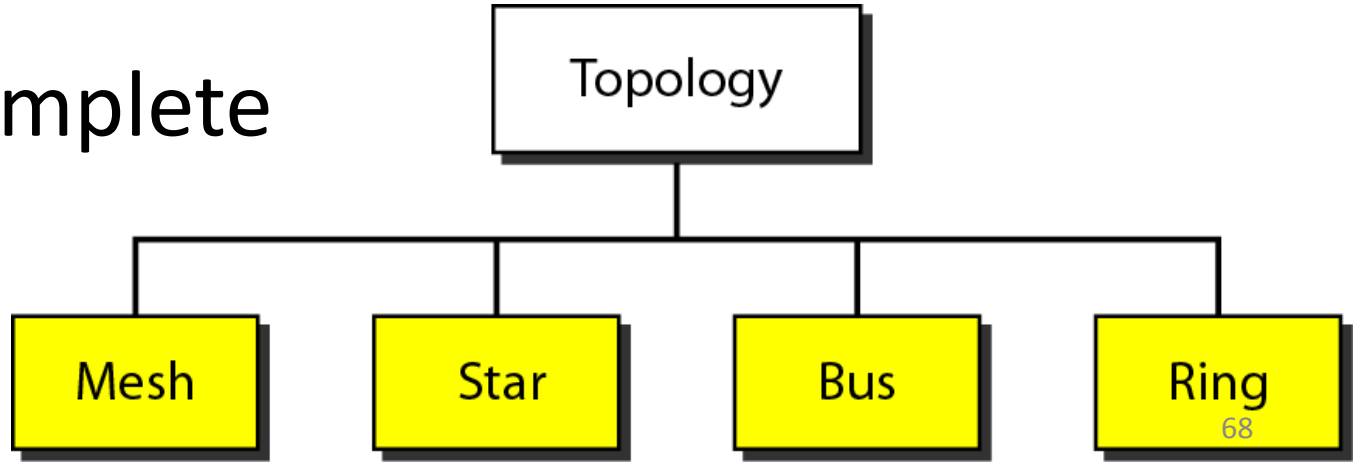
Ways of classifying networks Cont'd …

- **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.

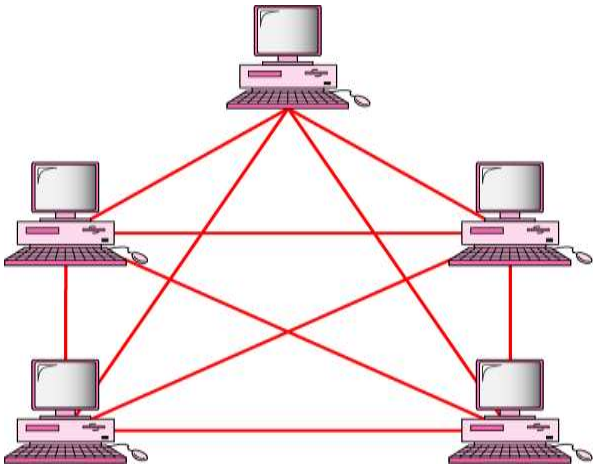
- Some of the basic topologies:
  - Star
  - Ring
  - Bus
  - Mesh/Complete



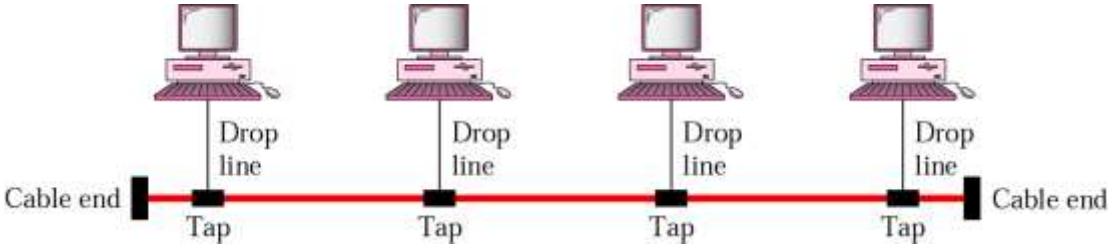
Topology Concerns

- Performance issues
  - Reliability, Ability to recover through/after failure of one or more nodes
- Physical constraints
  - Transmission speed, distance between nodes
  - In a LAN 100 meters is maximum distance to connect two LAN segments (or two switches).
- Other issues
  - Susceptibility / Vulnerability to errors
  - Growth of the network (Scalability)
  - Capability and types of equipment the network needs
  - Cost, geographical area

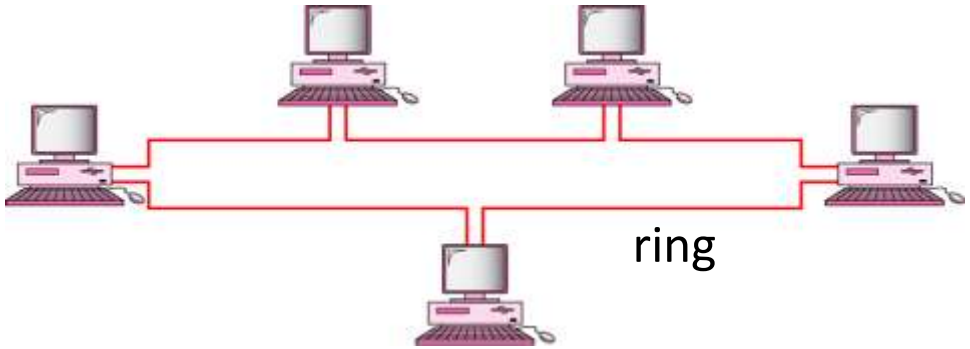
Mostly used network topologies



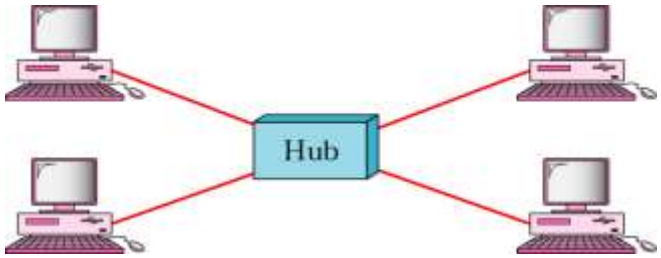
mesh



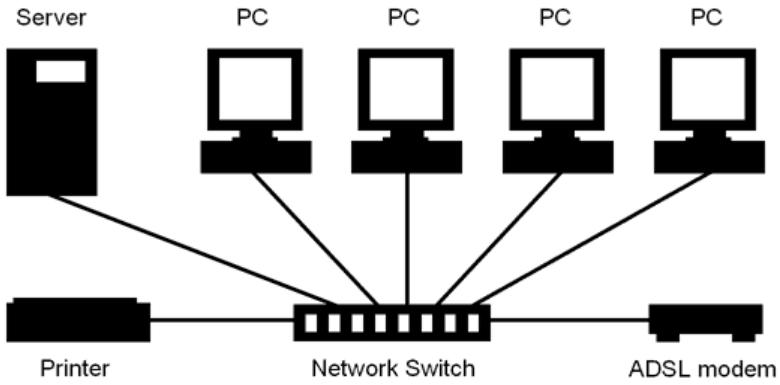
bus



ring



Star (Most Commonly Used Type)



Star *Topology*

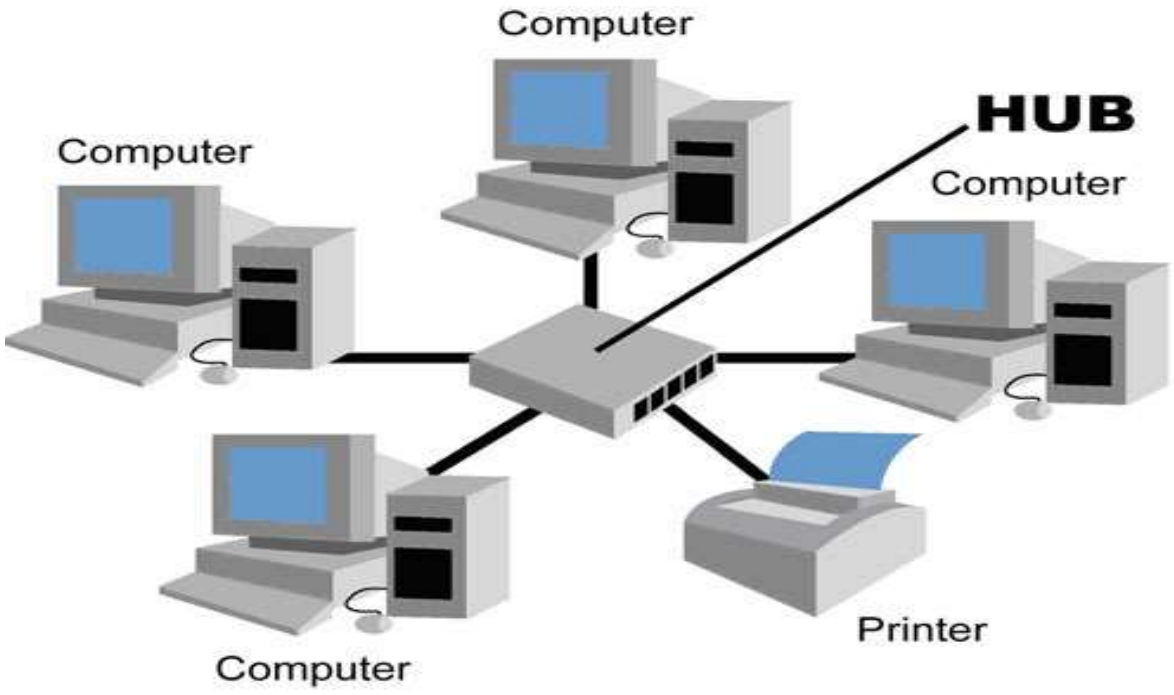
- A number of workstations (or nodes) are directly linked to a central node called a hub.
- Any communication between stations on a star LAN must pass through the central node.
- There is *bi-directional* communication between various nodes.
- The central node controls all the activities of the nodes.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

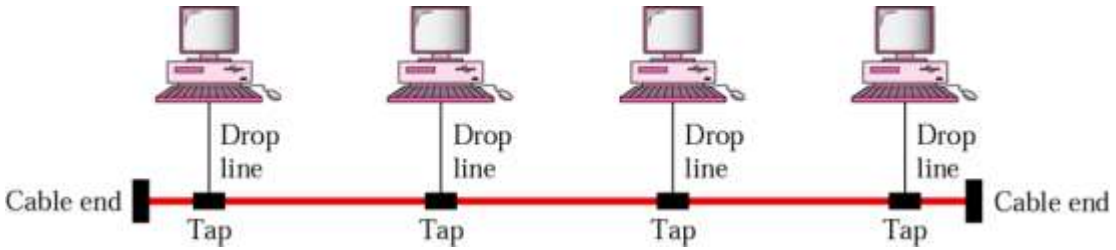
- *Each station is attached to a nearby stations on a point to point basis so that the entire system is in the form of a Ring.*
- *Data is transmitted mostly in one direction only or in recent designs both directions.*
- *Thus the data packets circulate along the ring in either clockwise or anti-clockwise 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 (protocol)

- *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

- *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*

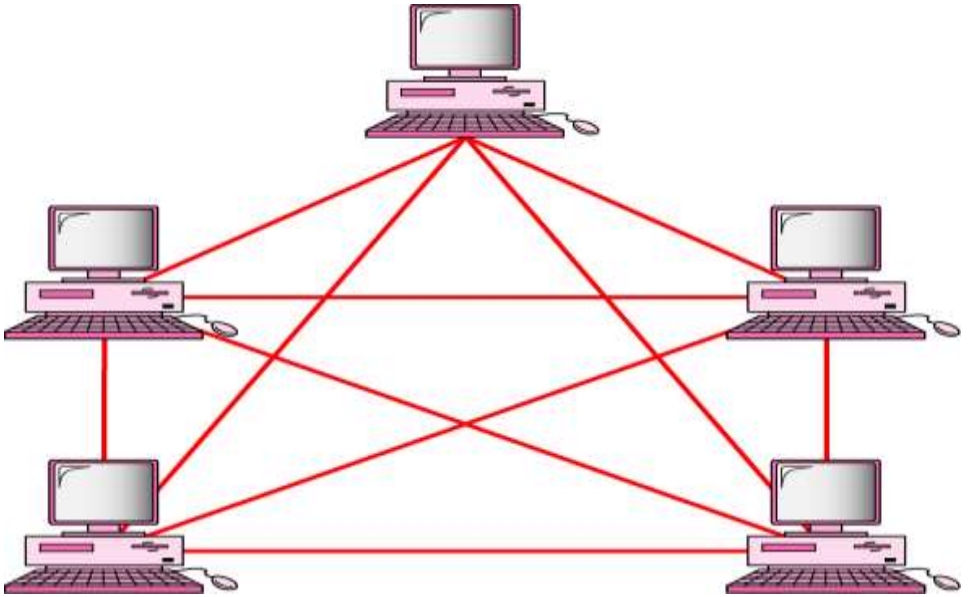


Bus Cont…

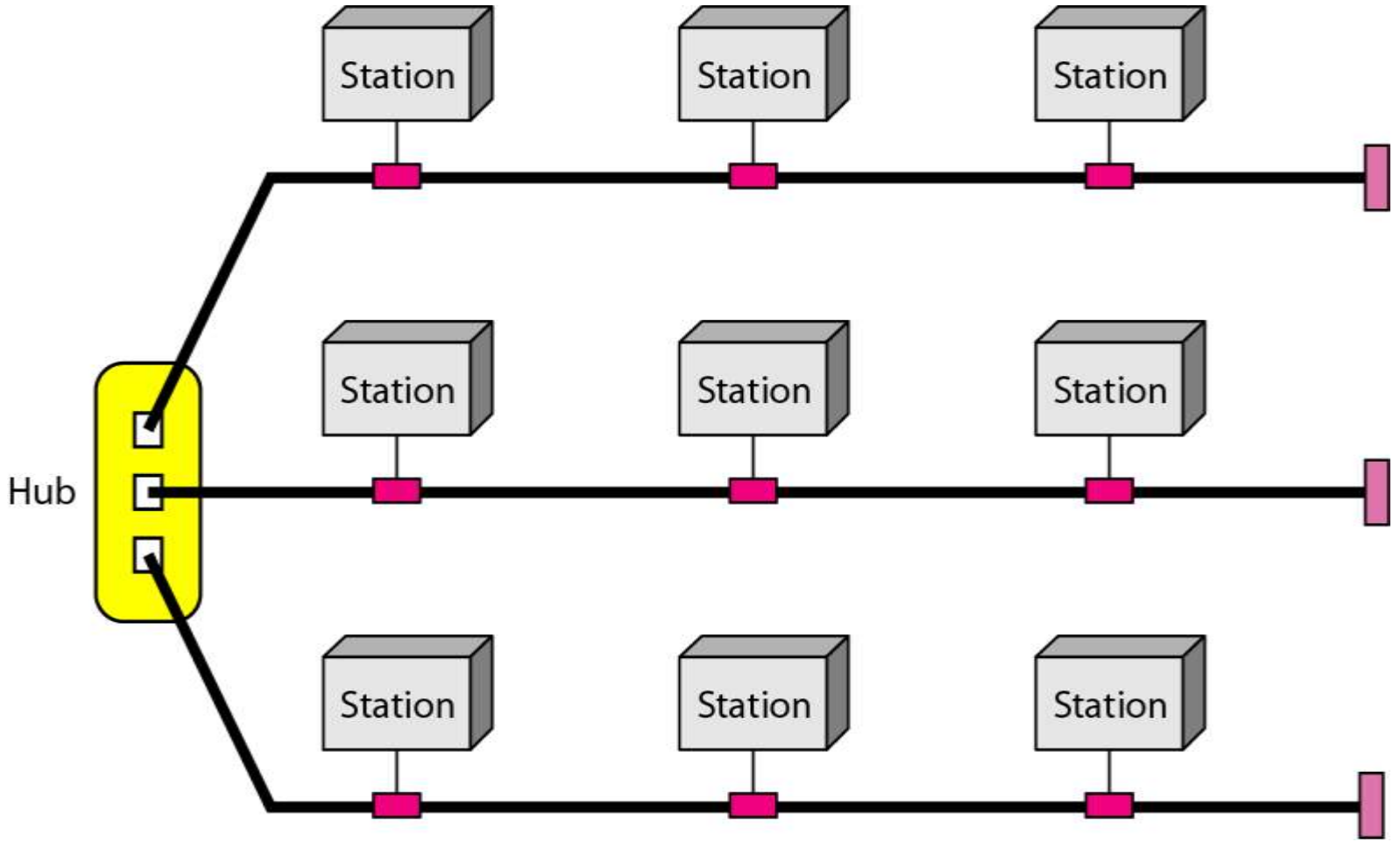
- *Transmission from any station travels the length of the bus in both directions and can be received by all workstations.*
- *The advantage of the bus topology is that it is quite easy to set up.*
- *If one station of the topology fails it does not affect the entire system.*
- *The disadvantage of bus 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. If one node fails the whole network will fail.** **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 (P2P)**
    - **File sharing (e.g. BitTorrent)**
    - **Internet telephony (e.g. Skype)**
    - **In a peer-to-peer system there are no fixed clients and servers.**
  - **Client/Server (also called server-based)**

- Left for you as a reading assignment

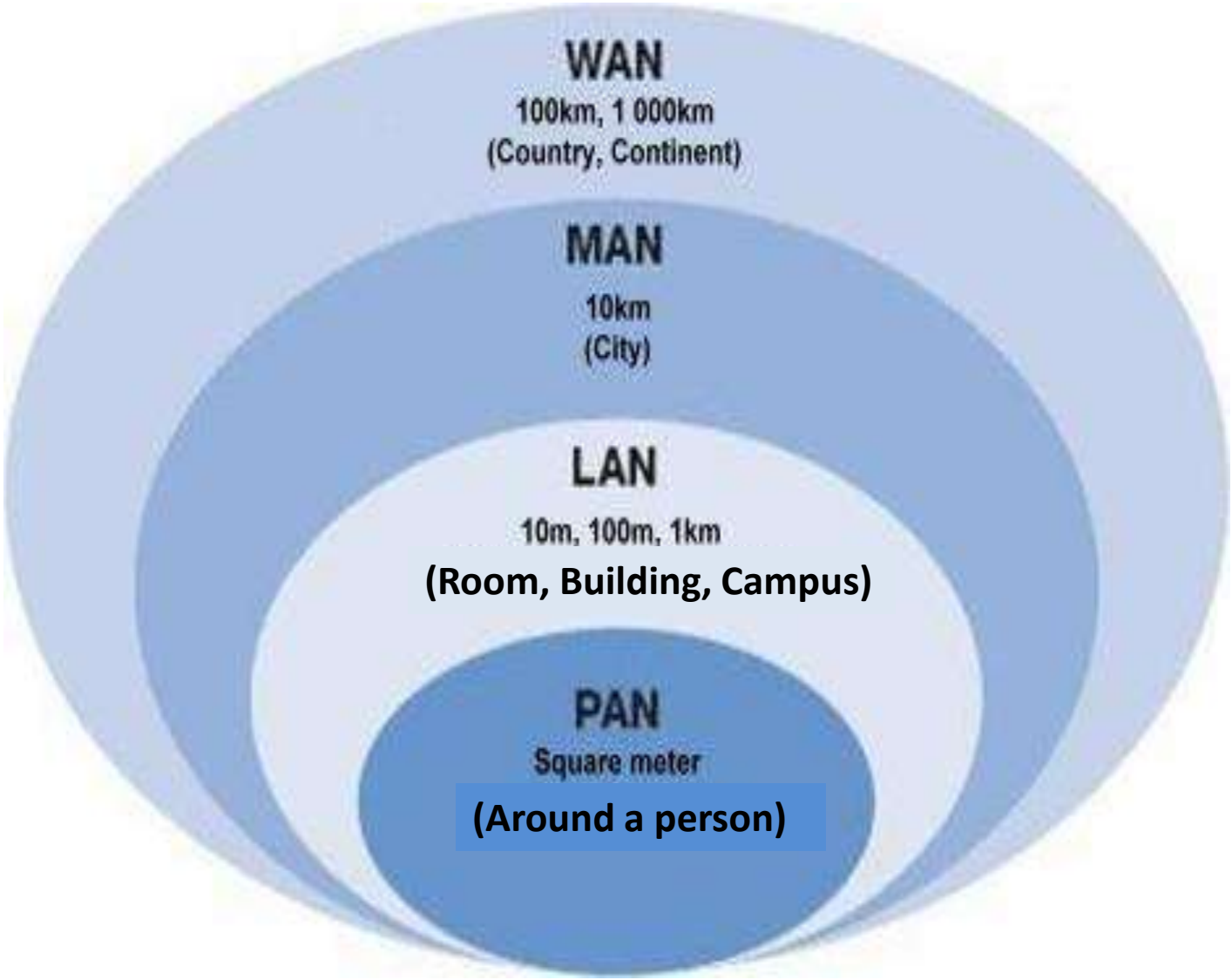
Network Classification based on Scale

- **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…

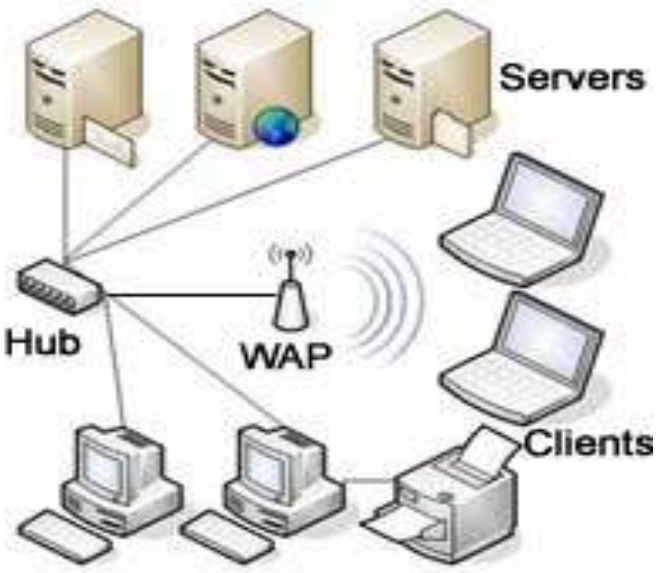


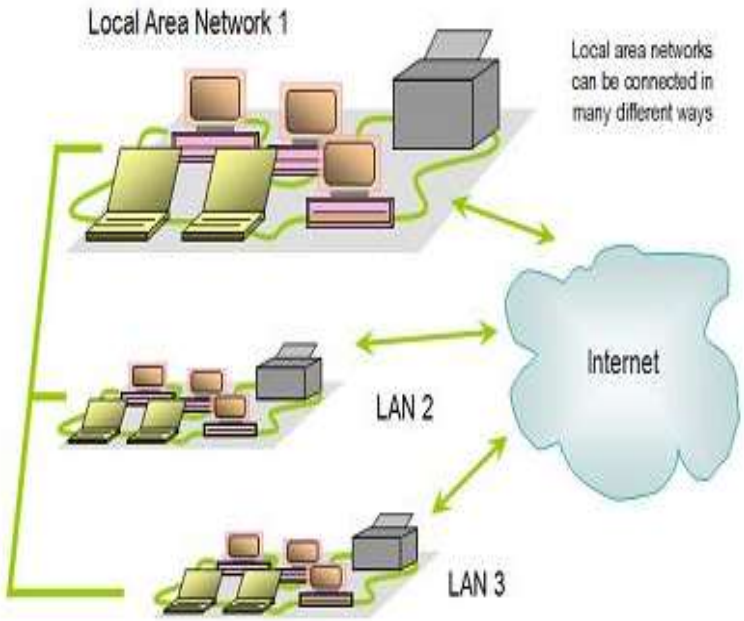
Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

Classification of interconnected processors (nodes) by scale

Local Area Network (LAN)

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



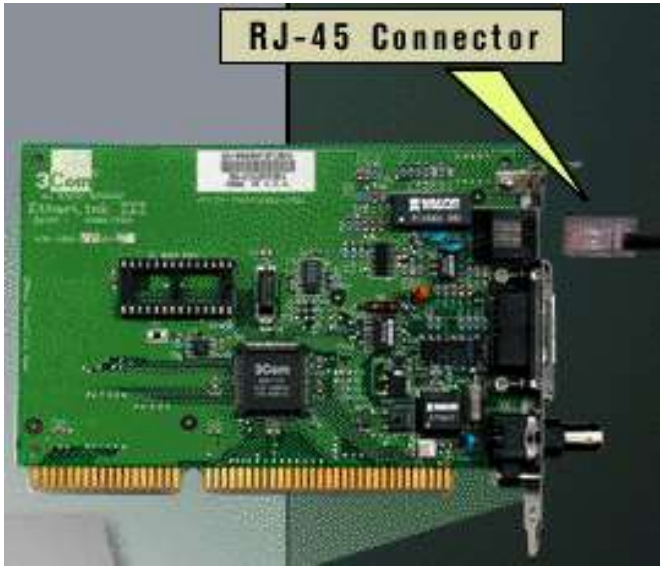


Setting up home networks

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

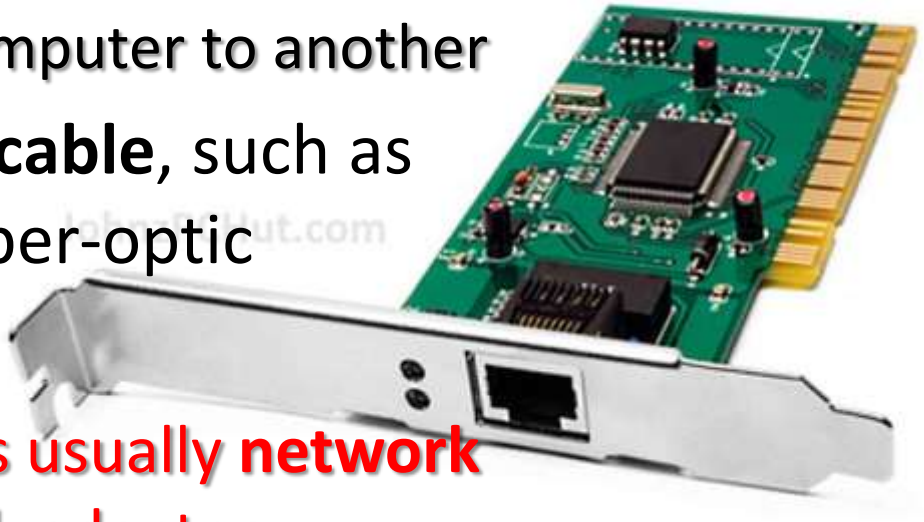
Network adapter card or NIC

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



Network Medium Carries Network Messages

- Computers share access to common network medium that carries signals from one computer to another
  - Medium may be physical **cable**, such as twisted pair, coaxial, or fiber-optic
  - Medium may be **wireless**
- Physical interface to medium is usually **network interface card** (NIC) or network adapter
- Kind of medium dictates type of connector and limits number and type of devices as well as distance a single LAN can span



Extending a LAN

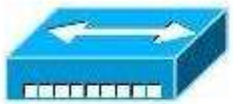
- **To alleviate the distance limitation of LAN**
  - **Methods Available**
    - **Repeaters**: (physical layer devices)
      - **tap into the network and boost the signal**
      - **Connect two LAN segments**
      - **Repeat and regenerate the signal and forward noise and collision as well**
      - **Amplifiers and repeaters belong to the physical layer of the OSI model**

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
  - Repeats input to all other ports
  - **A signal appearing on one cable is cleaned up, amplified, and put out on another cable.**

Cont…

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



Hub

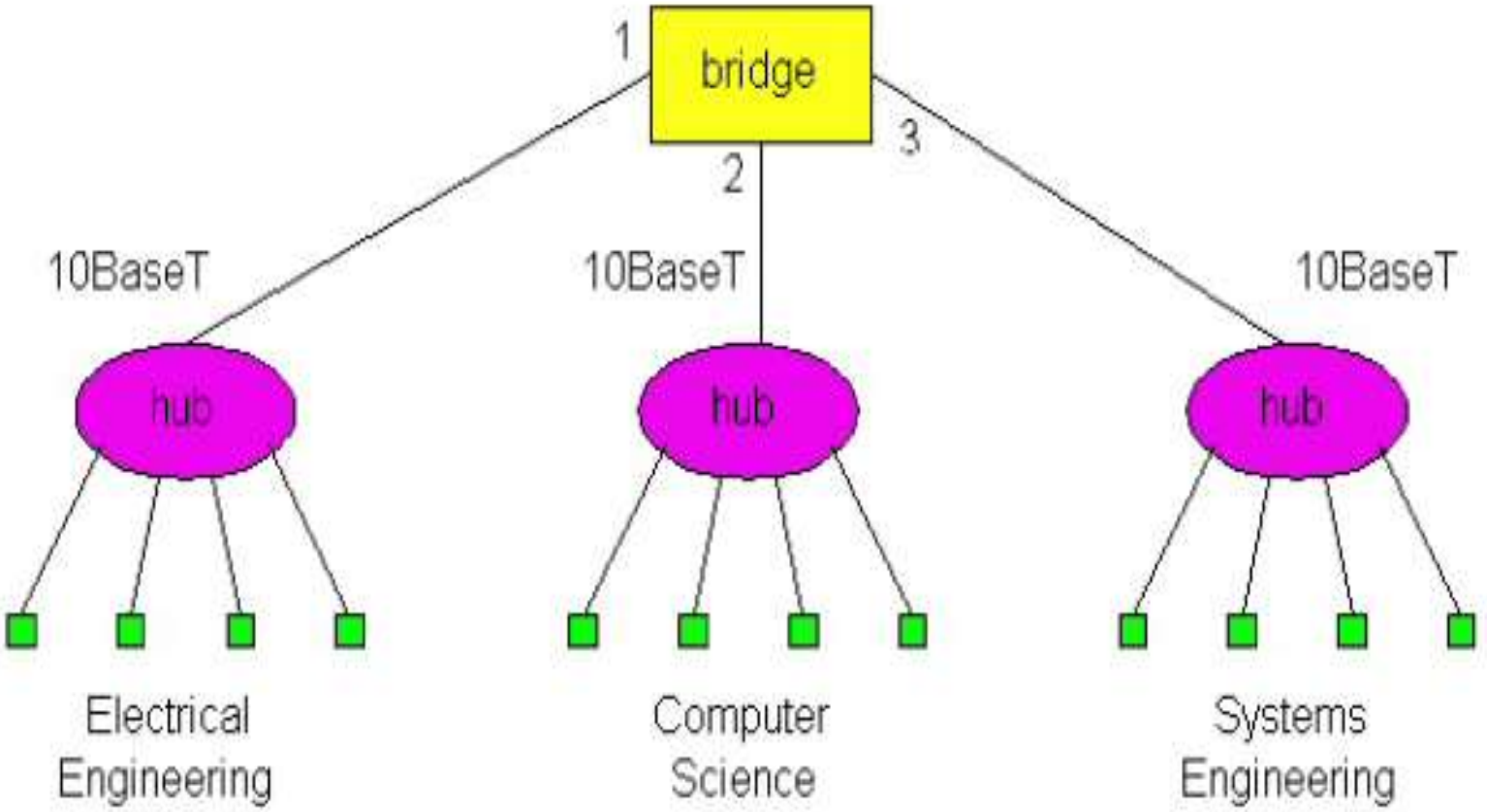
Switch

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.

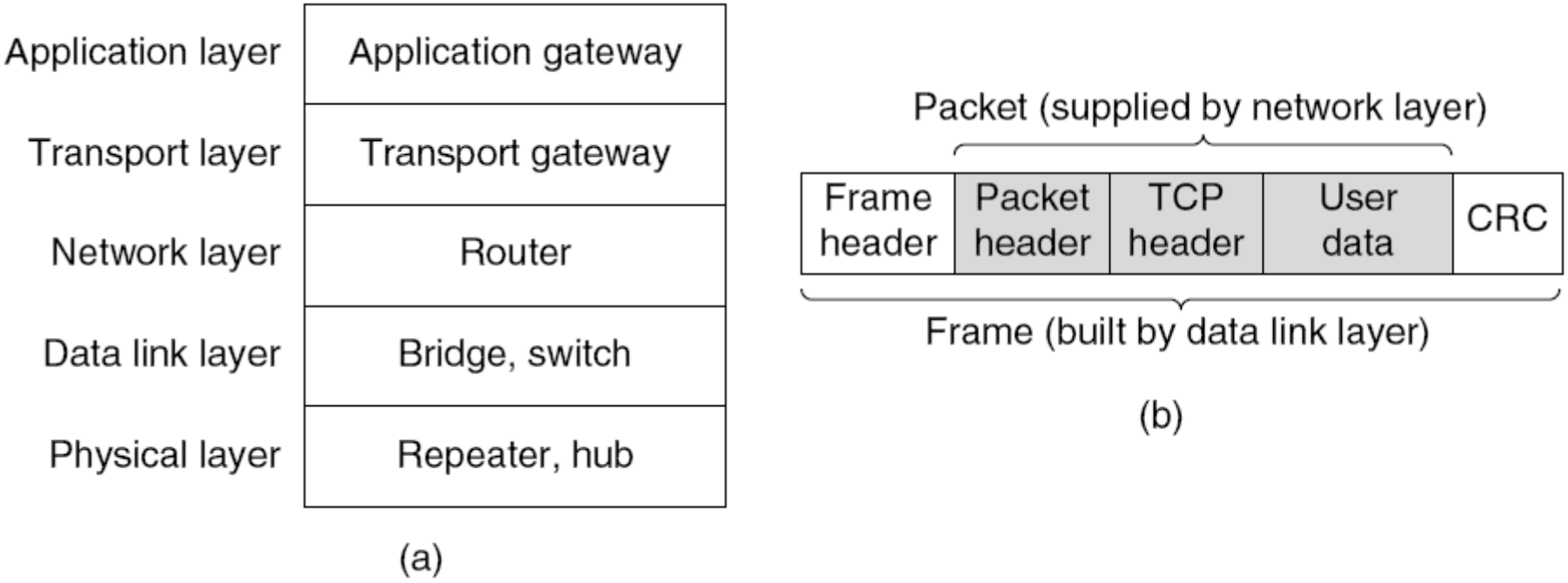
Three collision domains.

Cont…

- **Switch (network 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 that use different protocols. It is located at network perimeters. They are layer 4 and above devices (ex. SMS gateway)
- **Router**
  - Routers are responsible for routing data packets from source to destination within a LAN comprised of different networks, and for providing connectivity to a 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.
- **Routers are Layer 3, network layer devices (uses IP address also called logical address)**



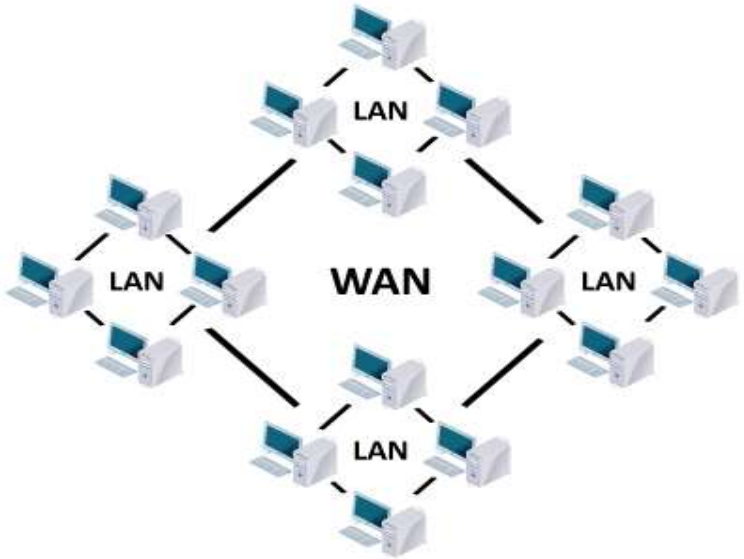
(a) Which device is in which layer.
(b) Frames, packets, and headers.

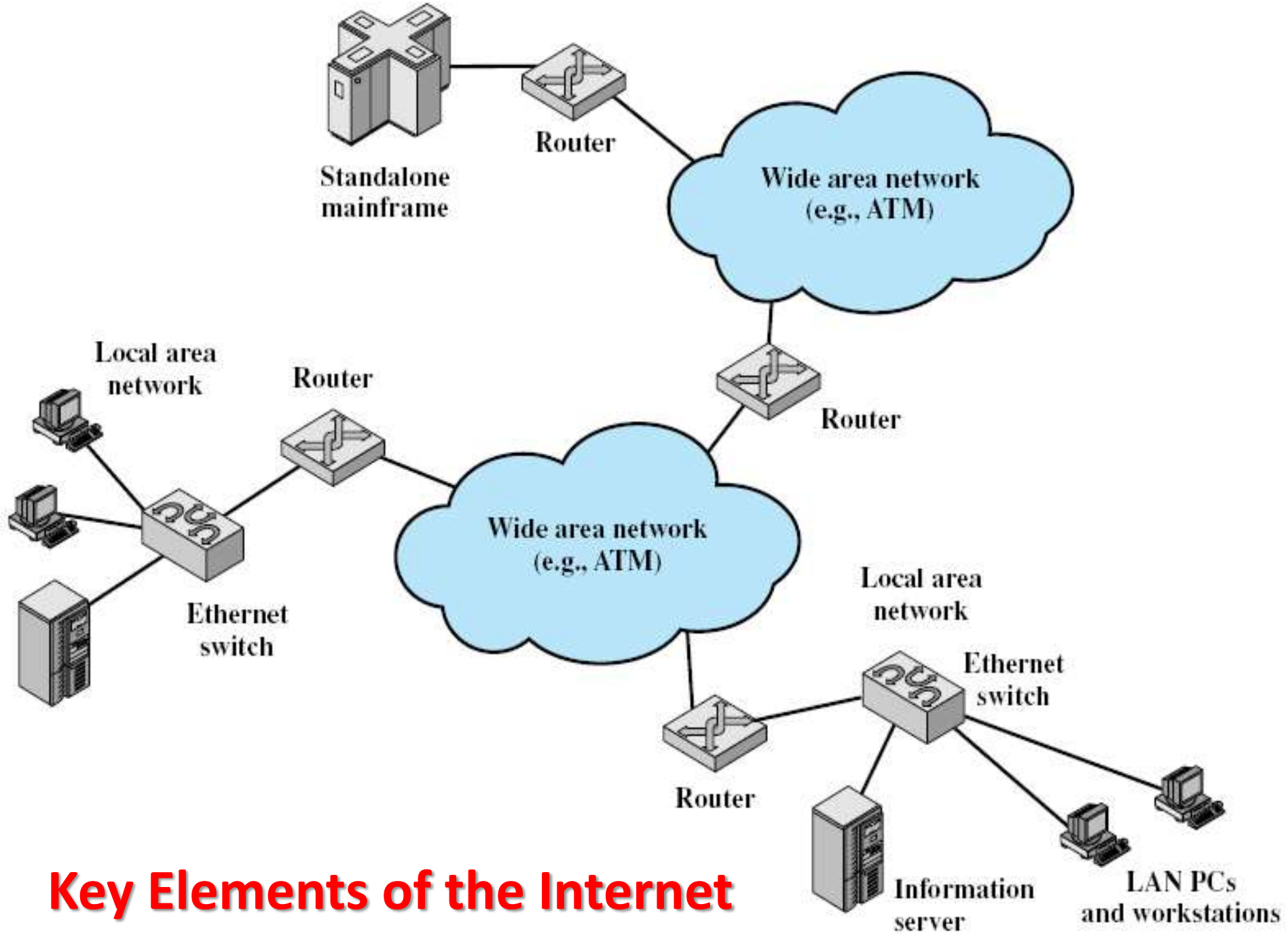
Metropolitan Area Networks (MANs)

- 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

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
  - Recursive resolution of host name to IP address

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

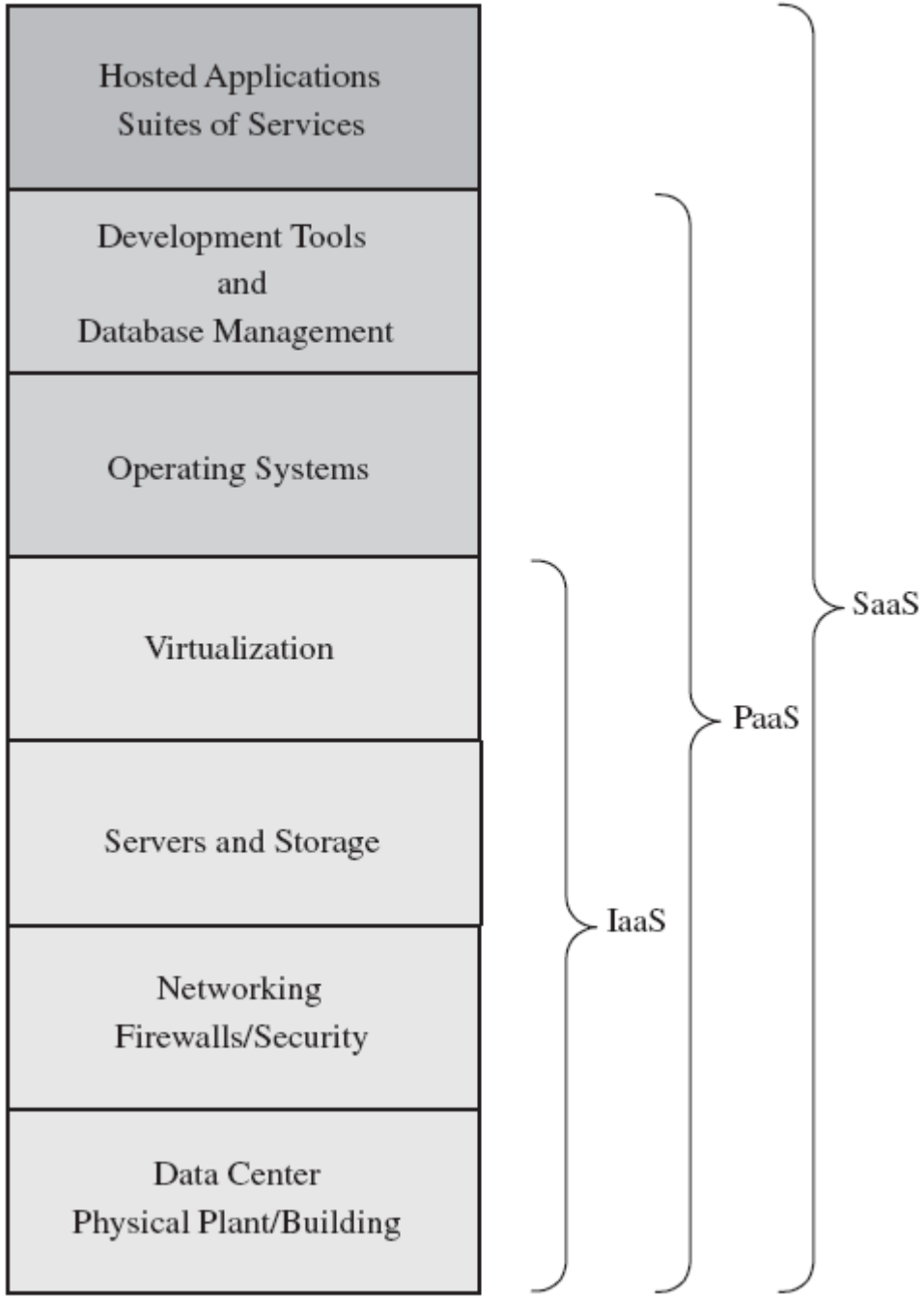
IPv4 address uses 32 bits
IPv6 address uses 128 bits

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.

Widely used examples of **SaaS** include web-based mail systems, such as Yahoo and Gmail, and office applications, such as Google Docs and Office 365.



Intranet and Extranet

- Intranet
  - Is a private network that uses 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 using part of their private 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
  - Web 2.0, Web 3.0
  - Next Generation Internet
  - Mobile Internet
  - Value Added Network
  - Semantic Web
  - Cloud Computing