UNIT- 1: Introduction to Data Communication:

1.1 Introduction:

- When we communicate, we are sharing information. This sharing can be local or remote.
- Between individuals, local communication usually occurs face to face, while remote communication takes place over distance.
- The term telecommunication, which includes telephony, telegraphy, and television, means communication at a distance (tele is Greek for "far").
- The word data refers to information presented in whatever form is agreed upon by the parties creating and using the data.
- Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable.
- For data communications to occur, the communicating devices must be part of a communication system made up of a combination of hardware (physical equipment) and software (programs).
- The effectiveness of a data communications system depends on four fundamental characteristics:

1. delivery

2. accuracy

3. timeliness and

4. Jitter.

- **Delivery:**

The system must deliver data to the correct destination. Data must be received by the intended device or user and only by that device or user.

- **Accuracy:**

The system must deliver the data accurately. Data that have been altered in transmission and left uncorrected are unusable.

- **Timeliness:**

The system must deliver data in a timely manner. Data delivered late are useless. In the case of video and audio, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay. This kind of delivery is called real-time transmission.

- **Jitter:**

Jitter refers to the variation in the packet arrival time. It is the uneven delay in the delivery of audio or video packets.

For example, let us assume that video packets are sent every 3D ms.

If some of the packets arrive with 3D-ms delay and others with 4D-ms delay, an uneven quality in the video is the result.

1.2Components:

- A data communications system has five components (see Figure 1.1).

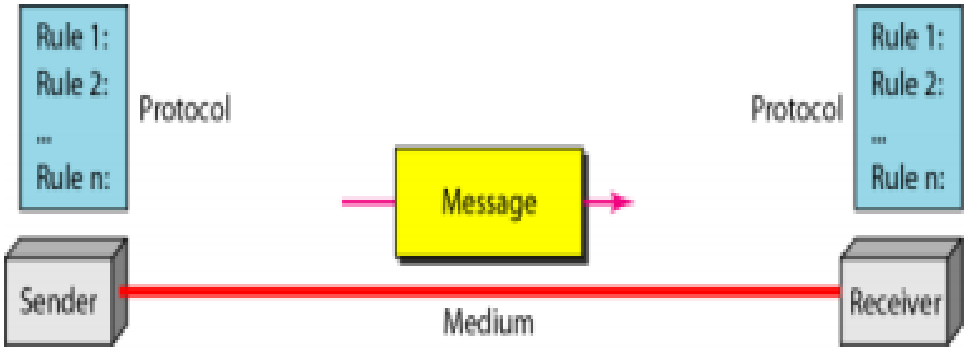


Figure 1.1 Five components of data communication

- **Message:**

The message is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.

- **Sender:**

The sender is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.

- **Receiver:**

The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.

- **Transmission medium:**

The transmission medium is the physical path by which a message travels from sender to receiver. Examples: twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves.

- **Protocol:**

A protocol is a set of rules that govern data communications. It represents an agreement between the communicating devices. Without a protocol, two devices may be connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.

1.3 Data Representation:

Information today comes in different forms such as text, numbers, images, audio, and video.

1. **Text :**

- In data communications, text is represented as a bit pattern, a sequence of bits (0s or 1s).
- Different sets of bit patterns have been designed to represent text symbols.
- Each set is called a code, and the process of representing symbols is called coding.
- 2 standards for representing letters and numbers are:

ASCII - American Standard Code for Information Interchange

- 7 bit code
- 8 th bit is unused
- 2 7 =128 codes

Unicode – Extended version of ASCII

- 16 bit code
- 2 16 = over 65 thousand codes

- Today, the prevalent coding system is called Unicode, which uses 32 bits to represent a symbol or character used in any language in the world.
- **Numbers:**

- Numbers are also represented by bit patterns.

- A code such as ASCII is not used to represent numbers; the number is directly converted to a binary number to simplify mathematical operations.

- **Images:**

- Images are also represented by bit patterns.

- In its simplest form, an image is composed of a matrix of pixels (picture elements), where each pixel is a small dot.

- The size of the pixel depends on the resolution.

- For example, an image can be divided into 1000 pixels or 10,000 pixels. In the second case, there is a better representation of the image (better resolution), but more memory is needed to store the image.

- After an image is divided into pixels, each pixel is assigned a bit pattern.

- The size and the value of the pattern depend on the image. Ø Co lour is expressed in a computer as an RGB(red-green-blue)value, which is actually a three numbers (255,255,255).

- **Audio:**

- Audio refers to the recording or broadcasting of sound or music.

- Audio is by nature different from text, numbers, or images. It is continuous, not discrete. Therefore it is necessary to convert analog signals to digital form.

- In particular, samples of the sound will have to be taken and each sample will have to be quantized to the nearest binary code in the digital representation.

- **Video:**

- Video refers to the recording or broadcasting of a picture or movie. Video can either be produced as a continuous entity (e.g., by a TV camera), or it can be a combination of images, each a discrete entity, arranged to convey the idea of motion. Again we can change video to a digital or an analog signal.

1.4 Data Flow:

- Communication between two devices can be simplex, half-duplex, or full-duplex as shown in Figure 1.2.

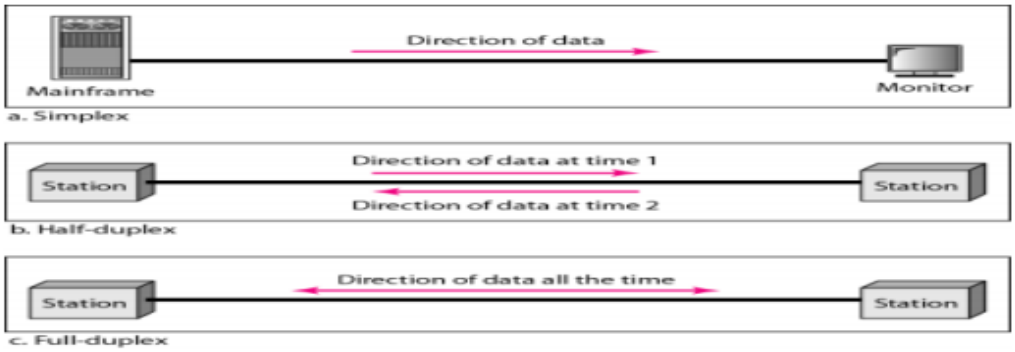


Figure 1.2 Data flow (simplex, half-duplex, andfull-duplex)

- **Simplex:**

- In simplex mode, the communication is unidirectional, as on a one-way street.

- Only one of the two devices on a link can transmit; the other can only receive (see Figure 1.2a).
- The simplex mode can use the entire capacity of the channel to send data in one direction.

- Ex: Keyboards and traditional monitors. The keyboard can only introduce input; the monitor can only accept output.

- **Half-Duplex:**

- In half-duplex mode, each station can both transmit and receive, but not at the same time. When one device is sending, the other can only receive, and vice versa (see Figure 1.2b).
- The half-duplex mode is like a one-lane road with traffic allowed in both directions. When cars are travelling in one direction, cars going the other way must wait.
- In a half-duplex transmission, the entire capacity of a channel is taken over by whichever of the two devices is transmitting at the time.
- Walkie-talkies and CB (citizens band) radios are both half-duplex systems.

- **Full-Duplex:**

- In full-duplex mode (also called duplex), both stations can transmit and receive simultaneously (see Figure 1.2c).

- The full-duplex mode is like a two-way street with traffic flowing in both directions at the same time.

- In full-duplex mode, signals going in one direction share the capacity of the link: with signals going in the other direction.
- Ex: Telephone network. When two people are communicating by a telephone line, both can talk and listen at the same time.
- The full-duplex mode is used when communication in both directions is required all the time.

1.5 Categories of Networks :

- The three primary categories of networks are:

1.Local-area networks (LAN)

2. Metropolitan Area Network (MAN)

3. Wide-area networks (WAN)

- These categories depending on various factors like size of the network, the distance it covers and the type of link used in interconnection.

1.5.1 Local Area Network (LAN) :

- A local area network (LAN) is usually privately owned and links the devices in a single office, building, or campus of up to few kilometres in size(see Figure 1.10).
- LANs are designed to allow resources to be shared between personal computers or workstations.
- The resources to be shared can include hardware (e.g., a printer), software (e.g., an application program), or data.
- A common example of a LAN, found in many business environments, links a workgroup of task-related computers, for example, engineering workstations or accounting PCs. One of the computers may be given a large capacity disk drive and may become a server to clients.

Software can be stored on this central server and used as needed by the whole group. In this example, the size of the LAN may be determined by licensing restrictions on the number of users per copy of software, or by restrictions on the number of users licensed to access the operating system.

- Usually, LANs offers a bandwidth of 10 to 100 mpbs.

- In general, LAN will use only one type of transmission medium.
- The most common LAN topologies are bus, ring, and star.

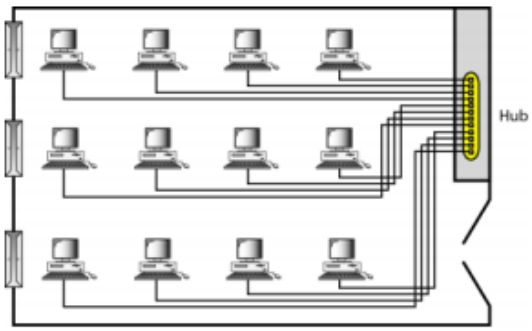


Figure 1.10 An isolated IAN connecting 12 computers to a hub in a closet

1.5.2 Metropolitan Area Networks (MAN):

- A metropolitan area network (MAN) is a network with a size between a LAN and a WAN.
- It normally covers the area inside a town or a city.
- It is designed for customers who need a high-speed connectivity, normally to the Internet, and have endpoints spread over a city or part of city.
- A good example of a MAN is the part of the telephone company network that can provide a high-speed DSL line to the customer.
- Another example is the cable TV network that originally was designed for cable TV, but today can also be used for high-speed data connection to the Internet.

1.5.3 Wide Area Network (WAN):

- A wide area network (WAN) provides long-distance transmission of data, image, audio, and video information over large geographic areas that may comprise a country, a continent, or even the whole world.
- WANs are designed to serve an area of hundreds or thousands miles.
- A WAN can be as complex as the backbones that connect the Internet or as simple as a dialup line that connects a home computer to the Internet. We normally refer to the first as a switched WAN and to the second as a point-to-point WAN (Figure 1.11).
    - The switched WAN connects the end systems, which usually comprise a router (internetworking connecting device) that connects to another LAN or WAN.

- The point-to-point WAN is normally a line leased from a telephone or cable TV provider that connects a home computer or a small LAN to an Internet service provider (lSP). This type of WAN is often used to provide Internet access.

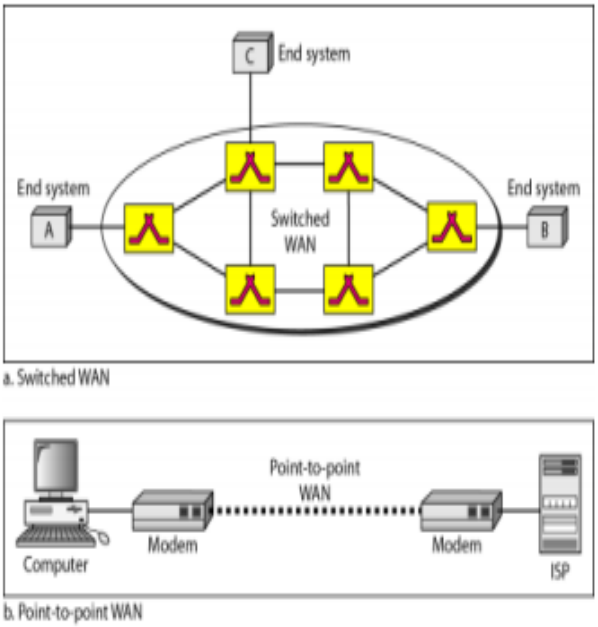


Figure 1.11 WANs: a switched WAN and a point-to-point WAN

1.6 Interconnection of Networks: Internetwork:

- When two or more networks are connected, they become an internetwork, or internet.
- It may consist of several local, metropolitan or wide area networks interconnected via a LAN, MAN or WAN oriented communication technology.
- Individual networks are joined into internet works by using internetworking devices like bridges, routers and gateways.
- Common form of internet is a collection of LANs connected by a WAN.
- There exist 3 classes of internetworks for most of particle and analytical purposes:
  - The Global public internetwork: The Internet
  - The owned /private internetworks: Intranets
  - The hybrid internetwork :Extranets

- As an example, assume that an organization has two offices, one on the east coast and the other on the west coast.

- The established office on the west coast has a bus topology LAN; the newly opened office on the east coast has a star topology LAN.
- The president of the company lives somewhere in the middle and needs to have control over the company from her Horne.
- To create a backbone WAN for connecting these three entities (two LANs and the president's computer), a switched WAN (operated by a service provider such as a telecom company) has been leased.
- To connect the LANs to this switched WAN, however, three point-to-point WANs are required.
- These point-to-point WANs can be a high-speed DSL line offered by a telephone company or a cable modern line offered by a cable TV provider as shown in Figure 1.12.

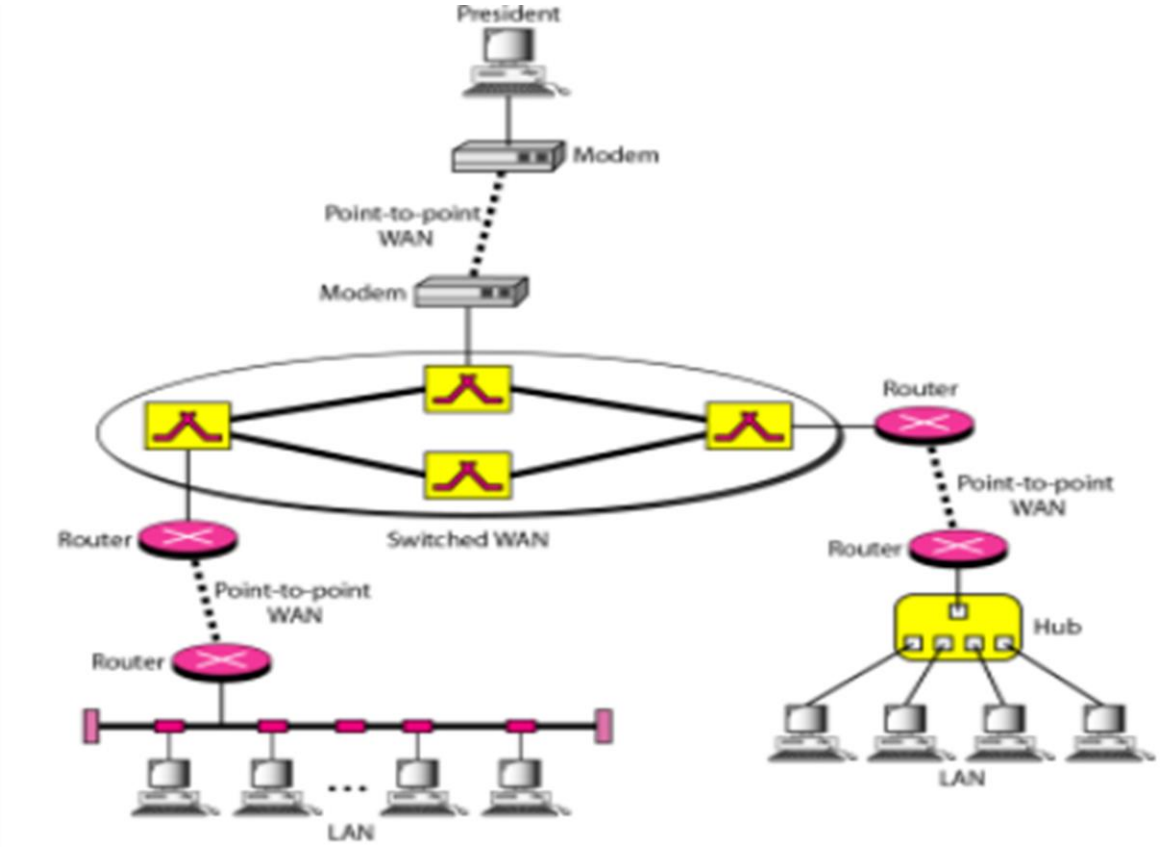


Figure 1.12 A heterogeneous network made of four WANs and two LANs

PROTOCOLS:

"A protocol is a set of rules that govern data communications."

A protocol defines what is communicated, how it is communicated, and when it is communicated.

The key elements of a protocol are

o syntax,

o semantics, and

o timing.

Syntax:

Ø The term syntax refers to the structure or format of the data, meaning the order in which they are presented.

For example, a simple protocol might expect the first 8 bits of data to be the address of the sender, the second 8 bits to be the address of the receiver, and the rest of the stream to be the message itself.

Semantics:

Ø The word semantics refers to the meaning of each section of bits.

Ø How is a particular pattern to be interpreted, and what action is to be taken based on that interpretation?

Ø For example, does an address identify the route to be taken or the final destination of the message?

Timing:

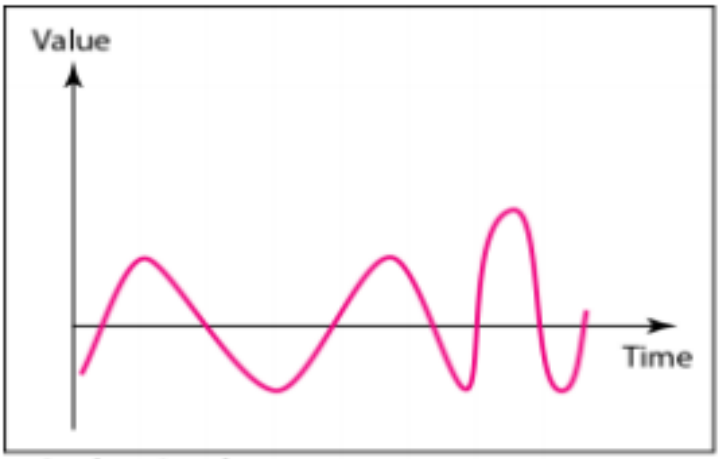
Ø The term timing refers to two characteristics: when data should be sent and how fast they can be sent.

Ø For example, if a sender produces data at 100 Mbps but the receiver can process data at only 1 Mbps, the transmission will overload the receiver and some data will be lost.

Analog and Digital Signals:

- Whenever we want to transmit data such as text, number, pictures, video etc., on a computer network, it must be transformed to **Electromagnetic Signals.**
- The electromagnetic signals may be
  - Analog signal or,
  - Digital signal.

- **Analog data:** It refers to information that is continuous.
- **Digital data:** It refers to information that has discrit values.
- **Analog Signal:** " It is a continuous waveform having an infinite number of values in a range".



a. Analog signal

- The **vertical axis** represents the **values of a signal** and the **horizontal axis** represents the **time.** The curve represents analog signal passes through an infinite number of points.
- **Digital Signal:** " It is a discrete waveform having only a limited number of values. Digital signals can be represented by 0 & 1.

b. Digital signal

- The **vertical axis** represents the **values of a signal** and the **horizontal axis** represents the **time.** The curve represents the sudden jump that the signal makes from value to value.

Periodic & non-Periodic Signals:

1. **Periodic Signals:** " Periodic signal completes a pattern within a measurable time frame".
2. **Non-Periodic Signals:** " Non-periodic signal changes without computing the pattern or cycle that repeats over time".

Sine Wave:

- The sine wave is the most fundamental form of a periodic analog signal.
- A sine wave can be represented by three parameters:
  - the peak amplitude,
  - the frequency, and
  - the phase.

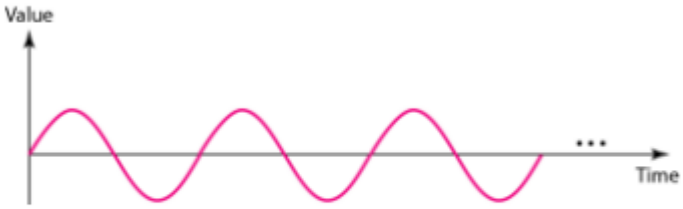
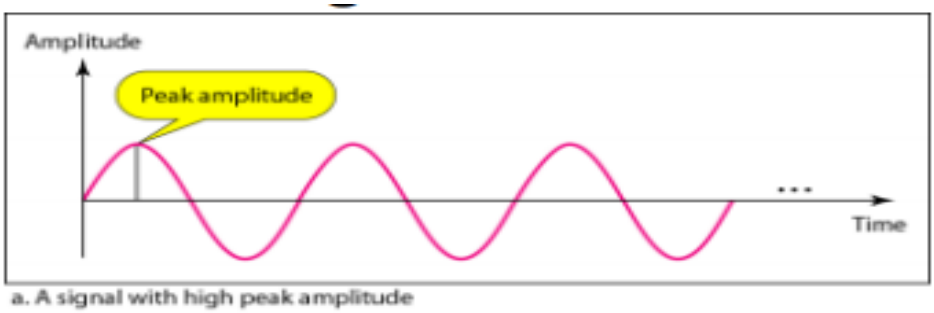


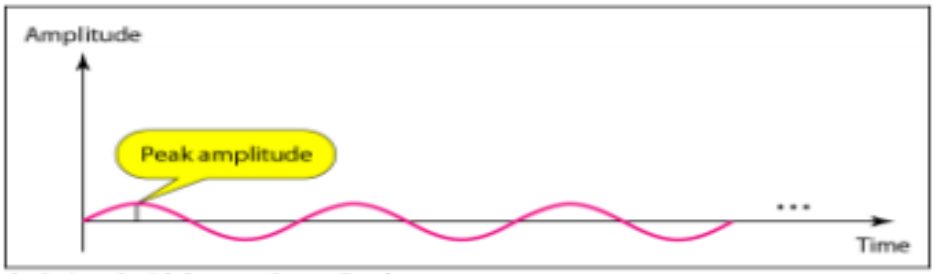
Figure 3.2 A sine wave

Peak Amplitude:

- The peak amplitude of a signal is the absolute value of its highest intensity, proportional to the energy it carries.



a. A signal with high peak amplitude



b. A signal with low peak amplitude

- **Period** refers to the amount of time, in seconds, a signal needs to complete 1 cycle. Denoted by **t.**

t=1/f

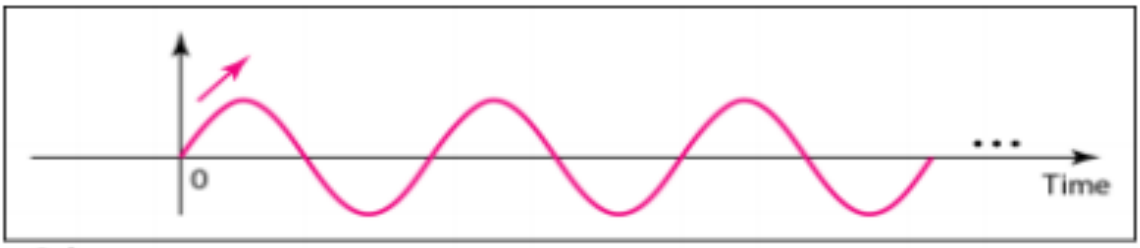
- **Frequency** refers to the number of periods in 1s. Denoted by **f.**

f=1/t

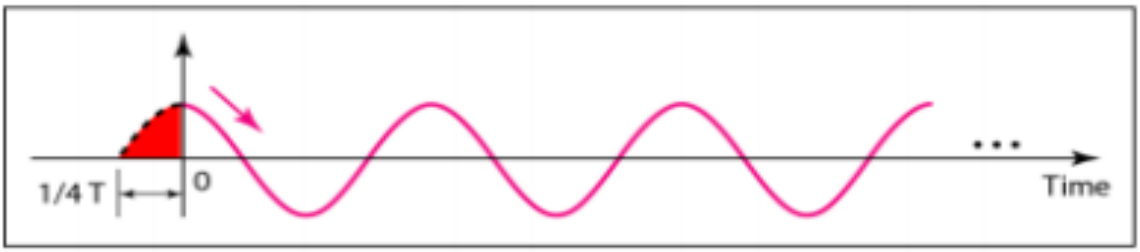
Phase:

- The term phase describes the position of the waveform relative to time 0.
- Phase is measured in degrees or radians.

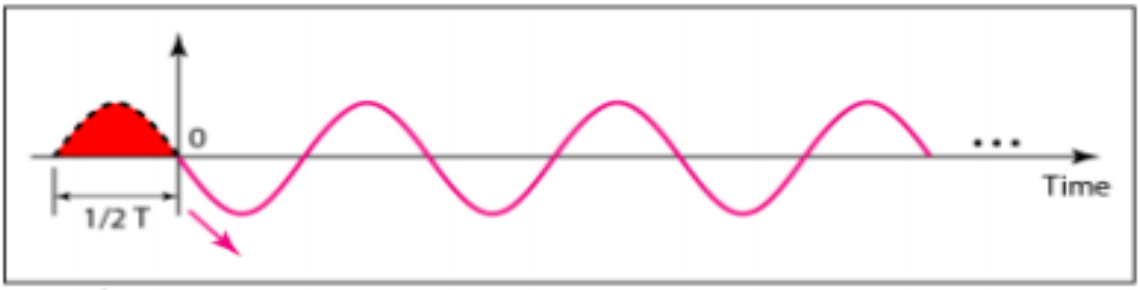
- A phase shift of **360°** corresponds to a shift of a **complete period**;
- a phase shift of **180°** corresponds to a shift of **one-half of a period**;
- and a phase shift of **90°** corresponds to a shift of **one-quarter of a period.**



a. 0 degrees

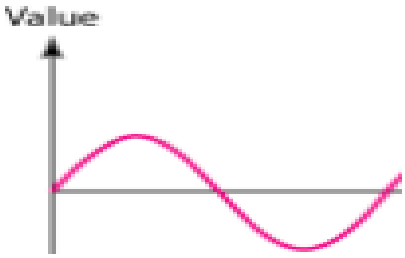


b. 90 degrees



c. 180 degrees

- **Wavelength:** " The distance between one peak value of the wave to the next peak value of the wave".



Wavelength =propagation speed x period

= propagation speed/frequency

- **Λ=c/f or Λ=c.t**

- **Bit rate:** " It is the number of bits sent in 1 second."It can be expressed in terms of bit per second.(b/s)

- **Bit Length:** " It is the distance occupied by one bit on the transmission media."

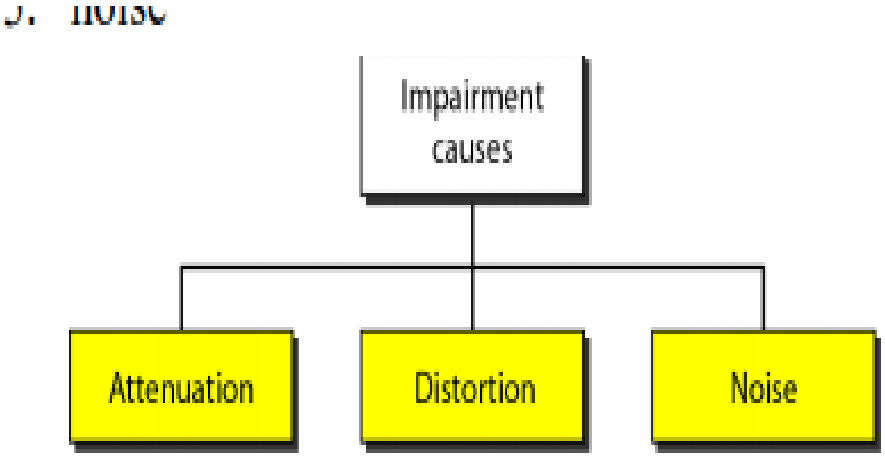
Bit length = propagation speed * bit duration.

Transmission Impairments:

"When a signal transmit from one medium to other, the signal that is received may differ from the signal that is transmitted due to various impairments**."**

Three reasons for transmission Impairment:

1. **Attenuation.**
2. **Distortion.**
3. **Noise.**



Attenuation: It means **loss of energy.** When a **signal** passes through the **medium it losses some energy.** Some of its **electrical energy** is converted into **heat,** to compensate this loss, **amplifiers are used.**

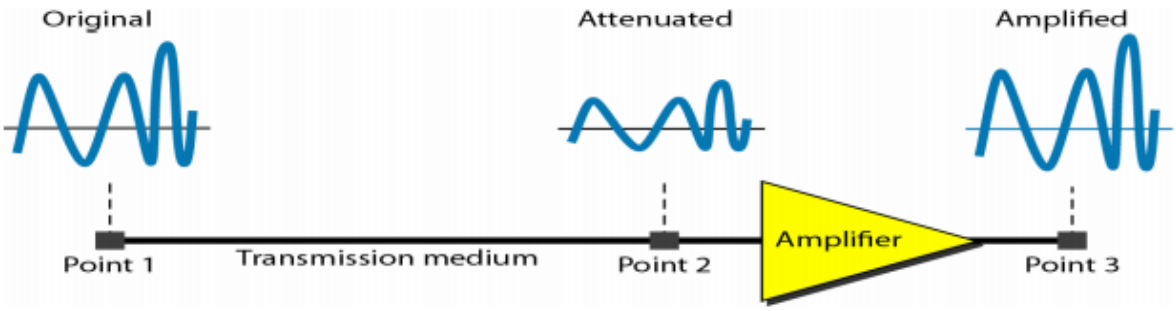


Figure 3.26 Attenuation

- To show that a signal has lost or gained strength, engineers use the unit of the **decibel.**

- The decibel (dB) measures the **relative strengths of two signals or one signal at two different points.**
- Note that the **decibel is negative if a signal is attenuated and positive if a signal is amplified.**

Distortion: " It means the **signal changes its shape or form.** It can occur in a composite signals made of different frequencies each signal has its own propagation speed**."**

- Signal components at the receiver have phases different from what they had at the sender.
- The shape of the composite signal is therefore not the same.

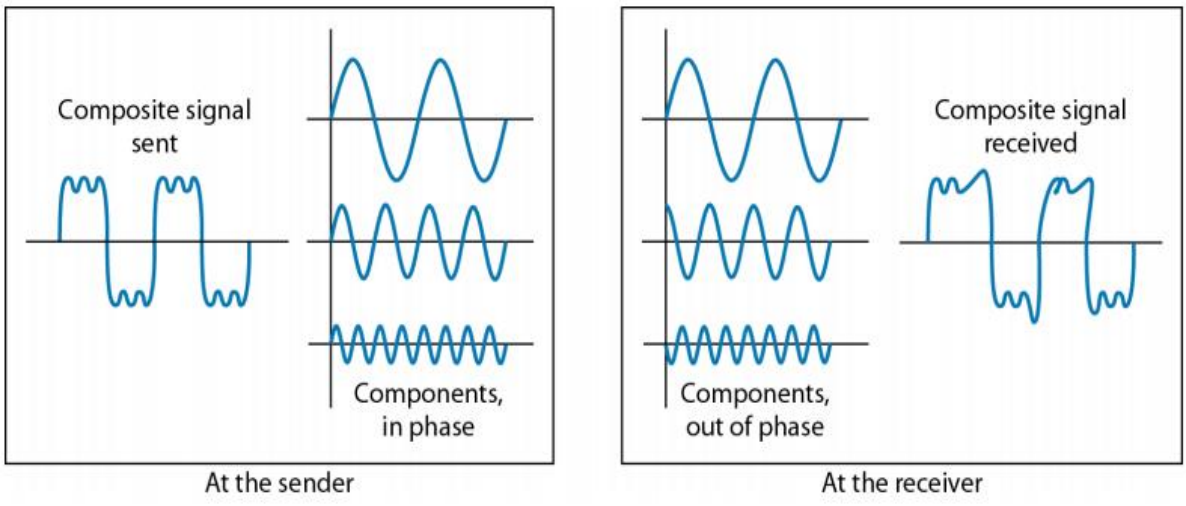


Figure 3.28Distortion

Noise:

- Noise is another cause of impairment.

Several types of noise, such as,

1. **Thermal noise,**
2. **Induced noise,**
3. **Crosstalk, and**
4. **Impulse noise.**

Thermal noise is the random motion of electrons in a wire which creates an extra signal not originally sent by the transmitter.

Induced noise comes from sources such as motors and appliances.

Crosstalk is the effect of one wire on the other.

- **Impulse noise** is a spike (a signal with high energy in a very short time) that comes from power lines, lightning, and so on.

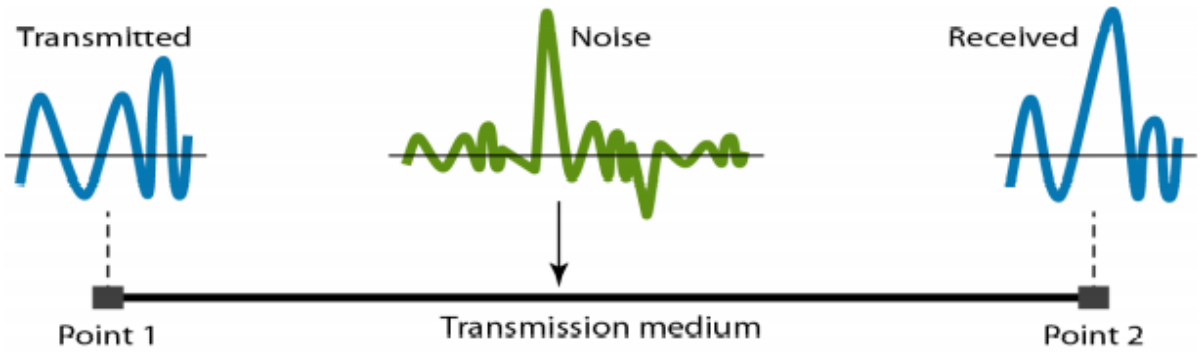


Figure 3.29 Noise

Performance:

- One important issue in networking is the performance of the network-how good is it?
- The parameter used to measures the performance are

1. Bandwidth

2. Throughput

3. Latency

4. Jitter

- **Bandwidth: "** It is a characterise of network performance, the term bandwidth can be used into two context.

i. **Bandwidth in Hz:** It refers to a range of frequencies in a composite signal.

ii. **Bandwidth in bits per sec:** It refers to the number of bits transmitted per second in a channel.

- **Through put: "** It is a measure of how fast the data can be send to receiver through a network.**"**
- **Latency: "** It defines how long it takes for an entire message to arrive the destination.**"**

Consists of 4 components:

1. Propagation time,

2. Transmission time,

3. Queuing time and

4. Processing delay.

- **Jitter: "** It is another performance issue i.e, related to delay. If different packets of data encounters different delays.**"**

TRANSMISSION MODES:

- The transmission of binary data across a link can be accomplished in either parallel or serial mode.

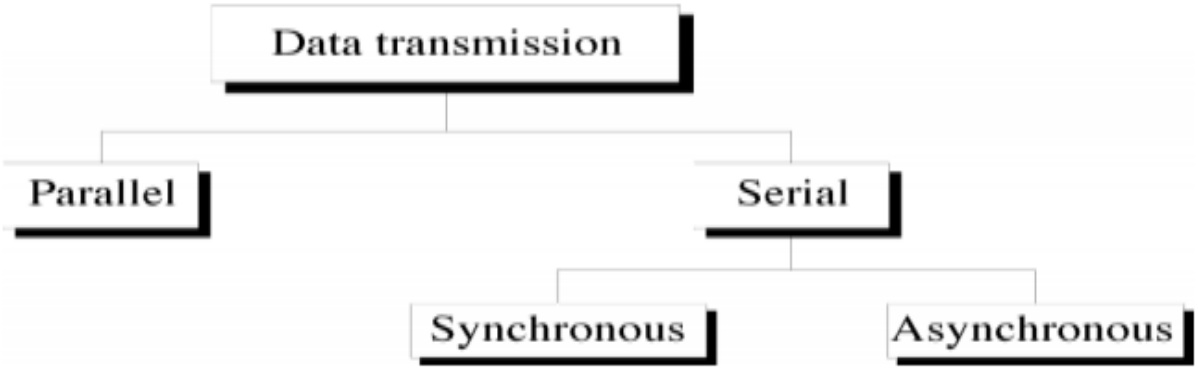
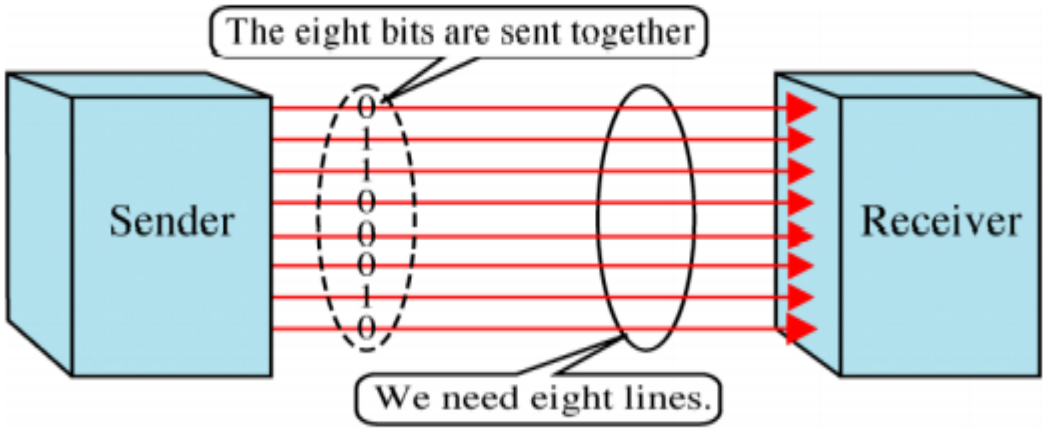


Figure 4.31 Data transmission and modes

- **Parallel Transmission:** It means transmitting several bits of data simultaneously using multiple lines.
- N-lines or wires can send n-bits of data at a time.
- Each bit has its own wire, and all n bits of one group can be transmitted from one device to another.

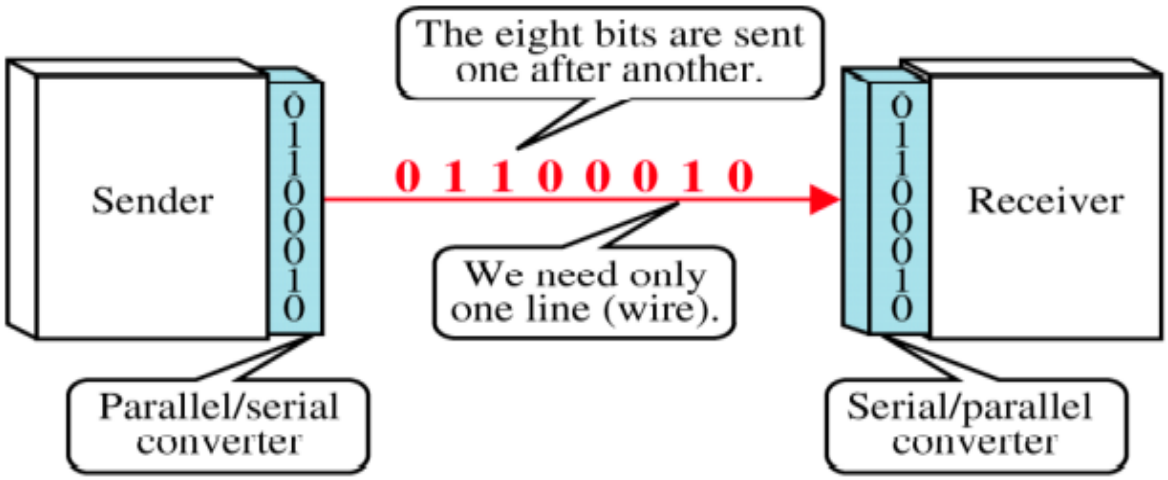


- **Advantage:**

1. Parallel transmission can increase the transfer speed by a factor n over serial transmission.

- **Disadvantage:**

1. It requires n-communication line to transmit the data. Resulting in high cost.
2. It is expensive and limited to short distance.
3. **Serial Transmission:** It sends the data bit by bit OR one bit follows the another bit.
4. It requires only one communication channel.



- **Advantage:**

1. We make use of only one communication channel for data transfer, resulting in **reduce of cost.**

- Serial transmission occurs in one of three ways:

1. asynchronous,
2. synchronous,
3. isochronous.

1. **Asynchronous Transmission:**

- Asynchronous transmission is so named because the timing of a signal is unimportant.
- Patterns are based on grouping the bit stream into bytes. Each group, usually **8 bits, is sent along the link as a unit.**
- The sending system handles each group independently, and sends it to the receiver through link whenever the information is ready, **without regard to a timer.**
- To alert the receiver to the arrival of a new group, an **extra bit** is added to the beginning of each byte. **(Start bit=0)**

- To alert the receiver to the end of a every group, an **extra bits** are added to the end of each byte. **(End bit=1 or more bits)**
- The transmission of each byte may then be followed by a gap of varying duration. This gap can be represented **either by an idle channel or by a stream of additional stop bits.**
- **Advantage:**

cheap and **effective.**

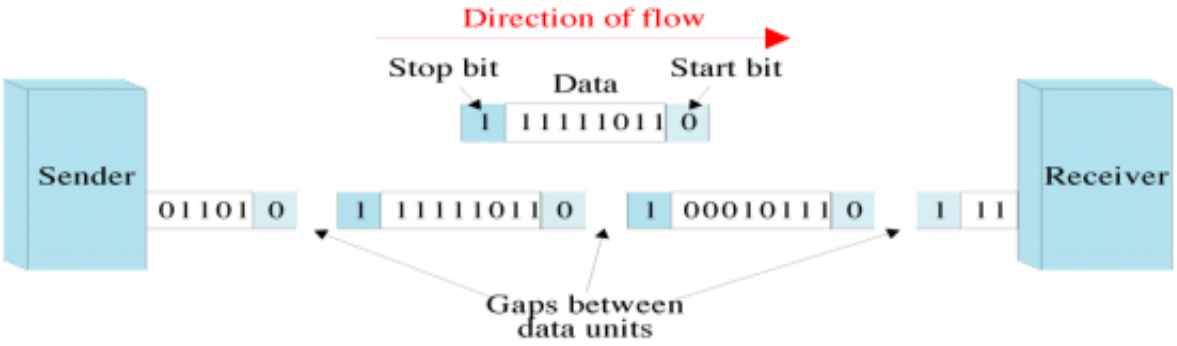


Figure 4.34 Asynchronous transmission

2. Synchronous Transmission:

- In synchronous transmission, we send bits one after another without start or stop bits or gaps. It is the responsibility of the receiver to group the bits.

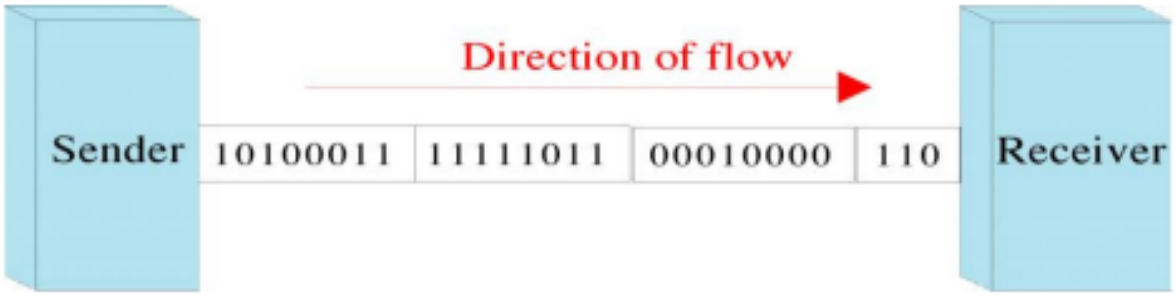


Figure 4.35 Synchronous transmission

- **Advantage:**

➢ The advantage of synchronous **transmission is speed.**

➢ It is more useful for **high-speed applications** such as the **transmission of data from one computer to another.**