UNIT 1:
Data Communication Networks

Data Communication – Definition, Components, Types, Channels

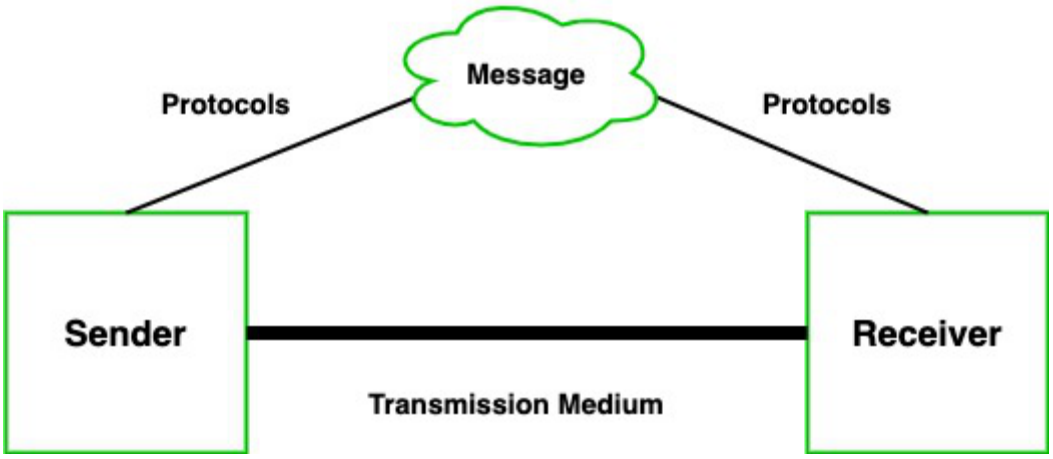
Human beings are the only creatures on the earth who are able to communicate with each other through the medium of language. But humans take this gift to another extent. Distance, time, and physical existence of the person don't matter in communication these days because they build a communication system through which they can communicate or share data like images, videos, text, files, etc with their loved ones anytime anywhere. Communication is defined as a process in which more than one computer transfers information, instructions to each other and for sharing resources. Or in other words, communication is a process or act in which we can send or receive data. A network of computers is defined as an interconnected collection of autonomous computers. Autonomous means no computer can start, stop or control another computer.

Components of Data Communication

A communication system is made up of the following components:

1. **Message:** A message is a piece of information that is to be transmitted from one person to another. It could be a text file, an audio file, a video file, etc.
2. **Sender:** It is simply a device that sends data messages. It can be a computer, mobile, telephone, laptop, video camera, or workstation, etc.
3. **Receiver:** It is a device that receives messages. It can be a computer, telephone mobile, workstation, etc.

4. **Transmission Medium / Communication Channels:** Communication channels are the medium that connect two or more workstations. Workstations can be connected by either wired media or wireless media.
5. **Set of rules (Protocol):** When someone sends the data (The sender), it should be understandable to the receiver also otherwise it is meaningless. For example, Sonali sends a message to Chetan. If Sonali writes in Hindi and Chetan cannot understand Hindi, it is a meaningless conversation.



Therefore, there are some set of rules (protocols) that is followed by every computer connected to the internet and they are:

- **TCP(Transmission Control Protocol)**: It is responsible for dividing messages into packets on the source computer and reassembling the received packet at the destination or recipient computer. It also makes sure that the packets have the information about the source of the message data, the destination of the message data, the sequence in which the message data should be re-assembled, and checks if the message has been sent correctly to the specific destination.
- **IP(Internet Protocol)**: Do You ever wonder how does computer determine which packet belongs to which device. What happens if the message you sent to your friend is received by your father? Scary Right. Well! IP is responsible for handling the address of the destination computer so that each packet is sent to its proper destination.

Type of data communication

As we know that data communication is communication in which we can send or receive data from one device to another. The data communication is divided into three types:

1. **Simplex Communication:** It is one-way communication or we can say that unidirectional communication in which one device only receives and another device

only sends data and devices uses their entire capacity in transmission. For example, IoT, entering data using a keyboard, listing music using a speaker, etc.

2. **Half Duplex communication:** It is a two-way communication or we can say that it is a bidirectional communication in which both the devices can send and receive data but not at the same time. When one device is sending data then another device is only receiving and vice-versa. For example, walkie-talkie.
3. **Full-duplex communication:** It is a two-way communication or we can say that it is a bidirectional communication in which both the devices can send and receive data at the same time. For example, mobile phones, landlines, etc.

Communication Channels

Communication channels are the medium that connects two or more workstations. Workstations can be connected by either wired media or wireless media. It is also known as a transmission medium. The transmission medium or channel is a link that carries messages between two or more devices. We can group the communication media into two categories:

- Guided media transmission
- Unguided media transmission

1. Guided Media: In this transmission medium, the physical link is created using wires or cables between two or more computers or devices, and then the data is transmitted using these cables in terms of signals. Guided media transmission of the following types:

1. Twisted pair cable: It is the most common form of wire used in communication. In a twisted-pair cable, two identical wires are wrapped together in a double helix. The twisting of the wire reduces the crosstalk. It is known as the leaking of a signal from one wire to another due to which signal can corrupt and can cause network errors. The twisting protects the wire from internal crosstalk as well as external forms of signal interference. Types of Twisted Pair Cable :

- **Unshielded Twisted Pair (UTP):** It is used in computers and telephones widely. As the name suggests, there is no external shielding so it does not protects from external interference. It is cheaper than STP.
- **Shielded Twisted Pair (STP):** It offers greater protection from crosstalk due to shield. Due to shielding, it protects from external interference. It is heavier and costlier as compare to UTP.

2. Coaxial Cable: It consists of a solid wire core that is surrounded by one or more foil or wire shields. The inner core of the coaxial cable carries the signal and the outer shield provides the ground. It is widely used for television signals and also used by large corporations in building security systems. Data transmission of this cable is better but expensive as compared to twisted pair.

3. Optical fibers: Optical fiber is an important technology. It transmits large amounts of data at very high speeds due to which it is widely used in internet cables. It carries data as a light that travels inside a thin glass fiber. The fiber optic cable is made up of three pieces:

1. **Core:** Core is the piece through which light travels. It is generally created using glass or plastic.
2. **Cladding:** It is the covering of the core and reflects the light back to the core.
3. **Sheath:** It is the protective covering that protects fiber cable from the environment.

2. Unguided Media: The unguided transmission media is a transmission mode in which the signals are propagated from one device to another device wirelessly. Signals can wave through the air, water, or vacuum. It is generally used to transmit signals in all directions. Unguided Media is further divided into various parts :

1. Microwave: Microwave offers communication without the use of cables. Microwave signals are just like radio and television signals. It is used in long-distance communication. Microwave transmission consists of a transmitter, receiver, and atmosphere. In microwave communication, there are parabolic antennas that are mounted on the towers to send a beam to another antenna. The higher the tower, the greater the range.

2. Radio wave: When communication is carried out by radio frequencies, then it is termed radio waves transmission. It offers mobility. It is consists of the transmitter and the receiver. Both use antennas to radiate and capture the radio signal.

3. Infrared: It is short-distance communication and can pass through any object. It is generally used in TV remotes, wireless mouse,etc.

Difference between the Analog signals and Digital signals

Analog signals	Digital signals
Analog signals are difficult to get analysed at first.	Digital signals are easy to analyse.
Analog signals are more accurate than digital signals.	Digital signals are less accurate.
Analog signals take time to be stored. It has infinite memory.	Digital signals can be easily stored.

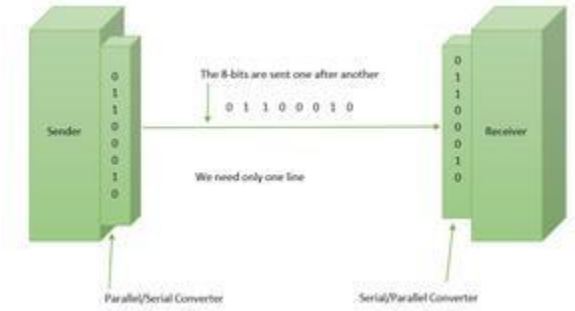
To record an analog signal, the technique used, preserves the original signals.	In recording digital signal, the sample signals are taken and preserved.
There is a continuous representation of signals in analog signals.	There is a discontinuous representation of signals in digital signals.
Analog signals produce too much noise.	Digital signals do not produce noise.
Examples of analog signals are Human voice, Thermometer, Analog phones etc.	Examples of digital signals are Computers, Digital Phones, Digital pens, etc.

Difference between Serial and Parallel Transmission

There are two methods used for transferring data between computers which are given below: Serial Transmission and Parallel Transmission.

Serial Transmission:

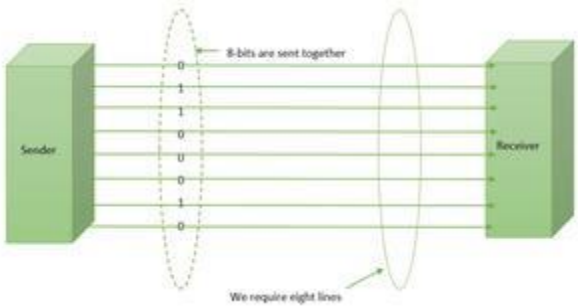
In Serial Transmission, data-bit flows from one computer to another computer in bi-direction. In this transmission, one bit flows at one clock pulse. In Serial Transmission, 8 bits are transferred at a time having a start and stop bit.



Serial Transmission

Parallel Transmission:

In Parallel Transmission, many bits are flow together simultaneously from one computer to another computer. Parallel Transmission is faster than serial transmission to transmit the bits. Parallel transmission is used for short distance.



Parallel Transmission

Difference between Serial and Parallel Transmission:

S.NO	Serial Transmission	Parallel Transmission
1.	In this type, a single communication link is used to transfer data from one end to another	In this type, multiple parallels links used to transmit the data
2.	In serial transmission, data(bit) flows in bi-direction.	In Parallel Transmission, data flows in multiple lines.
3.	Serial Transmission is cost-efficient.	Parallel Transmission is not cost-efficient.
4.	In serial transmission, one bit transferred at one clock pulse.	In Parallel Transmission, eight bits transferred at one clock pulse.
5.	Serial Transmission is slow in comparison of Parallel Transmission.	Parallel Transmission is fast in comparison of Serial Transmission.
6.	Generally, Serial Transmission is used for long-distance.	Generally, Parallel Transmission is used for short distance.
7.	The circuit used in Serial Transmission is simple.	The circuit used in Parallel Transmission is relatively complex.

S.NO	Serial Transmission	Parallel Transmission
8.	Serial Transmission is full duplex as sender can send as well as receive the data	Parallel Transmission is half-duplex since the data is either send or receive
9.	Converters are required in a serial transmission to convert the data between internal and parallel form	No converters are required in Parallel Transmission
10.	Serial transmission is reliable and straightforward.	Parallel transmission is unreliable and complicated.

Difference between Synchronous and Asynchronous Transmission

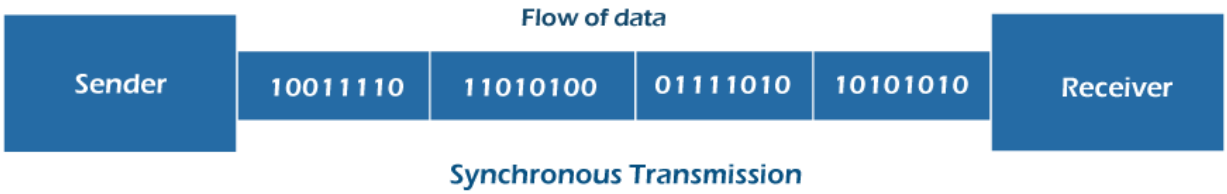
Before starting the topic difference between ***synchronous*** and ***asynchronous transmission***, you must know about the transmission. The action of transferring data or anything from one place to other is referred to as transmission. It is a method of sharing data between two devices linked by a network, also known as communication mode. Synchronous and asynchronous transmissions are the two main types of transmission used in computer networking.

In both synchronous and asynchronous transmission, data is sent between the transmitter and the receiver based on a clock pulse utilized for synchronization. These serial data transmission techniques are both known as synchronous transmission.

In this article, you will learn about the difference between ***Synchronous*** and ***Asynchronous transmission***. But before discussing the differences, you must know about Synchronous and Asynchronous transmission with their advantages and disadvantages.

What is Synchronous Transmission?

Synchronous transmission is an effective and dependable method of sending huge amounts of data. The data travels in a full-duplex method in the type of frames or blocks in Synchronous Transmission. The transmitter and receiver must be synced so that the sender knows where to start the new byte. As a result, every data block is marked with synchronization characters, and the receiving device obtains the data until a certain ending character is found.



Synchronous Transmission

It also allows connected devices to interact in real time. Synchronous transmission can be seen in chat rooms, video conferencing, telephonic talks, and face-to-face interactions. It utilizes the broad-band and voice band channels because they enable quicker speeds of up to ***1200 bps*** and meet the objective of high data transfer speed.

Advantages and Disadvantages of Synchronous Transmission

There are various advantages and disadvantages of synchronous transmission. Some advantages and disadvantages of synchronous transmission are as follows:

Advantages

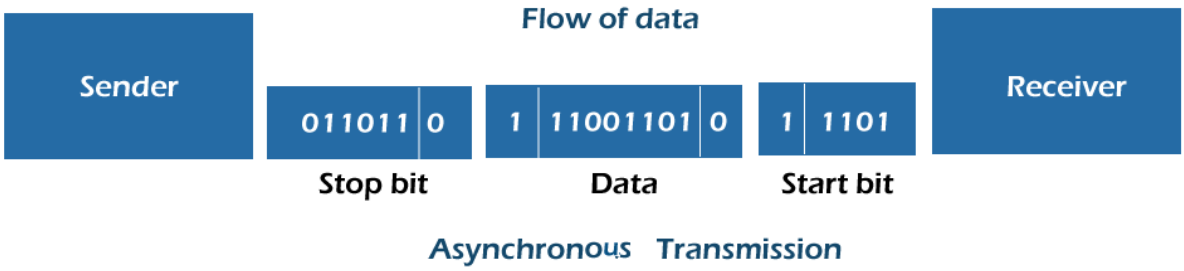
1. It aids the user in transferring a huge amount of data.
2. Every byte is sent without a pause before the next.
3. It also helps to reduce timing errors.
4. It allows connected devices to communicate in real-time.

Disadvantages

1. The sender and receiver must operate at the same clock frequency simultaneously.
2. The accuracy of the received data is determined by the receiver's capacity to count the received bits precisely.

What is Asynchronous Transmission?

Asynchronous transmission is also referred to as start and stop transmission. It sends data from the transmitter to the receiver using the flow control approach and synchronizes data between the source and destination without utilizing a clock.



This transmission technique sends ***8 bits*** or one letter at a time. In this system, each character transmits the start bit before the transmission process begins, and it also transmits the stop bit when the character is sent. The total number of bits is ***10***, including the character, start, and stop bits.

It employs character-based synchronization for the receiving terminal to synchronize with receiving data on a character. It is easy, quick, and inexpensive and doesn't need two-way communication. Asynchronous transmission is demonstrated via letters, televisions, emails, forums, and radios.

Asynchronous transmission makes use of voice-band channels that are narrow and operate at a slower speed. In this case, the transmitting device operates manually or intermittently.

Advantages and Disadvantages of Asynchronous Transmission

There are various advantages and disadvantages of Asynchronous transmission. Some advantages and disadvantages of Asynchronous transmission are as follows:

Advantages

1. It doesn't require synchronizing the receiver and transmitter.
2. It is a very flexible technique of data transmission.
3. This kind of transmission is simple to implement.

4. It allows users to send signals from sources with varying bit rates.
5. When the data byte transmission is complete, the data transmission may be resumed.

Disadvantages

1. The timing errors may occur because synchronization is difficult to determine.
2. These bits could be mistakenly recognized due to the noise on the channel.
3. The start and stop bits are extra bits that must be utilized in asynchronous transmission.
4. It transmits information at a slower rate.

Key differences between Synchronous and Asynchronous Transmission

Here, you will learn about the key differences between ***Synchronous*** and ***Asynchronous Transmission***. Some of the main differences between Synchronous and Asynchronous Transmission are as follows:

1. A synchronous transmission is a form of transmission that enables synchronized communication by sharing a common clock pulse between the sender and the receiver. In contrast, an asynchronous transmission is a form of transmission in which the transmitter and receiver have their internal clocks and hence don't require an external common clock pulse.
2. Data is transmitted as frames in synchronous transmission. In contrast, asynchronous transmission transmits data one byte at a time.
3. In synchronous transmission, the amount of time between two successive broadcasts remains constant. In contrast, the time gap between two successive transmissions is random in asynchronous transmission.
4. The data transfer rate of synchronous transmission is fast. In contrast, the data transfer rate of asynchronous transmission is slow.
5. Synchronous transmission is complicated and costly. In contrast, asynchronous transmission is simple and cost-effective.
6. Synchronous transmission is simple to design. In contrast, asynchronous transmission is both complex in nature and design.

7. There is no gap between data in Synchronous transmission due to the common clock pulse. Whereas there is a gap between the data bytes in asynchronous transmission. It has start and end bits between which actual data is present.
8. Local storage is not necessary for synchronous transmission at the terminal end. In contrast, local buffer storages are needed to construct blocks at both ends of the line in asynchronous transmission.
9. In Synchronous Transmission, the voice-band and broad-band channels are primarily utilized. In contrast, asynchronous transfer is employed with voice-band channels that have a limited type.

Head-to-head comparison between Synchronous and Asynchronous Transmission

Here, you will learn the head-to-head comparisons between Synchronous and Asynchronous Transmission. The main differences between Synchronous and Asynchronous Transmission are as follows:

Features	Synchronous Transmission	Asynchronous Transmission
Definition	It is a type of transmission that enables synchronized communication by sharing a common clock pulse between the transmitter and the receiver.	It is a form of transmission in which the transmitter and receiver have their own internal clocks and hence don't require an external common clock pulse.
Basic	The transmission begins with the block header, which contains a bit sequence.	It employs the start and stops bits to precede and follow a character.
Data Unit	Data is transmitted as frames in synchronous transmission.	It transmits data one byte at a specific time.
Storage	It doesn't require any storage at the terminal end.	The local buffer storages are needed to construct blocks at both ends of the line in asynchronous transmission.
Transmission speed	The data transfer rate of synchronous transmission is fast.	The data transfer rate is slow.
Cost	It is complicated and costly.	It is simple and cost-effective.
Gap between the data	There is no gap between data in Synchronous transmission due to the common clock pulse.	There is a gap between the data bytes, and it has start and end bits between which actual data is present.
Implementation	It is implemented by hardware and software.	It is only implemented by hardware.
Time interval	The time delay between two transmissions is constant.	The time delay between two transmissions is random.
Bits	The start and stop bits are not utilized in data transmission.	The start and stop bits are used to transmit data with additional overhead.

Synchronized clocks	It doesn't require any synchronized clocks.	It needs synchronized clocks at both ends.
Complexity	It is simple and easy to design.	It is complex to design.
Band Channels	It mainly uses both voice-band and broad-band channels.	It mainly uses voice-band channels that have a limited type.
Examples	Some examples of synchronous transmission are Video Conferencing, Chat Rooms, and Telephonic Conversations.	Some examples of asynchronous transmission are emails, letters, forums, etc.

Conclusion

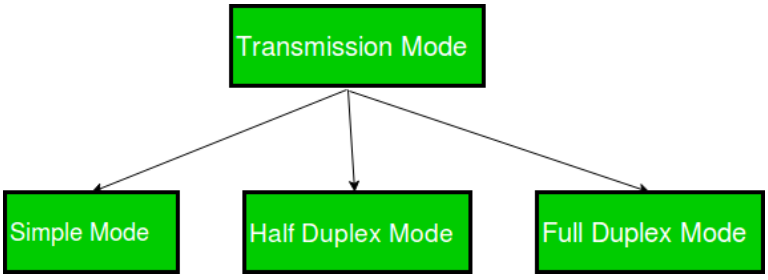
Both synchronous and asynchronous transmission has some benefits and drawbacks. Asynchronous transmission is easy and inexpensive for sending small amounts of data.

In contrast, synchronous transmission is utilized to transfer most of the data because it is more efficient and has less overhead. As a result, the conclusion is that data transfer requires both synchronous and asynchronous transmission.

Transmission Modes in Computer Networks (Simplex, Half-Duplex and Full-Duplex)

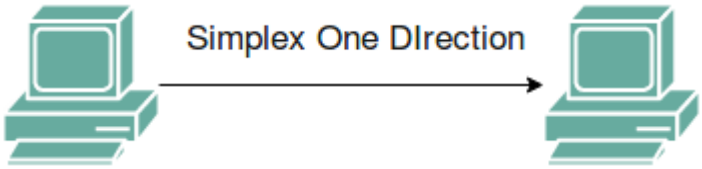
Transmission mode means transferring data between two devices. It is also known as a communication mode. Buses and networks are designed to allow communication to occur between individual devices that are interconnected.

There are three types of transmission mode:-



These are explained as following below.

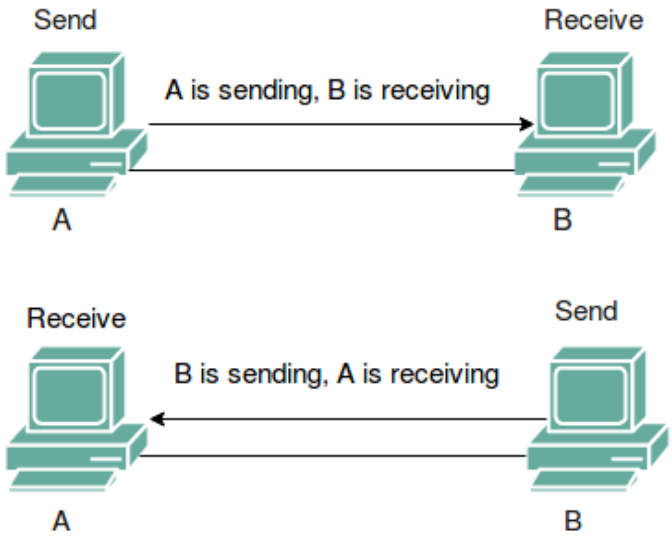
1. Simplex Mode –
In Simplex mode, the communication is unidirectional, as on a one-way street. Only one of the two devices on a link can transmit, the other can only receive. The simplex mode can use the entire capacity of the channel to send data in one direction.
Example: Keyboard and traditional monitors. The keyboard can only introduce input, the monitor can only give the output.



Advantages:
- Simplex mode is the easiest and most reliable mode of communication.
- It is the most cost-effective mode, as it only requires one communication channel.
- There is no need for coordination between the transmitting and receiving devices, which simplifies the communication process.
- Simplex mode is particularly useful in situations where feedback or response is not required, such as broadcasting or surveillance.

Disadvantages:
- Only one-way communication is possible.
- There is no way to verify if the transmitted data has been received correctly.
- Simplex mode is not suitable for applications that require bidirectional communication.

2. Half-Duplex Mode –
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. The half-duplex mode is used in cases where there is no need for communication in both directions at the same time. The entire capacity of the channel can be utilized for each direction.
Example: Walkie-talkie in which message is sent one at a time and messages are sent in both directions.
`Channel capacity=Bandwidth * Propagation Delay`



Advantages:

- Half-duplex mode allows for bidirectional communication, which is useful in situations where devices need to send and receive data.
- It is a more efficient mode of communication than simplex mode, as the channel can be used for both transmission and reception.
- Half-duplex mode is less expensive than full-duplex mode, as it only requires one communication channel.

Disadvantages:

- Half-duplex mode is less reliable than Full-Duplex mode, as both devices cannot transmit at the same time.
- There is a delay between transmission and reception, which can cause problems in some applications.
- There is a need for coordination between the transmitting and receiving devices, which can complicate the communication process.

3. Full-Duplex Mode –

In full-duplex mode, both stations can transmit and receive simultaneously. In full_duplex mode, signals going in one direction share the capacity of the link with signals going in another direction, this sharing can occur in two ways:

- Either the link must contain two physically separate transmission paths, one for sending and the other for receiving.
- Or the capacity is divided between signals traveling in both directions.

Full-duplex mode is used when communication in both directions is required all the time. The capacity of the channel, however, must be divided between the two directions.

Example: Telephone Network in which there is communication between two persons by a telephone line, through which both can talk and listen at the same time.

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Channel Capacity=2* Bandwidth*propagation Delay
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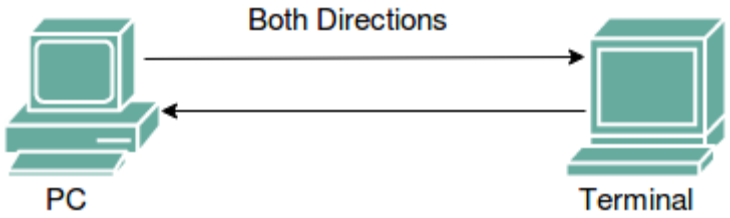


Advantages:

- Full-duplex mode allows for simultaneous bidirectional communication, which is ideal for real-time applications such as video conferencing or online gaming.
- It is the most efficient mode of communication, as both devices can transmit and receive data simultaneously.
- Full-duplex mode provides a high level of reliability and accuracy, as there is no need for error correction mechanisms.

Disadvantages:

- Full-duplex mode is the most expensive mode, as it requires two communication channels.
- It is more complex than simplex and half-duplex modes, as it requires two physically separate transmission paths or a division of channel capacity.
- Full-duplex mode may not be suitable for all applications, as it requires a high level of bandwidth and may not be necessary for some types of communication.

What is Multiplexing?

Multiplexing is a technique used to combine and send the multiple data streams over a single medium. The process of combining the data streams is known as multiplexing and hardware used for multiplexing is known as a multiplexer.

Multiplexing is achieved by using a device called Multiplexer (**MUX**) that combines n input lines to generate a single output line. Multiplexing follows many-to-one, i.e., n input lines and one output line.

Demultiplexing is achieved by using a device called Demultiplexer (**DEMUX**) available at the receiving end. DEMUX separates a signal into its component signals (one input and n outputs). Therefore, we can say that demultiplexing follows the one-to-many approach.

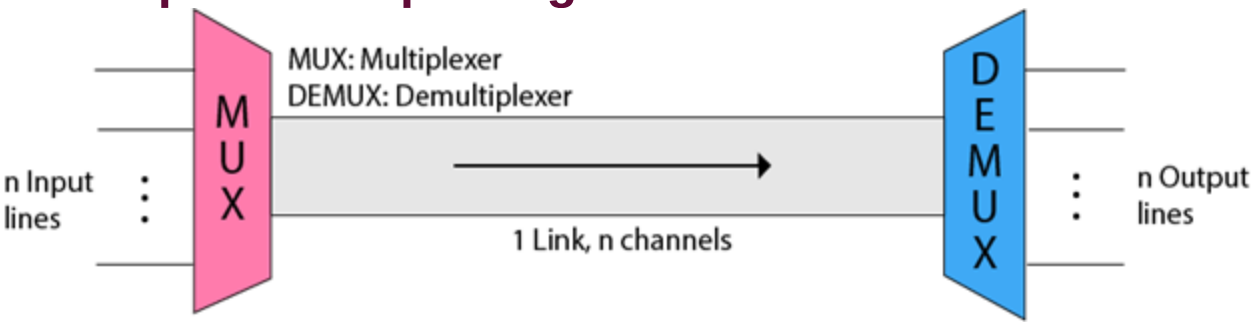
Why Multiplexing?

- The transmission medium is used to send the signal from sender to receiver. The medium can only have one signal at a time.
- If there are multiple signals to share one medium, then the medium must be divided in such a way that each signal is given some portion of the available bandwidth. For example: If there are 10 signals and bandwidth of medium is100 units, then the 10 unit is shared by each signal.
- When multiple signals share the common medium, there is a possibility of collision. Multiplexing concept is used to avoid such collision.
- Transmission services are very expensive.

History of Multiplexing

- Multiplexing technique is widely used in telecommunications in which several telephone calls are carried through a single wire.
- Multiplexing originated in telegraphy in the early 1870s and is now widely used in communication.
- George Owen Squier developed the **telephone carrier multiplexing** in 1910.

Concept of Multiplexing



- The 'n' input lines are transmitted through a multiplexer and multiplexer combines the signals to form a composite signal.
- The composite signal is passed through a Demultiplexer and demultiplexer separates a signal to component signals and transfers them to their respective destinations.

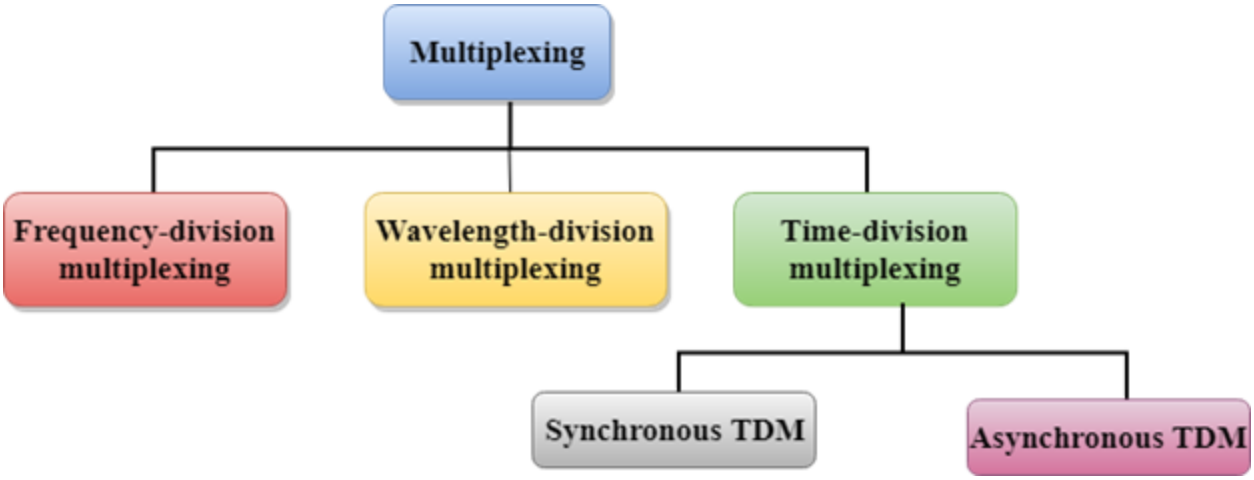
Advantages of Multiplexing:

- More than one signal can be sent over a single medium.

- The bandwidth of a medium can be utilized effectively.

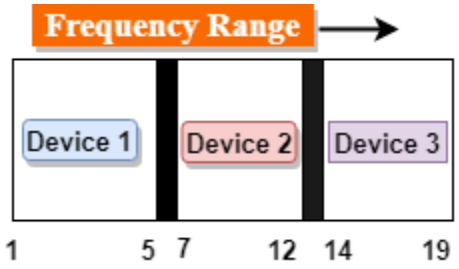
Multiplexing Techniques

Multiplexing techniques can be classified as:



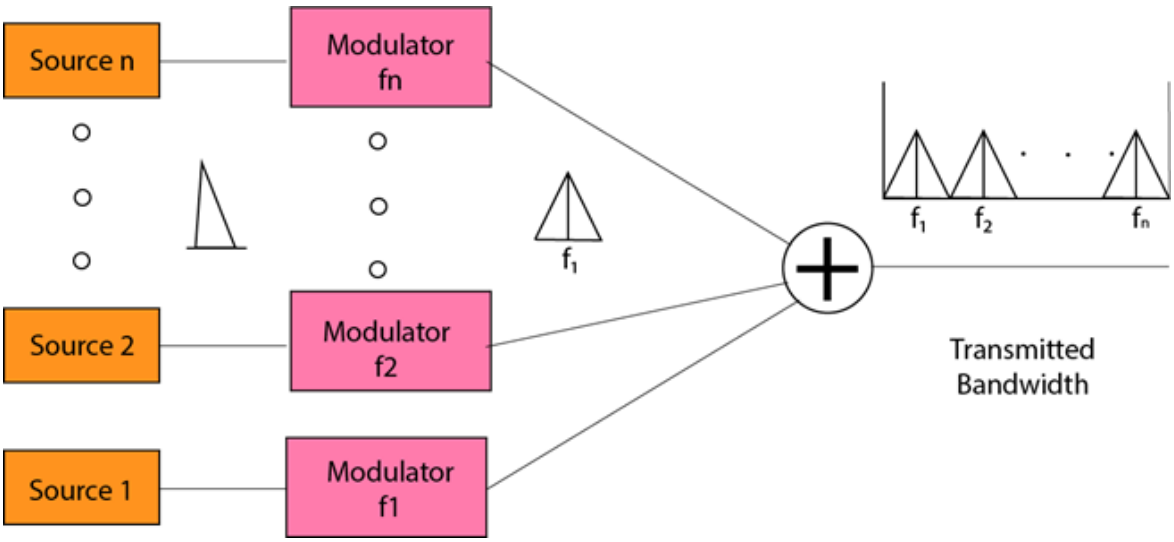
Frequency-division Multiplexing (FDM)

- It is an analog technique.
- **Frequency Division Multiplexing** is a technique in which the available bandwidth of a single transmission medium is subdivided into several channels.



- In the above diagram, a single transmission medium is subdivided into several frequency channels, and each frequency channel is given to different devices. Device 1 has a frequency channel of range from 1 to 5.
- The input signals are translated into frequency bands by using modulation techniques, and they are combined by a multiplexer to form a composite signal.

- The main aim of the FDM is to subdivide the available bandwidth into different frequency channels and allocate them to different devices.
- Using the modulation technique, the input signals are transmitted into frequency bands and then combined to form a composite signal.
- The carriers which are used for modulating the signals are known as **sub-carriers**. They are represented as f1,f2..fn.
- **FDM** is mainly used in radio broadcasts and TV networks.



Advantages Of FDM:

- FDM is used for analog signals.
- FDM process is very simple and easy modulation.
- A Large number of signals can be sent through an FDM simultaneously.
- It does not require any synchronization between sender and receiver.

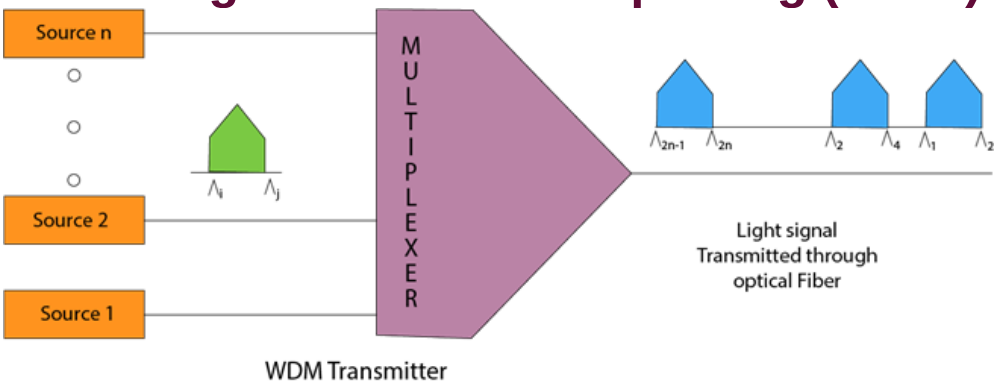
Disadvantages Of FDM:

- FDM technique is used only when low-speed channels are required.
- It suffers the problem of crosstalk.
- A Large number of modulators are required.
- It requires a high bandwidth channel.

Applications Of FDM:

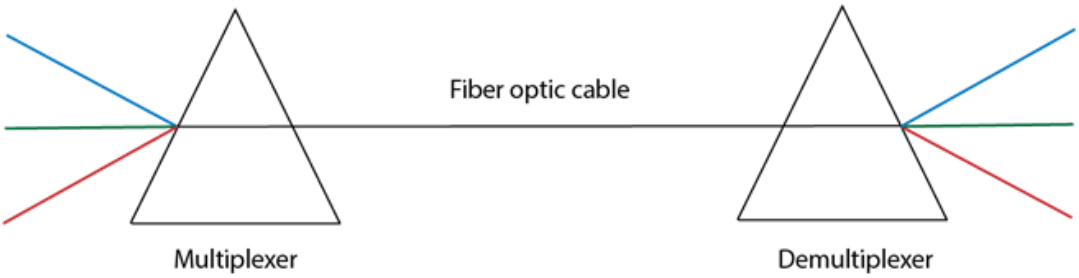
- FDM is commonly used in TV networks.
- It is used in FM and AM broadcasting. Each FM radio station has different frequencies, and they are multiplexed to form a composite signal. The multiplexed signal is transmitted in the air.

Wavelength Division Multiplexing (WDM)



WDM Transmitter

- Wavelength Division Multiplexing is same as FDM except that the optical signals are transmitted through the fibre optic cable.
- WDM is used on fibre optics to increase the capacity of a single fibre.
- It is used to utilize the high data rate capability of fibre optic cable.
- It is an analog multiplexing technique.
- Optical signals from different source are combined to form a wider band of light with the help of multiplexer.
- At the receiving end, demultiplexer separates the signals to transmit them to their respective destinations.
- Multiplexing and Demultiplexing can be achieved by using a prism.
- Prism can perform a role of multiplexer by combining the various optical signals to form a composite signal, and the composite signal is transmitted through a fibre optical cable.
- Prism also performs a reverse operation, i.e., demultiplexing the signal.



Time Division Multiplexing

- It is a digital technique.
- In Frequency Division Multiplexing Technique, all signals operate at the same time with different frequency, but in case of Time Division Multiplexing technique, all signals operate at the same frequency with different time.
- In **Time Division Multiplexing technique**, the total time available in the channel is distributed among different users. Therefore, each user is allocated with different time interval known as a Time slot at which data is to be transmitted by the sender.
- A user takes control of the channel for a fixed amount of time.
- In Time Division Multiplexing technique, data is not transmitted simultaneously rather the data is transmitted one-by-one.
- In TDM, the signal is transmitted in the form of frames. Frames contain a cycle of time slots in which each frame contains one or more slots dedicated to each user.
- It can be used to multiplex both digital and analog signals but mainly used to multiplex digital signals.

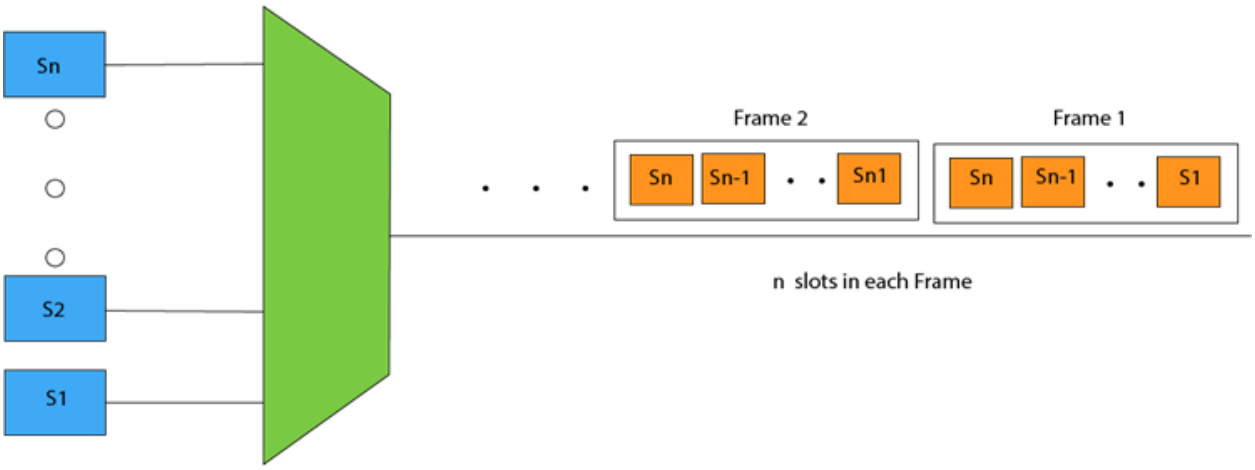
There are two types of TDM:

- Synchronous TDM
- Asynchronous TDM

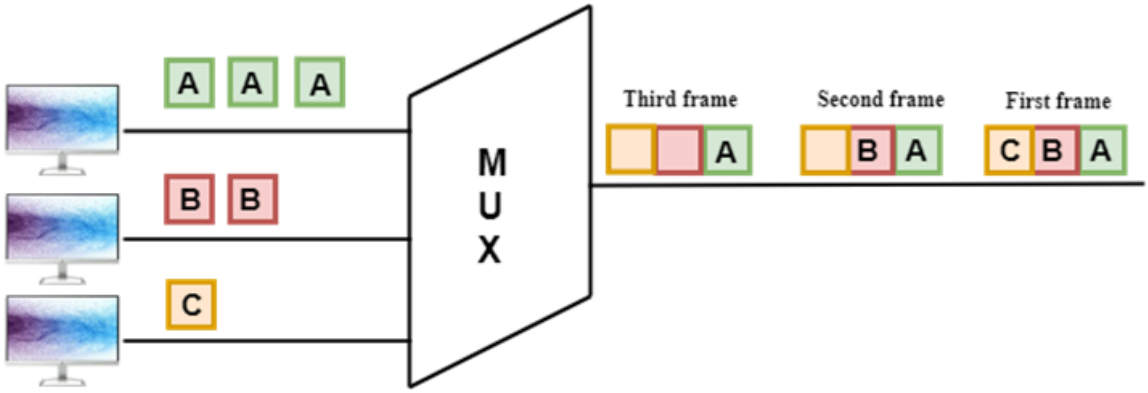
Synchronous TDM

- A Synchronous TDM is a technique in which time slot is preassigned to every device.
- In Synchronous TDM, each device is given some time slot irrespective of the fact that the device contains the data or not.
- If the device does not have any data, then the slot will remain empty.

- In Synchronous TDM, signals are sent in the form of frames. Time slots are organized in the form of frames. If a device does not have data for a particular time slot, then the empty slot will be transmitted.
- The most popular Synchronous TDM are T-1 multiplexing, ISDN multiplexing, and SONET multiplexing.
- If there are n devices, then there are n slots.



Concept Of Synchronous TDM



In the above figure, the Synchronous TDM technique is implemented. Each device is allocated with some time slot. The time slots are transmitted irrespective of whether the sender has data to send or not.

Disadvantages Of Synchronous TDM:

- The capacity of the channel is not fully utilized as the empty slots are also transmitted which is having no data. In the above figure, the first frame is completely filled, but in the

last two frames, some slots are empty. Therefore, we can say that the capacity of the channel is not utilized efficiently.

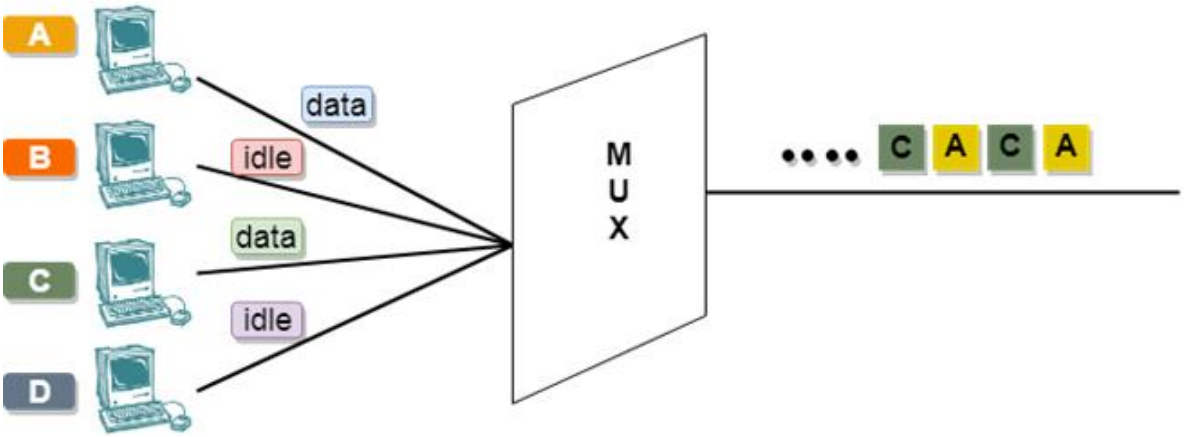
- The speed of the transmission medium should be greater than the total speed of the input lines. An alternative approach to the Synchronous TDM is Asynchronous Time Division Multiplexing.

Asynchronous TDM

- An asynchronous TDM is also known as Statistical TDM.
- An asynchronous TDM is a technique in which time slots are not fixed as in the case of Synchronous TDM. Time slots are allocated to only those devices which have the data to send. Therefore, we can say that Asynchronous Time Division multiplexor transmits only the data from active workstations.
- An asynchronous TDM technique dynamically allocates the time slots to the devices.
- In Asynchronous TDM, total speed of the input lines can be greater than the capacity of the channel.
- Asynchronous Time Division multiplexor accepts the incoming data streams and creates a frame that contains only data with no empty slots.
- In Asynchronous TDM, each slot contains an address part that identifies the source of the data.

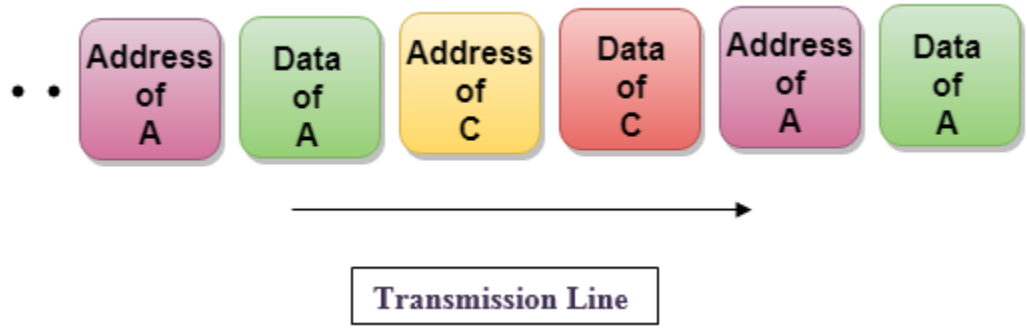
- The difference between Asynchronous TDM and Synchronous TDM is that many slots in Synchronous TDM are unutilized, but in Asynchronous TDM, slots are fully utilized. This leads to the smaller transmission time and efficient utilization of the capacity of the channel.
- In Synchronous TDM, if there are n sending devices, then there are n time slots. In Asynchronous TDM, if there are n sending devices, then there are m time slots where m is less than n (**m<n**).
- The number of slots in a frame depends on the statistical analysis of the number of input lines.

Concept Of Asynchronous TDM



In the above diagram, there are 4 devices, but only two devices are sending the data, i.e., A and C. Therefore, the data of A and C are only transmitted through the transmission line.

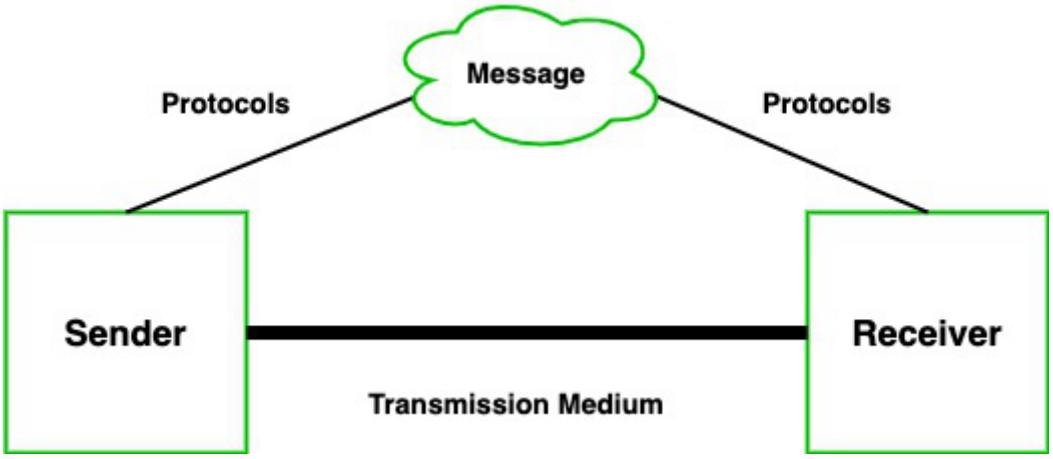
Frame of above diagram can be represented as:



The above figure shows that the data part contains the address to determine the source of the data.

Encoding and Decoding in Communication Process

Encoding refers to “Codes that are used to convert a body of information from one system to another.” The secret meaning of a code is represented by a set of characters, symbols, or signs. Coding, according to John Fiske, “Includes both signs and rules that govern how and when these signals are used, as well as how they might be combined to construct more sophisticated messages.” The following diagram clearly illustrates the effective communication process.



The encoder or source gives individuals structure to the message, idea, or information in the aforementioned process, i.e. proper encoding of the message in the mind of the individual, and then sends it to the destination or receiver. The receiver then interprets the message based on his prior experience. Therefore, no communication is possible without the source. As a result, it is the most crucial factor. However, it must be very straightforward and clear so that the receiver may grasp the receiver's statements.

The communication process has been observed to be continuous. Because one encodes the message and the other decodes it, there is no end to it.

Decoding refers to the process in which the decoder decodes or interprets a message that has been encoded by a source using his experiences and intellect. The message has been kept simple and basic. As a result, the decoder will be able to quickly and easily decode the received message and send it back to the source. In other words, we can say that the communication process will be understandable, as the receiver will readily comprehend the simple and clear message, and will decode the message to the source using all of his fine sense. Decoding is the technical term for the receiver or destination.

The message must be clear, factual, and meaningful, and it must be crafted in such a way that listeners, readers, and viewers do not misunderstand the meaning and goal.

Why Encoding and Decoding in Communication Process is required?

The data in a message should be useful to the receiving process. While transmitting data from the sending process's address space to the receiving process's address space the program objects structure should be maintained. But this is not the possibility in the case of a heterogeneous system, as the sending and receiving processes are carried out on machines having different architectures. It is also a challenging situation in the homogeneous systems as well due to the following reasons:

- An absolute pointer value loses its meaning when transferring from one process address space to another. Hence, the software objects which use the value of

absolute pointer cannot be transferred in their original form and will require representation in some other way.

- The amount of storage take up varies with different program objects. To be meaningful, a message should typically contain a variety of program objects, such as variable-length character strings, long numbers, small integers, and so on. In this instance, the receiver must be able to determine which program object is stored wherein the message buffer and also determine space utilization by each program object for the message to be relevant to the receiver.

Due to these problems Encoding and Decoding in Communication Process are carried out. Message buffers are used to store program objects after they have been transformed to a stream format appropriate for transmission. Encoding of message data is the name for this conversion procedure that takes place on the sender's side. The received message on the receiver side must be converted back to the original program objects from the stream form before it can be further used. Hence, Decoding refers to reconstructing program objects from message data by the receiver.

Representations for encoding and decoding message data:

The Tagged and Untagged are the two representations for encoding and decoding message data:

- **Tagged Representation:** Here, the encoding is done on the type of each program object, and its value. In this representation, the coded data format describes itself quite well which helps the receiving process to check the type of each program object in the message using this manner.
- **Untagged representation:** The message data in an untagged representation simply contains program objects and contains no information about the kind of each program object. In this representation, receiving process must know in advance regarding the procedure of decoding the incoming data because coded data format is not able to describe itself.

Error Detection

Error is a condition when the receiver's information does not match the sender's information. During transmission, digital signals suffer from noise that can introduce errors in the binary bits traveling from sender to receiver. That means a 0 bit may change to 1 or a 1 bit may change to 0.

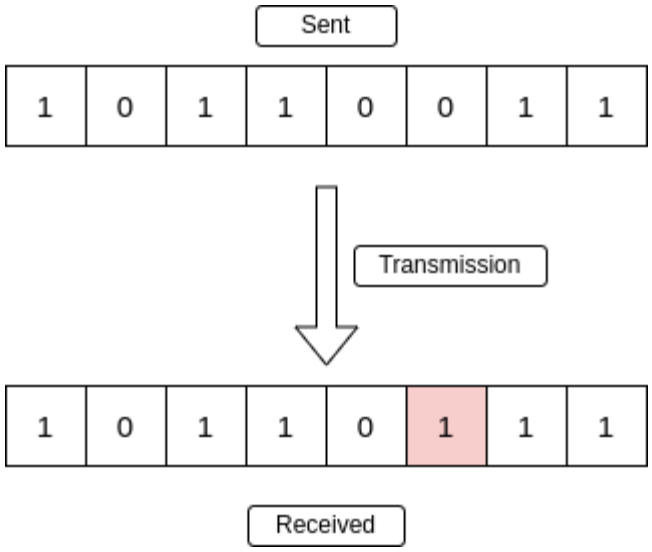
Data (Implemented either at the Data link layer or Transport Layer of the OSI Model) may get scrambled by noise or get corrupted whenever a message is transmitted. To prevent such errors, error-detection codes are added as extra data to digital messages.

This helps in detecting any errors that may have occurred during message transmission.

Types of Errors

Single-Bit Error

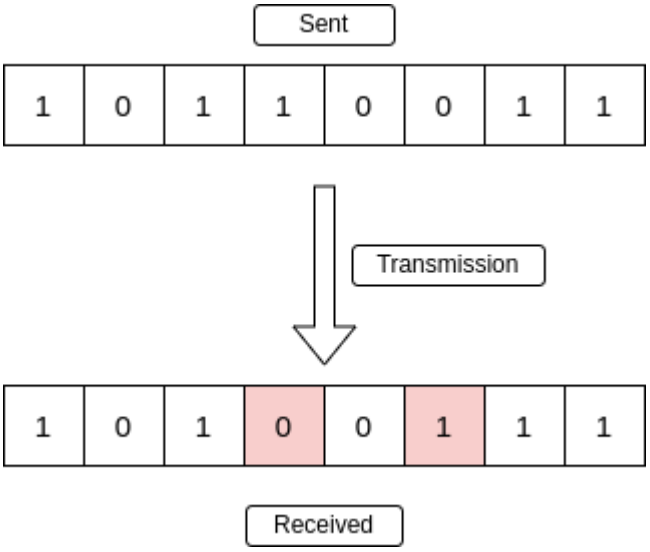
A single-bit error refers to a type of data transmission error that occurs when one bit (i.e., a single binary digit) of a transmitted data unit is altered during transmission, resulting in an incorrect or corrupted data unit.



Single-Bit Error

Multiple-Bit Error

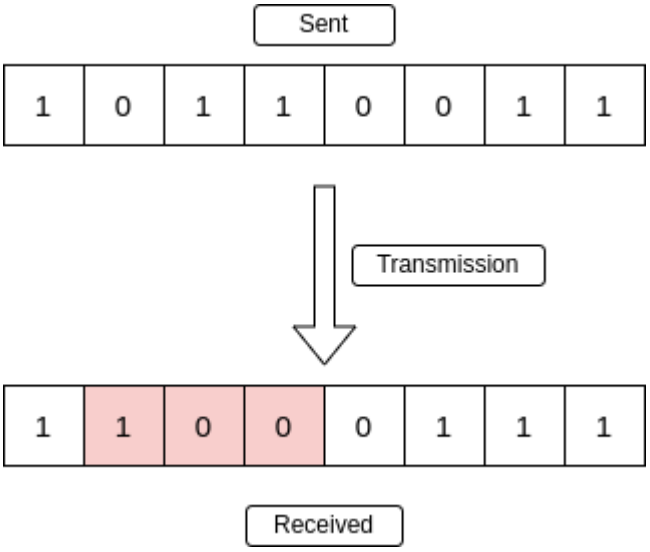
A multiple-bit error is an error type that arises when more than one bit in a data transmission is affected. Although multiple-bit errors are relatively rare when compared to single-bit errors, they can still occur, particularly in high-noise or high-interference digital environments.



Multiple-Bit Error

Burst Error

When several consecutive bits are flipped mistakenly in digital transmission, it creates a burst error. This error causes a sequence of consecutive incorrect values.



Burst Error

To detect errors, a common technique is to introduce redundancy bits that provide additional information. Various techniques for error detection include::

1. Simple Parity Check
2. Two-dimensional Parity Check

3. Checksum
4. Cyclic Redundancy Check (CRC)

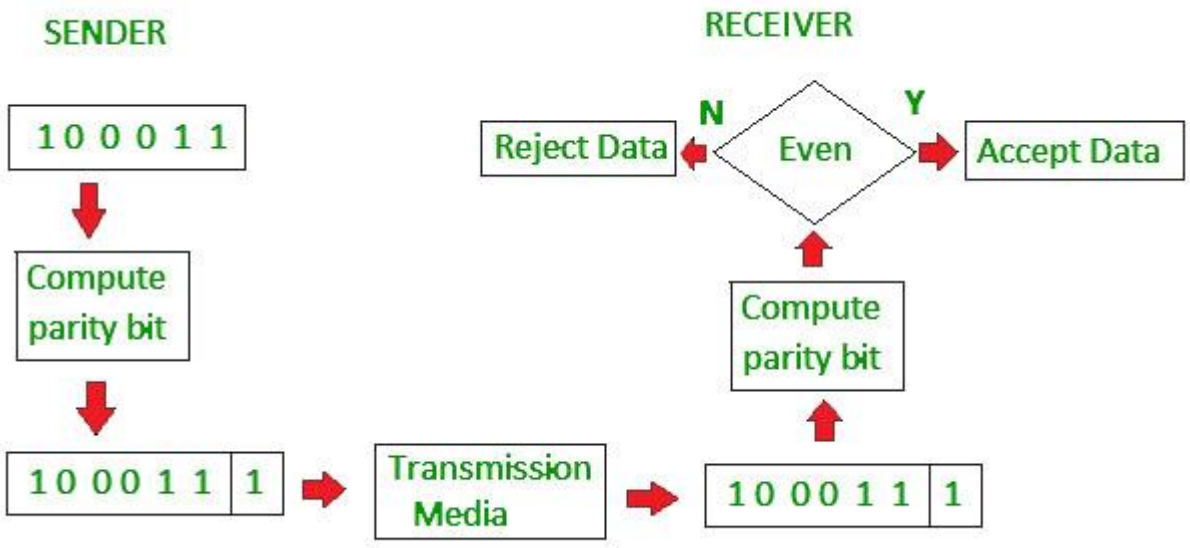
Error Detection Methods

Simple Parity Check

Simple-bit parity is a simple error detection method that involves adding an extra bit to a data transmission. It works as:

- 1 is added to the block if it contains an odd number of 1's, and
- 0 is added if it contains an even number of 1's

This scheme makes the total number of 1's even, that is why it is called even parity checking.

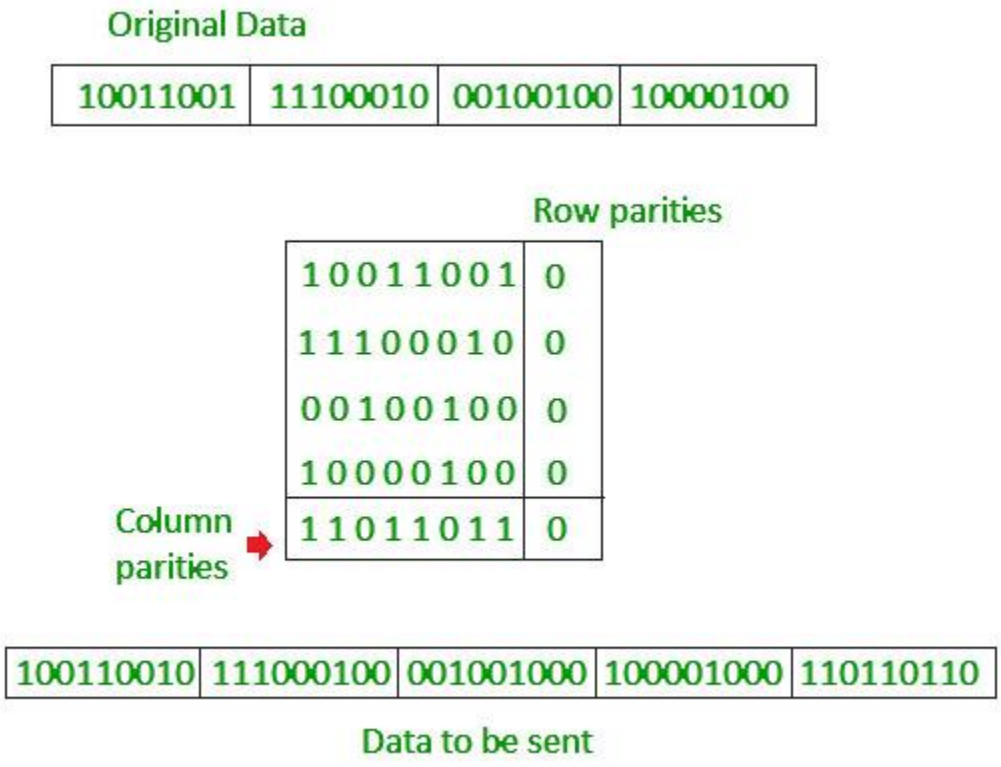


Disadvantages

- Single Parity check is not able to detect even no. of bit error.
- **For example,** the Data to be transmitted is **101010**. Codeword transmitted to the receiver is 1010101 (we have used even parity).
  Let's assume that during transmission, two of the bits of code word flipped to 1111101.
  On receiving the code word, the receiver finds the no. of ones to be even and hence **no error,** *which is a wrong assumption.*

Two-dimensional Parity Check

Two-dimensional Parity check bits are calculated for each row, which is equivalent to a simple parity check bit. Parity check bits are also calculated for all columns, then both are sent along with the data. At the receiving end, these are compared with the parity bits calculated on the received data.



Checksum

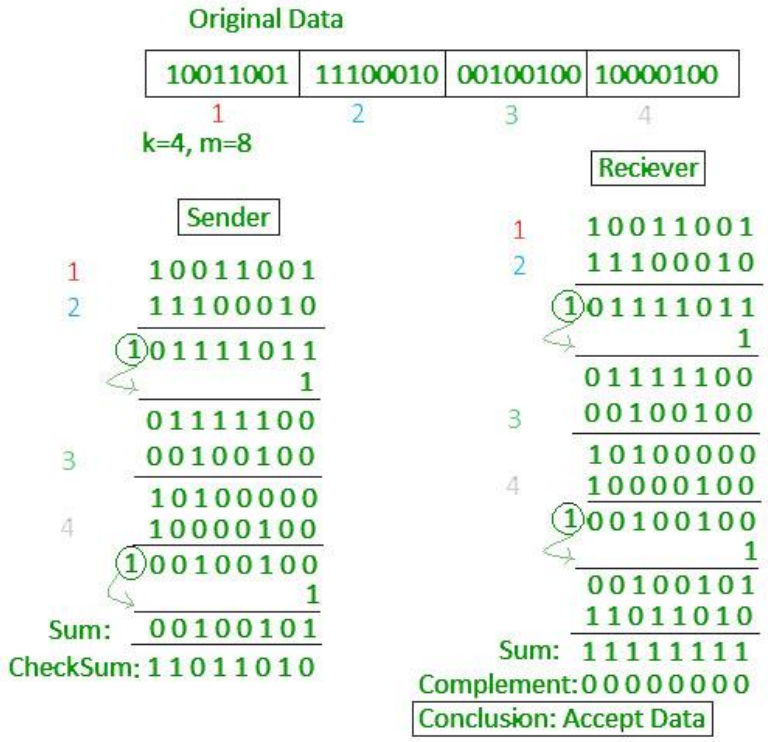
Checksum error detection is a method used to identify errors in transmitted data. The process involves dividing the data into equally sized segments and using a 1's complement to calculate the sum of these segments. The calculated sum is then sent along with the data to the receiver. At the receiver's end, the same process is repeated and if all zeroes are obtained in the sum, it means that the data is correct.

Checksum – Operation at Sender's Side

- Firstly, the data is divided into k segments each of m bits.
- On the sender's end, the segments are added using 1's complement arithmetic to get the sum. The sum is complemented to get the checksum.
- The checksum segment is sent along with the data segments.

Checksum – Operation at Receiver's Side

- At the receiver's end, all received segments are added using 1's complement arithmetic to get the sum. The sum is complemented.
- If the result is zero, the received data is accepted; otherwise discarded.

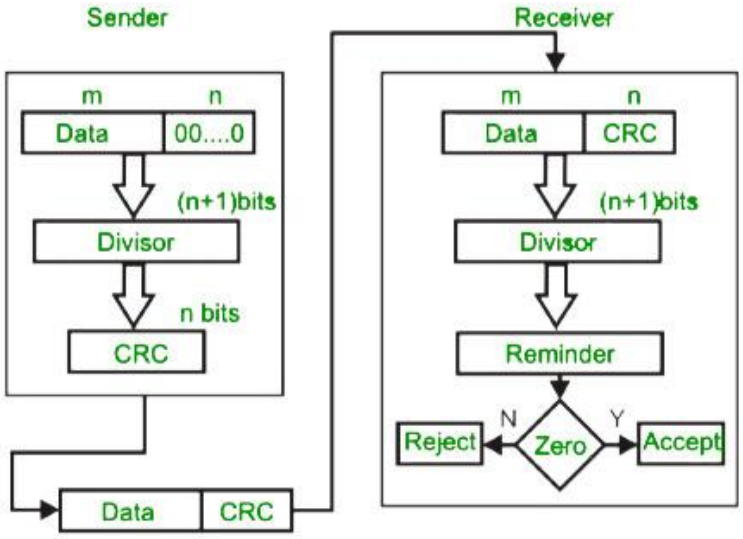


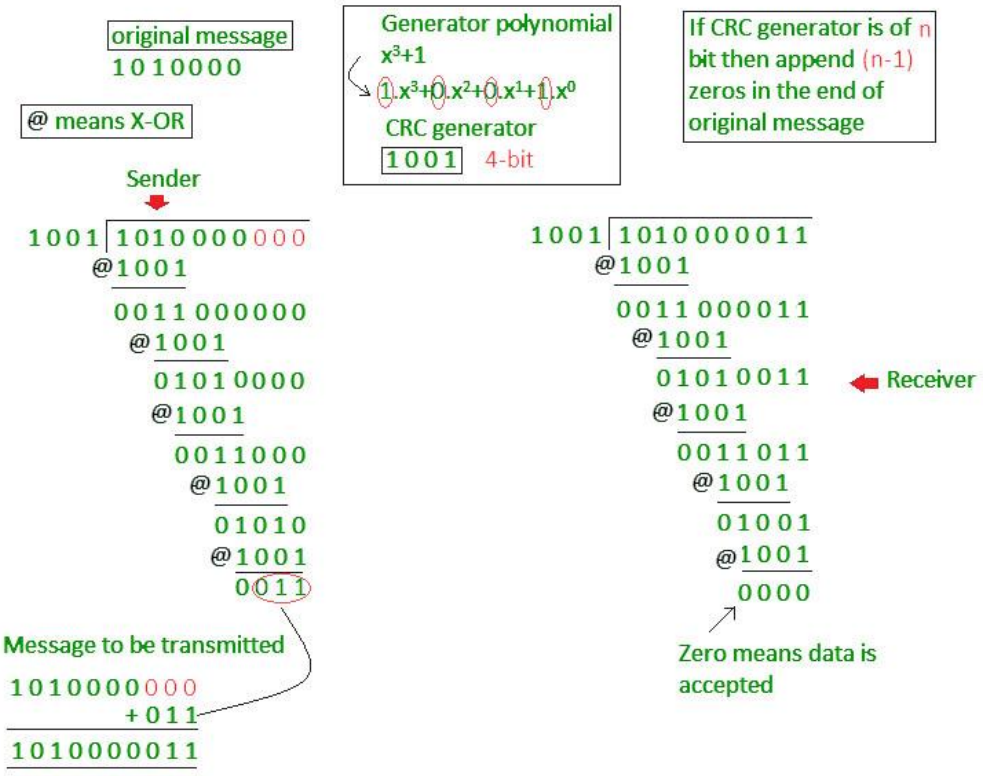
Disadvantages

- If one or more bits of a segment are damaged and the corresponding bit or bits of opposite value in a second segment are also damaged.

Cyclic Redundancy Check (CRC)

- Unlike the checksum scheme, which is based on addition, CRC is based on binary division.
- In CRC, a sequence of redundant bits, called cyclic redundancy check bits, are appended to the end of the data unit so that the resulting data unit becomes exactly divisible by a second, predetermined binary number.
- At the destination, the incoming data unit is divided by the same number. If at this step there is no remainder, the data unit is assumed to be correct and is therefore accepted.
- A remainder indicates that the data unit has been damaged in transit and therefore must be rejected.





Advantages:

Increased Data Reliability: Error detection ensures that the data transmitted over the network is reliable, accurate, and free from errors. This ensures that the recipient receives the same data that was transmitted by the sender.

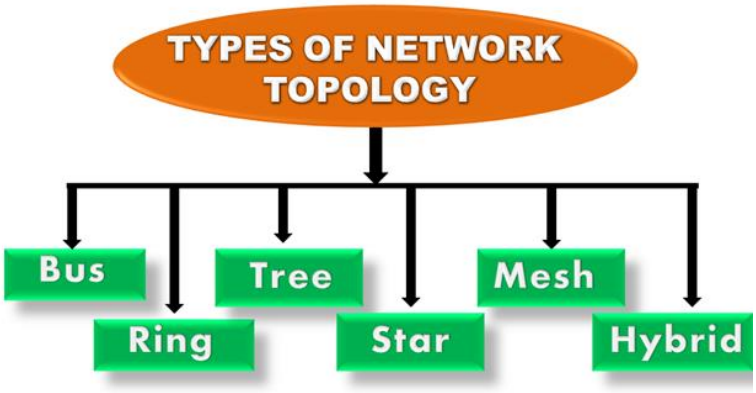
Improved Network Performance: Error detection mechanisms can help to identify and isolate network issues that are causing errors. This can help to improve the overall performance of the network and reduce downtime.
Enhanced Data Security: Error detection can also help to ensure that the data transmitted over the network is secure and has not been tampered with.
Disadvantages:
Overhead: Error detection requires additional resources and processing power, which can lead to increased overhead on the network. This can result in slower network performance and increased latency.
False Positives**:** Error detection mechanisms can sometimes generate false positives, which can result in unnecessary retransmission of data. This can further increase the overhead on the network.
Limited Error Correction**:** Error detection can only identify errors but cannot correct them. This means that the recipient must rely on the sender to retransmit the data, which can lead to further delays and increased network overhead.

What is Network Topology?

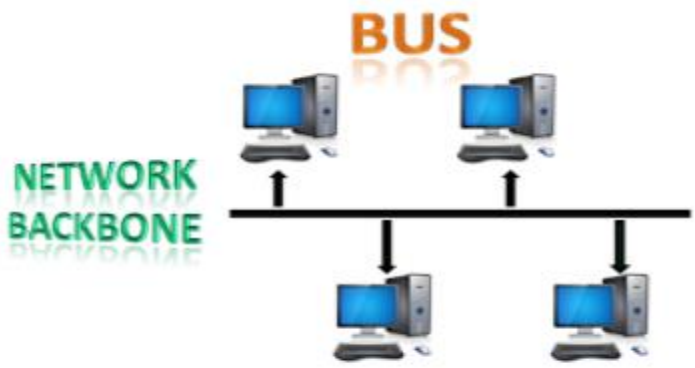
Topology defines the structure of the network of how all the components are interconnected to each other. There are two types of topology: physical and logical topology.

Types of Network Topology

Physical topology is the geometric representation of all the nodes in a network. There are six types of network topology which are Bus Topology, Ring Topology, Tree Topology, Star Topology, Mesh Topology, and Hybrid Topology.



1) Bus Topology



- The bus topology is designed in such a way that all the stations are connected through a single cable known as a backbone cable.
- Each node is either connected to the backbone cable by drop cable or directly connected to the backbone cable.
- When a node wants to send a message over the network, it puts a message over the network. All the stations available in the network will receive the message whether it has been addressed or not.
- The bus topology is mainly used in 802.3 (ethernet) and 802.4 standard networks.
- The configuration of a bus topology is quite simpler as compared to other topologies.
- The backbone cable is considered as a **"single lane"** through which the message is broadcast to all the stations.
- The most common access method of the bus topologies is **CSMA** (Carrier Sense Multiple Access).

CSMA: It is a media access control used to control the data flow so that data integrity is maintained, i.e., the packets do not get lost. There are two alternative ways of handling the problems that occur when two nodes send the messages simultaneously.

- **CSMA CD:** CSMA CD (**Collision detection**) is an access method used to detect the collision. Once the collision is detected, the sender will stop transmitting the data. Therefore, it works on "**recovery after the collision**".

- **CSMA CA: CSMA CA (Collision Avoidance)** is an access method used to avoid the collision by checking whether the transmission media is busy or not. If busy, then the sender waits until the media becomes idle. This technique effectively reduces the possibility of the collision. It does not work on "recovery after the collision".

Advantages of Bus topology:

- **Low-cost cable:** In bus topology, nodes are directly connected to the cable without passing through a hub. Therefore, the initial cost of installation is low.
- **Moderate data speeds:** Coaxial or twisted pair cables are mainly used in bus-based networks that support upto 10 Mbps.
- **Familiar technology:** Bus topology is a familiar technology as the installation and troubleshooting techniques are well known, and hardware components are easily available.
- **Limited failure:** A failure in one node will not have any effect on other nodes.

Disadvantages of Bus topology:

- **Extensive cabling:** A bus topology is quite simpler, but still it requires a lot of cabling.
- **Difficult troubleshooting:** It requires specialized test equipment to determine the cable faults. If any fault occurs in the cable, then it would disrupt the communication for all the nodes.
- **Signal interference:** If two nodes send the messages simultaneously, then the signals of both the nodes collide with each other.
- **Reconfiguration difficult:** Adding new devices to the network would slow down the network.
- **Attenuation:** Attenuation is a loss of signal leads to communication issues. Repeaters are used to regenerate the signal.

---

2) Ring Topology

- Ring topology is like a bus topology, but with connected ends.
- The node that receives the message from the previous computer will retransmit to the next node.
- The data flows in one direction, i.e., it is unidirectional.
- The data flows in a single loop continuously known as an endless loop.
- It has no terminated ends, i.e., each node is connected to other node and having no termination point.
- The data in a ring topology flow in a clockwise direction.
- The most common access method of the ring topology is **token passing**.
    - **Token passing:** It is a network access method in which token is passed from one node to another node.
    - **Token:** It is a frame that circulates around the network.

Working of Token passing

- A token moves around the network, and it is passed from computer to computer until it reaches the destination.
- The sender modifies the token by putting the address along with the data.
- The data is passed from one device to another device until the destination address matches. Once the token received by the destination device, then it sends the acknowledgment to the sender.
- In a ring topology, a token is used as a carrier.

Advantages of Ring topology:

- **Network Management:** Faulty devices can be removed from the network without bringing the network down.
- **Product availability:** Many hardware and software tools for network operation and monitoring are available.
- **Cost:** Twisted pair cabling is inexpensive and easily available. Therefore, the installation cost is very low.
- **Reliable:** It is a more reliable network because the communication system is not dependent on the single host computer.

Disadvantages of Ring topology:

- **Difficult troubleshooting:** It requires specialized test equipment to determine the cable faults. If any fault occurs in the cable, then it would disrupt the communication for all the nodes.
- **Failure:** The breakdown in one station leads to the failure of the overall network.
- **Reconfiguration difficult:** Adding new devices to the network would slow down the network.
- **Delay:** Communication delay is directly proportional to the number of nodes. Adding new devices increases the communication delay.

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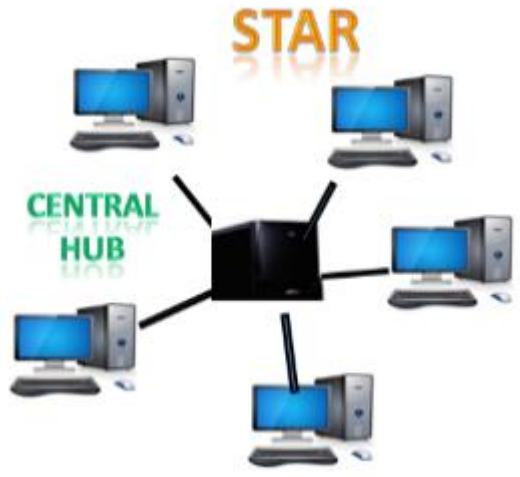
3) Star Topology



- Star topology is an arrangement of the network in which every node is connected to the central hub, switch or a central computer.
- The central computer is known as a **server**, and the peripheral devices attached to the server are known as **clients**.
- Coaxial cable or RJ-45 cables are used to connect the computers.
- Hubs or Switches are mainly used as connection devices in a **physical star topology**.
- Star topology is the most popular topology in network implementation.

Advantages of Star topology

- **Efficient troubleshooting:** Troubleshooting is quite efficient in a star topology as compared to bus topology. In a bus topology, the manager has to inspect the kilometers of cable. In a star topology, all the stations are connected to the centralized network. Therefore, the network administrator has to go to the single station to troubleshoot the problem.
- **Network control:** Complex network control features can be easily implemented in the star topology. Any changes made in the star topology are automatically accommodated.
- **Limited failure:** As each station is connected to the central hub with its own cable, therefore failure in one cable will not affect the entire network.
- **Familiar technology:** Star topology is a familiar technology as its tools are cost-effective.
- **Easily expandable:** It is easily expandable as new stations can be added to the open ports on the hub.
- **Cost effective:** Star topology networks are cost-effective as it uses inexpensive coaxial cable.
- **High data speeds:** It supports a bandwidth of approx 100Mbps. Ethernet 100BaseT is one of the most popular Star topology networks.

Disadvantages of Star topology

- **A Central point of failure:** If the central hub or switch goes down, then all the connected nodes will not be able to communicate with each other.
- **Cable:** Sometimes cable routing becomes difficult when a significant amount of routing is required.

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4) Tree topology

- Tree topology combines the characteristics of bus topology and star topology.
- A tree topology is a type of structure in which all the computers are connected with each other in hierarchical fashion.
- The top-most node in tree topology is known as a root node, and all other nodes are the descendants of the root node.
- There is only one path exists between two nodes for the data transmission. Thus, it forms a parent-child hierarchy.

Advantages of Tree topology

- **Support for broadband transmission:** Tree topology is mainly used to provide broadband transmission, i.e., signals are sent over long distances without being attenuated.
- **Easily expandable:** We can add the new device to the existing network. Therefore, we can say that tree topology is easily expandable.
- **Easily manageable:** In tree topology, the whole network is divided into segments known as star networks which can be easily managed and maintained.
- **Error detection:** Error detection and error correction are very easy in a tree topology.
- **Limited failure:** The breakdown in one station does not affect the entire network.
- **Point-to-point wiring:** It has point-to-point wiring for individual segments.

Disadvantages of Tree topology

- **Difficult troubleshooting:** If any fault occurs in the node, then it becomes difficult to troubleshoot the problem.

- **High cost:** Devices required for broadband transmission are very costly.
- **Failure:** A tree topology mainly relies on main bus cable and failure in main bus cable will damage the overall network.
- **Reconfiguration difficult:** If new devices are added, then it becomes difficult to reconfigure.

---

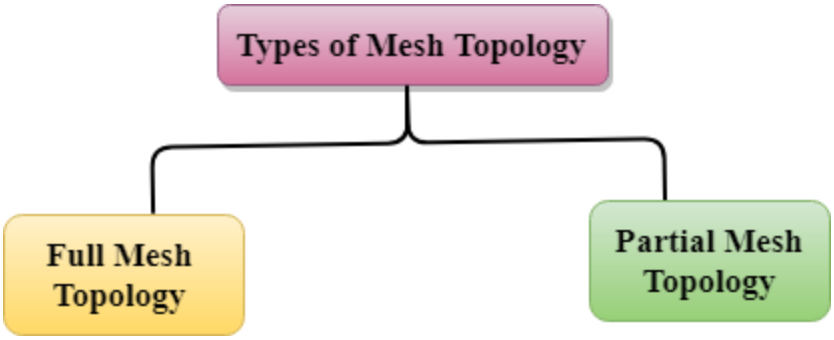
5) Mesh topology

- Mesh technology is an arrangement of the network in which computers are interconnected with each other through various redundant connections.
- There are multiple paths from one computer to another computer.
- It does not contain the switch, hub or any central computer which acts as a central point of communication.
- The Internet is an example of the mesh topology.
- Mesh topology is mainly used for WAN implementations where communication failures are a critical concern.
- Mesh topology is mainly used for wireless networks.
- Mesh topology can be formed by using the formula: **Number of cables = (n*(n-1))/2;**

Where n is the number of nodes that represents the network.

Mesh topology is divided into two categories:

- Fully connected mesh topology
- Partially connected mesh topology



- **Full Mesh Topology:** In a full mesh topology, each computer is connected to all the computers available in the network.
- **Partial Mesh Topology:** In a partial mesh topology, not all but certain computers are connected to those computers with which they communicate frequently.

Advantages of Mesh topology:

Reliable: The mesh topology networks are very reliable as if any link breakdown will not affect the communication between connected computers.

Fast Communication: Communication is very fast between the nodes.

Easier Reconfiguration: Adding new devices would not disrupt the communication between other devices.

Disadvantages of Mesh topology

- **Cost:** A mesh topology contains a large number of connected devices such as a router and more transmission media than other topologies.
- **Management:** Mesh topology networks are very large and very difficult to maintain and manage. If the network is not monitored carefully, then the communication link failure goes undetected.
- **Efficiency:** In this topology, redundant connections are high that reduces the efficiency of the network.

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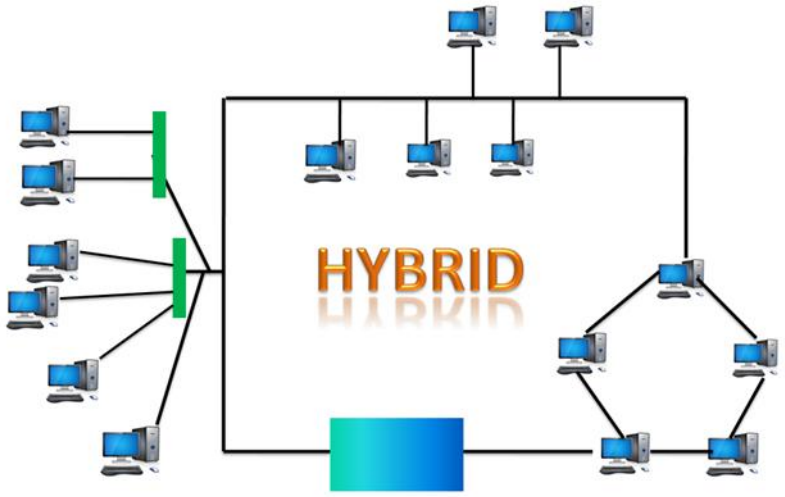
6) Hybrid Topology



- The combination of various different topologies is known as **Hybrid topology**.
- A Hybrid topology is a connection between different links and nodes to transfer the data.
- When two or more different topologies are combined together is termed as Hybrid topology and if similar topologies are connected with each other will not result in Hybrid topology. For example, if there exist a ring topology in one branch of ICICI bank and bus topology in another branch of ICICI bank, connecting these two topologies will result in Hybrid topology.

Advantages of Hybrid Topology

- **Reliable:** If a fault occurs in any part of the network will not affect the functioning of the rest of the network.
- **Scalable:** Size of the network can be easily expanded by adding new devices without affecting the functionality of the existing network.
- **Flexible:** This topology is very flexible as it can be designed according to the requirements of the organization.
- **Effective:** Hybrid topology is very effective as it can be designed in such a way that the strength of the network is maximized and weakness of the network is minimized.

Disadvantages of Hybrid topology

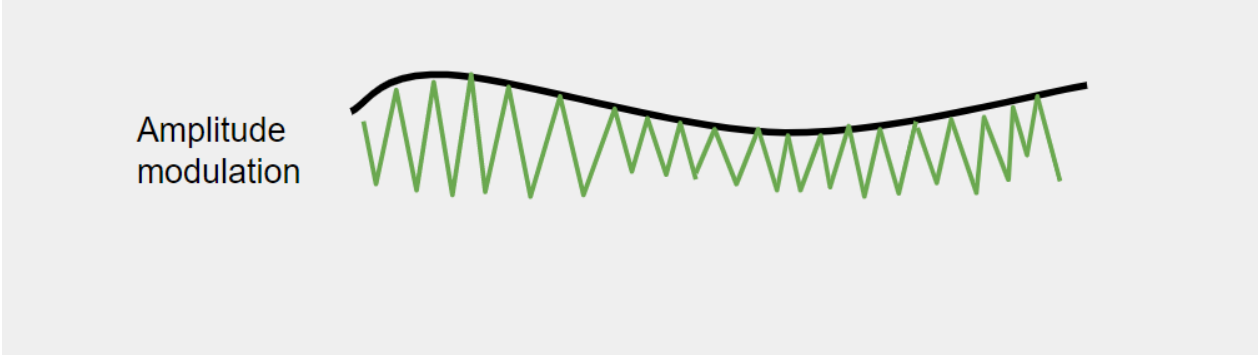
- **Complex design:** The major drawback of the Hybrid topology is the design of the Hybrid network. It is very difficult to design the architecture of the Hybrid network.
- **Costly Hub:** The Hubs used in the Hybrid topology are very expensive as these hubs are different from usual Hubs used in other topologies.
- **Costly infrastructure:** The infrastructure cost is very high as a hybrid network requires a lot of cabling, network devices, etc.

Modulation:

The process by which data/information is converted into electrical/digital signals for transferring that signal over a medium is called **modulation**. It increases strength for maximum reach of the signals. The process of extracting information/data from the transmitted signal is called **demodulation**. A Modem is a device that performs both modulation and demodulation processes. The various forms of modulation are designed to alter the characteristic of carrier waves. The most commonly altered characteristics of modulation include amplitude, frequency, and phase.
Carrier signal: The signals which contain no information but have a certain phase, frequency, and amplitude are called carrier signals.
Modulated signals: The signals which are the combination of the carrier signals and modulation signals are modulated signals. The modulated signal is obtained after the modulation of the signals.

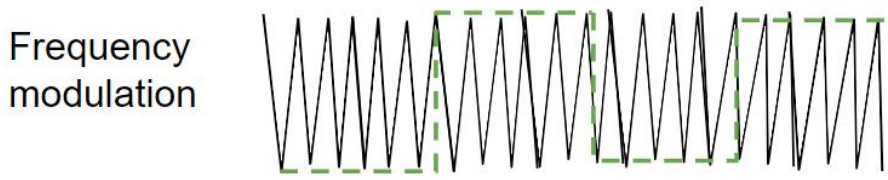
Types of modulation:

1. **Amplitude modulation:** It is a type of modulation in which only the amplitude of the carrier signal is varied to represent the data being added to the signals whereas the phase and the frequency of the signal are kept unchanged.



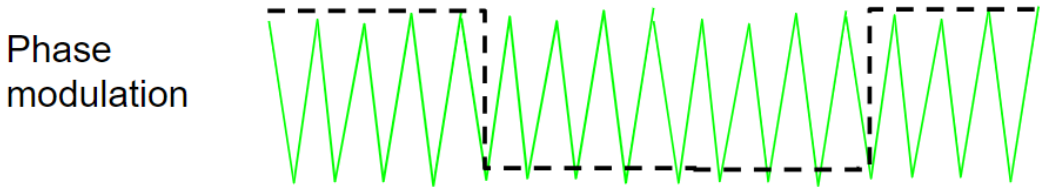
Amplitude Modulation

2. **Frequency modulation:** It is a type of modulation in which only the frequency of the carrier signal is varied to represent the frequency of the data whereas the phase and the amplitude of the signals are kept unchanged.



Frequency Modulation

3. **Phase modulation:** It is a type of modulation in which the phase of the carrier signal is varied to represent the data being added to the signal. Different information values are represented by different phases. For example: '1' may be represented by 0° while '0' by 180°.



Phase Modulation

What is the need for modulation?

- **Size of antenna:** As we know that the size of the antenna is inversely proportional to the frequency of the radiated signal and antenna size must be 1/10th of the wavelength. If the frequency signals are more than 5KHz in that case it is quite impossible to set up an antenna of that size. So, by using the modulation technique the size of the antenna is reduced.
- **Wireless communication:** Modulation provides a wireless connection to transmit the signals to a longer distance. Earlier we used wire systems (like the telephone) to transfer information with the help of telephonic wires but it was not possible to spread the wires all over the world for communication. By using the modulation

technique, the cost of wire is saved and even information can be transferred to longer distances faster.

Working of Modulation:

Information/data can be added to the carrier signal by varying its amplitude, frequency, and phase. Basically, modulation is applied to electromagnetic signals like radio waves, optics, and computer networks. It can also be applied to direct current that can be treated as a degenerate carrier wave with a fixed amplitude and frequency of 0 Hz by turning it off and on as in a digital current loop and in Morse code telegraphy.

Advantages of modulation:

- It reduces the size of the antenna.
- It reduces the cost of wires.
- It prohibits the mixing of signals.
- It increases the range of communication.
- It improves the reception quality.
- It easily multiplexes the signals.
- It also allows the adjustment of the bandwidth.

Disadvantages of modulation:

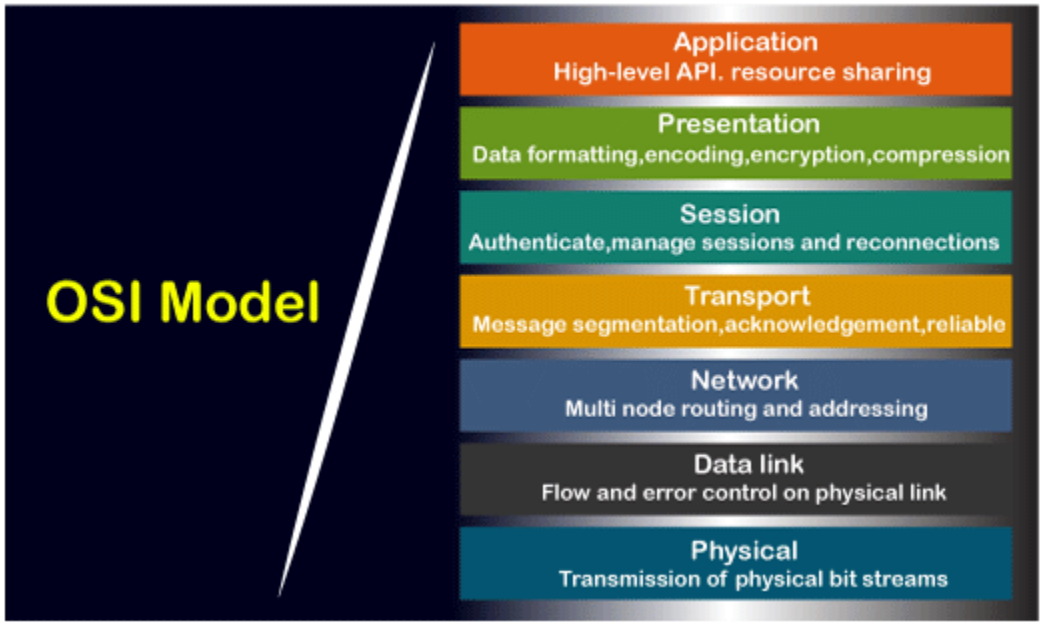
- The cost of the equipment is higher.
- The receiver and the transmitter are very complicated.
- For better communication, the antennas for the FM system must be kept closed.
- It is not efficient for large bandwidth.
- Power wastage takes place.

OSI vs TCP/IP

What is OSI model?

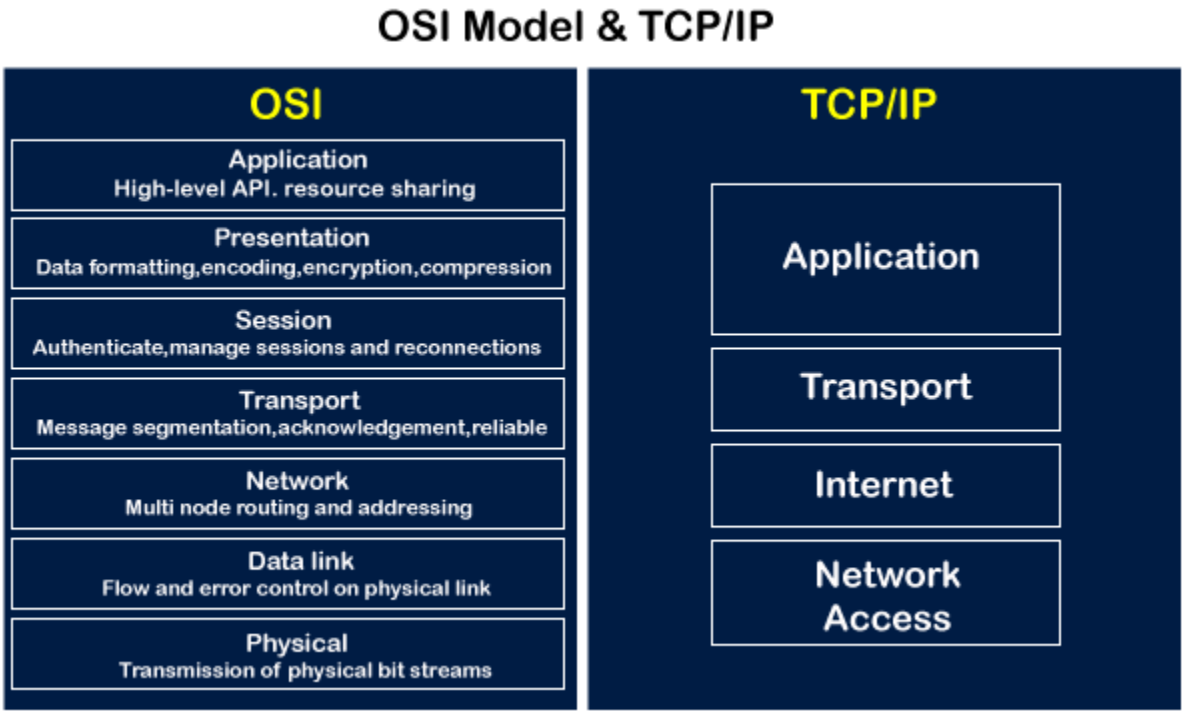
The OSI stands for Open System Interconnection, which was developed in 1980s. It is a conceptual model used for network communication. It is not implemented entirely, but it is still referenced today. This OSI model consists of seven layers, and each layer is connected to each other. The data moves down the OSI model, and each layer adds additional information. The data moves down until it reaches the last layer of the OSI model. When the data is received at the last layer of the OSI model, then the data is

transmitted over the network. Once the data is reached on the other side, then the process will get reversed.



What is TCP/IP model?

The TCP model stands for **Transmission Control Protocol,** whereas IP stands for **Internet Protocol**. A number of protocols that make the internet possibly comes under the TCP/IP model. Nowadays, we do not hear the name of the TCP/IP model much, we generally hear the name of the IPv4 or IPv6, but it is still valid. This model consists of 4 layers. Now, we will look at the diagrammatic representation of the TCP/IP model.



As shown in the above diagram, the TCP/IP model has 4 layers, while the OSI model consists of 7 layers. Diagrammatically, it looks that the 4 layers of the TCP/IP model exactly fit the 7 layers of the OSI model, but this is not reality. The application layer of the TCP/IP model maps to the first three layers, i.e., application, session, and presentation layer of the OSI model. The transport layer of the TCP maps directly to the transport layer of the OSI model. The internet layer of the TCP/IP model maps directly to the network layer of the OSI model. The last two layers of the OSI model map to the network layer of the TCP/IP model. TCP/IP is the most widely used model as compared to the OSI model for providing communication between computers over the internet.

Similarities between the OSI and TCP/IP model

The following are the similarities between the OSI and TCP/IP model:

- **Share common architecture**

Both the models are the logical models and having similar architectures as both the models are constructed with the layers.

- **Define standards**

Both the layers have defined standards, and they also provide the framework used for implementing the standards and devices.

- **Simplified troubleshooting process**

Both models have simplified the troubleshooting process by breaking the complex function into simpler components.

- **Pre-defined standards**

The standards and protocols which are already pre-defined; these models do not redefine them; they just reference or use them. For example, the Ethernet standards were already defined by the IEEE before the development of these models; instead of recreating them, models have used these pre-defined standards.

- **Both have similar functionality of 'transport' and 'network' layers**

The function which is performed between the **'presentation'** and the **'network'** layer is similar to the function performed at the **transport** layer.

Differences between the OSI and TCP/IP model

Let's see the differences between the OSI and TCP/IP model in a tabular form:

OSI Model	TCP/IP Model
It stands for **Open System Interconnection.**	It stands for **Transmission Control Protocol.**
OSI model has been developed by ISO (International Standard Organization).	It was developed by ARPANET (Advanced Research Project Agency Network).
It is an independent standard and generic protocol used as a communication gateway between the network and the end user.	It consists of standard protocols that lead to the development of an internet. It is a communication protocol that provides the connection among the hosts.
In the OSI model, the transport layer provides a guarantee for the delivery of the packets.	The transport layer does not provide the surety for the delivery of packets. But still, we can say that it is a reliable model.
This model is based on a vertical approach.	This model is based on a horizontal approach.
In this model, the session and presentation layers are separated, i.e., both the layers are different.	In this model, the session and presentation layer are not different layers. Both layers are included in the application layer.
It is also known as a reference model through which various networks are built. For example, the TCP/IP model is built from the OSI model. It is also referred to as a guidance tool.	It is an implemented model of an OSI model.
In this model, the network layer provides both connection-oriented and connectionless service.	The network layer provides only connectionless service.
Protocols in the OSI model are hidden and can be easily replaced when the technology changes.	In this model, the protocol cannot be easily replaced.
It consists of 7 layers.	It consists of 4 layers.

OSI model defines the services, protocols, and interfaces as well as provides a proper distinction between them. It is protocol independent.	In the TCP/IP model, services, protocols, and interfaces are not properly separated. It is protocol dependent.
The usage of this model is very low.	This model is highly used.
It provides standardization to the devices like router, motherboard, switches, and other hardware devices.	It does not provide the standardization to the devices. It provides a connection between various computers.