**Data communication**

1. **Introduction**

**Communication** is a process of transferring information from one entity (sender) to another (receiver).

**Communication system** is Information (message) is conveyed from its source (sender) to a destination (receiver) some distance away through a communication channel.

**Data communication** is the exchange of electronic data between two devices over some form of a communication medium.

**Data transmission** is the exchange of data between transmitter and receiver over some transmission medium in the form of electromagnetic waves

Properties of Signals

**Amplitude (A)** is the measurement of the energy carried by any wave.

**Frequency (f)** is the number of occurrences of a repeating event per unit time.

**Period (T)** is the time required to complete one cycle in a repeating event.

**Phase (Φ)** a measure of a relative position in time within a single period of a wave.

– ie: Phase is a fraction of a wave cycle which has elapsed relative to an arbitrary point.

**Wavelength (λ)** Distance between two points of corresponding phase in two consecutive cycles.

1. **Data transmission**

Direct link

* A transmission path between 2 devices
* Signals propagate directly from transmitter to receiver

Point to point

* Direct link, only 2 devices
* Amplifier or repeater

Multi point

* More than 2 devices

Simplex

* Signals are transmitted in only one direction.
* One station is the transmitter and the other is the receiver.

Half duplex

* Both stations may transmit, but only one at a time.

Full duplex (duplex)

* Both stations may transmit simultaneously.

Digital -> analog => modem

Analog -> digital => codec (coder-decoder)

Advantages digital transmission

* Technology advantages
  + Digital technology has caused a continuing drop in the cost and size of digital circuitry.
  + – Analog equipment has not shown a similar drop.
* Data integrity:
  + To achieve longer distances, analog systems use amplifiers to boost the energy in the signal.
  + Digital systems use repeaters.
* Capacity utilization:
  + It is economical to build transmission links of very high bandwidth.
  + High degree of multiplexing is needed and it is easier with digital techniques.
  + Encryption techniques can be easily applied to digital data.
* Integration:
  + Analog (voice, video) and digital data can be integrated into a single form (digital) and can be treated similarly.

Transmission media suffer from three major impairments

* Attenuation
* Delay distortion
* Noise

To minimize the transmission impairments

* Strength of the signal must be improved.
* Equalizing techniques must be introduced to reduce the speed gaps between signal components

To utilize signal bandwidth efficiently

* It is undesirable to have a wide range of frequencies in the signal.
* It is desirable to allow the simultaneous transmission of two or more signals by translating them to different frequencies.

Modulation Techniques

* Career signal
  + A continuous, constant-frequency signal
  + The carrier signal can be a direct current (DC), an alternating current (AC), or a pulse chain.
  + To transmit data, the carrier signal must be modulated
* Modulation
  + The process of varying certain characteristics of a carrier signal in accordance with an information signal
* Demodulation
  + The process by which the original signal is recovered from the signal produced by modulation.
* Modulating and modulated signals
  + The input signal (analog or digital) is called the modulating signal, or baseband signal.
  + The result of modulating the carrier signal is called the modulated signal.

**Analog modulation**

* Carrier signal can be described by the equation
* Where: • A = Peak amplitude of the carrier. • ω = Angular frequency of the carrier in radians per second. • t = Time. • Φ = Initial phase of the carrier at time t = 0. – And also, • ω = 2πf , where f is the frequency of the carrier signal
* – According to the equation, the following properties of the carrier signal can be changed: • Amplitude (A). • Frequency (f). • Phase (Φ).
* All modulation techniques involve operation on one or more of the above three parameters of the carrier signal.

Amplitude Modulation (AM)

* The amplitude of the carrier signal is varied in accordance with the modulating signal
* The frequency of the carrier signal remains constant
* Commonly used in radio broadcasting.

Frequency Modulation (FM)

* The frequency of the carrier signal is varied in accordance with the modulating signal
* The amplitude of the carrier signal remains constant
* Widely used in radio and TV broadcasting.

Phase Modulation (PM):

* The phase of the carrier signal is varied in accordance with the modulating signal.
* Commonly used to convey digital signals.
* All high performance modems use phase modulation.

**Digital Modulation**

* Digital modulation or encoding techniques transform digital data into analog signals.
* There are three basic digital techniques similar to the analog modulation:
* In all these case, the resulting signal occupies a bandwidth centered on the carrier frequency.

Amplitude-shift keying (ASK):

* The two binary values (0 and 1) are represented by two different amplitudes of the carrier frequency
* Commonly, one of the amplitudes is zero
* ASK is used to transmit digital data over optical fiber

Frequency-shift keying (FSK):

* The two binary values are represented by two different frequencies near the carrier frequency.
* Less error risk with compared to ASK.
* Used: • On voice-grade lines. • For high-frequency radio transmission. • On local area networks that use coaxial cable at higher frequencies.

Phase-shift keying (PSK)

* In PSK, the phase of the carrier signal is shifted to represent data.
* The carrier wave is systematically shifted 0 or 180 degrees at uniformly spaced intervals.
* A better scheme is to use shifts of 45, 135, 225, or 315 degrees rather than 0 or 180 degrees.
* Allows to transmit 2 bits of information per time interval.
* This known as quadrature phase-shift keying (QPSK).

**Transmission media**

1. **Guided media**

**Guided media**

Solid medium

The medium is more impotent

Limitations of transmission

* Medium capacity (in terms data rate or bandwidth).
* Distance (in terms of attenuation or repeater space).
* Number of receivers (point-to-point or multipoint).

Commonly used guided media are

* Twisted pair.
* Coaxial cable.
* Optical fiber.

**Twisted pair**

* Shielded twisted-pair (STP).
* Shielded with a metallic cover.
* Includes metal shielding over twisted pair bundle.
* Shielding protects cable from external EMI.
* Provides better performance at lower data rates.
* More expensive and difficult to work with and hard to install.
* Unshielded twisted-pair (UTP).
* Covered by plastic encasement only.
* The most common type of twisted-pair wiring.
* Less expensive and east to work with and simple to install.
* As not shielded, more sensitive to EMI.

Categories of UTP cables

* + The number of twists in the cable per unit distance.
  + Attenuation over distance.
  + Data transfer rate and bandwidth.
  + Diameter of the wires.
  + Material used in the wires etc.

**Coaxial cable.**

* Consists of two conductors
* The inner conductor is placed in a solid dielectric material.
* The outer conductor is covered with a shield.
* Operate over a wider range of frequencies.
* Much less susceptible to interference and crosstalk than is twisted pair.
  + Because of its shielded, concentric construction.
* Can be used over longer distances and supports more stations on a shared line than twisted pair.
  + Eg: Support up to 10,000 voice calls simultaneously.
* Widely used in video and communication networks.

**Optical fiber**

* A thin, flexible medium capable of conducting an optical ray.
* Consists of three concentric sections:
  + The core:
    - – The innermost section and consists of one or more very thin strands, or fibers, made of glass or plastic.
  + The cladding:
    - – A glass or plastic coating around the core and has optical properties different from those of the core.
  + The jacket:
    - – The outermost layer, surrounding one or a bundle of cladded (covered) fibers.
* Optical fibers transmit signals in the form of light.
* Three modes of transmission in optical fiber.
  + Step-index multimode
    - Multiple reflection angles (modes).
    - Multiple propagation paths exist:
      * Each with a different length and propagation time.
    - This causes signal elements to spread out in time:
      * Increase time between pulses.
      * Limits the data rate.
    - Suitable for short distances.
  + Single mode:
    - Better for long distance transmission.
  + Graded-index multimode:
    - Intermediate between the previous two modes
* Two different types of light source
  + LED (light emitting diode)
  + LD(Injection laser diode)
* Applications of optical fiber
  + Long-haul trunks
  + Metropolitan trunks
  + Rural exchange trunks
  + Subscriber loop
  + LANs
* Advantages of optical fiber
  + Greater capacity
  + Smaller size and weight.
  + Lower attenuation.
  + Electromagnetic isolation
  + Greater security
  + Greater repeater spacing

1. **Wireless media**

**Unguided media**

* Wireless transmission
* Bandwidth of the signal is more impotent
* Antenna
  + An electrical conductor that is used to radiate electromagnetic energy or, Collect electromagnetic energy.
  + For transmission electrical energy from the transmitter is converted to electromagnetic energy. Radiated into surrounding environment.
  + For reception: • Electromagnetic signal (energy) impinge on antenna is converted to electrical energy.
    - Parabolic Reflective Antenna:
      * Widely use
      * Directional
        + Transmitting antenna radiates focused electromagnetic beams in one or more directions.
        + Reduces interferences from unwanted sources.
      * Omnidirectional
        + Transmitted signal spreads out in all directions.
        + Signals can be received by many antennas.
* Three general ranges of frequencies
  + Microwave Transmission(20Hz-40GHz)
    - Terrestrial microwave transmission
      * Use directional antenna
      * **Application -** Long-haul telecommunications(voice and television transmission) , Short point-to-point links between buildings(CCTV, data link between LAN, to bypass public telecommunication system within a city )
      * **Advantages –** Cheap, Higher data rate, Useful in the situations when direct cabling is impossible
      * **Disadvantages -** Attenuation increases with rainfall, Interference increases with overlapped frequencies, Weather and frequency dependent, Interrupted by buildings
    - Satellite microwave transmission
      * placed in an orbit
      * communication satellite
        + **Application -** TV distribution, Long-distance telephone transmission, Private business networks, Global positioning system (GPS)
        + **Advantages -** Coverage over a large geographical area, High bandwidth.
        + **Disadvantages -** Launching satellites into orbit is costly, large propagation delay.
  + broadcast radio range (30MHz to 1GHz)
    - Widely used for communication, both indoors and outdoors
    - **Applications –** Radio, Broadcast radio, Number of data-networking applications
    - **Advantage** - No line of sight required, less sensitive to attenuation from rainfall, Easy to generate, can travel long distances, can penetrate buildings easily, less expensive
    - **Disadvantages -** interference with communication devices using similar frequencies, multipath interference
  + infrared portion spectrum(3 x 1011 Hz to 2 x 1014 Hz)
    - Widely used for short-range communication
    - **Applications -** The remote controls used on TVs, VCRsetc, night Vision Cameras, personal Area Networks (PANs)
    - **Advantages -** Cheap, and easy to build, no licensing is required, security and interference problems are not present
    - **Disadvantages -** Transceivers must be almost directly aligned. –Do not pass through solid objects. – Weather sensitive. – Limited distance. – Low data rate.

**Computer networks**

1. **Introduction**

A network is a series of points or nodes that are interconnected of lines or channels.

A computer network is a collection of computers that are connected together to allow them to exchange information and share resources.

Use of computer networks

* Business application
  + Resources sharing
  + Communication
  + E-business
  + E-commerce
* Home application
  + Access to remote information
  + Person to person communication
  + Interactive entertainment
  + E- commerce
* Mobile application
  + Message, call, fax, email
  + Surf the web
  + Access remote files
  + Log on to remote machines
* Scientific application
  + Access to remote data
  + Access to remote supercomputers
  + Cluster computing
  + Group works
  + Access to social network

Advantages

* Resources sharing
* Flexible access
* Speed
* Cost efficiency
* Communication capability
* Workgroup computing
* Centralized administration
* Security

Disadvantages

* Initial installation cost can be high
* Hardware failure
* Security issues
* Virus issues
* Administrative issues

Network components

* Computers
* Servers – file, mail, printer, web
* Workstation – computer for individual most powerful
* Network interface card (NIC)
* Repeaters
  + As signals travels down a cable or through the air, it gradually gets weaker.
  + Repeaters amplify the week data signals before sending them on to the uplinked segment.
  + Repeaters can be used to extend the network to a longer distance or a greater area
  + Also called an Extender.
  + Wireless or wired
* Hubs
  + Used to connect various components (computers as well as other devices) in the network.
* Bridges
  + Used to connect two separate networks or to divide one network into two.
* Switches
  + Switch is functionally like a bridge but speed and performance is faster and better than a bridge.
* Modem
  + Convert computer’s digital signal to analog signals or other side.
* Routers
  + Interconnect two or more wired or wireless networks together, and selectively interchanges data between them

1. **History**

SAGE – semi automatic ground environment

ARPANET – advanced research project agency(ARPA 1969)

1. **Network classification**

**Transmission technology**

1. Broadcast network
2. Point to point network

**Connection methods**

1. Ethernet
   * Device – hubs, switches, bridge, router
2. Fiber optic network
   * Use optical fiber
3. Wireless LANs
   * Use radio, infrared

**Geographical scale or scope**

1. Local area network (LAN)
   * Limit to area such as school, lab building
   * Use to share resources, exchange information
   * Most use Ethernet (coaxial, twisted pair )
   * WLAN also possible
   * Usually have higher data transfer rate
2. Metropolitan area network (MAN)
   * Large network
   * Covers large area like city or metropolitan area
   * Connect multiple LANS using switches and routers.
   * Fiber optics links
3. Wide area network (WAN)
   * Wide area state, country even whole world
   * Connect LAN, MAN through a subnet routers
   * Dedicated transoceanic cabling or satellite uplinks may be used
   * WAN is internet
4. Personal area network
   * A network for interconnecting devices centered around an individual person's workspace
   * Connections can be wired or wireless.
5. Home area network
   * Residential LANs which are used for communication between digital devices typically deployed in a home.
   * Sharing internet access
   * Commonly wireless technology. Home wiring also can be use
6. Campus area network (CAN)
   * Interconnects local area networks (LANs) within a limited geographical area.
   * All the networking equipment and transmission media are almost entirely owned by a particular institute.
   * Networking equipment: Switches, routers etc.
   * Transmission media: Optical fiber, twisted-pair etc.
7. Enterprise private network
   * Networks build by some enterprises to interconnect various company sites in order to share computer resources.
   * These networks are operated over telecommunication networks
8. Virtual private network (VPN)
   * Use a public telecommunication infrastructure to provide remote offices or individual users with secure access to their organization's network.
   * Some of the links between nodes are carried by some larger networks instead of physical rewiring.
   * Separate the traffic of different user communities over an underlying network with strong security features.
9. Storage area network
   * High-speed special-purpose networks that interconnects different kinds of data storage devices.
   * Typically, a SAN is a part of the existing network of an enterprise.
   * Generally not accessible through the regular network
   * Accessible to servers so the devices appear as locally attached to the operating system.

**Functional relationship**

1. Peer to peer network
   * Number of computers less than 15
2. Client server network
   * A computer (or few computers) plays a centralized role and is known as a server.
   * All other computers in the network are known as clients.
   * If server fails to respond or crash then the function of the entire network will stop.

**Topology**

1. Bus topology
   * All computers, or nodes, connect to the same cable.
   * When a computer sends data, that data is broadcast to all nodes on the network
   * Only the destination computer reads the sent message; the other computers ignore it.
   * **Advantages** – relatively simple, easy to install, inexpensive, easy to operate
   * **Disadvantages** – adding a new node is difficult, If a cable break, entire network goes down
2. Start topology
   * Connect network nodes through a central device, usually a hub.
   * Each device has a dedicated point-to-point link
   * **Advantages –** adding a new node is very easy, risk of an entire network failure is low
   * **Disadvantages –** depend on 1 single point the hub, more expensive than BUS
3. Ring network
   * Do not have a central connection point.
   * A cable connects one node to another, until a "ring" is formed.
   * When a node sends a message:
     1. • The message is processed by each computer in the ring.
     2. • If a computer is not the destination node, it will pass the message to the next node, until the message arrives at its destination.
     3. • If the message is not accepted by any node on the network, it will travel around the entire ring and return to the sender
     4. Unidirectional traffic can be a disadvantage.
     5. A break in the ring (such as a disabled station) can disable the entire network.
4. Mash Network
   * Connect devices with multiple paths.
   * All devices are cross-connected
   * The most fault-resistant network type
   * Traffic can be eliminated

**Layered network architecture**

1. Introduction

Layers

* The layers are implemented in each computer on the network.
* Corresponding layers on different computers are called peers (May be processes, hardware devices, or even human beings.)
* Layers are independent of each other

Protocol

* An agreement between the communicating parties on how communication is to proceed.

1. ISO- OSI reference model

OSI – open system interconnection, deployed by international standard organization (ISO) 1984

1 physical

2 data link

3 Network

4 transport

5 session

6 presentation

7 application

1. TCT/IP reference model

Transmission Control Protocol / Internet Protocol

1 network

2 internet

3 transport

4 application

* Contains the logic needed to support the various user applications.