MULTIPLEXING

What is multiplexing?

Multiplexing (Muxing) is a term used in the field of communications and computer networking. It generally refers to the process and technique of transmitting multiple analog or digital input signals or data streams over a single channel. Since multiplexing can integrate multiple low-speed channels into one high-speed channel for transmission, the high-speed channel is effectively utilized. By using multiplexing, communication carriers can avoid maintaining multiple lines, therefore, operating costs are effectively saved.

Multiplexer (Mux) is a device which performs the multiplexing process. It is a hardware component that combines multiple analog or digital input signals into a single line of transmission.

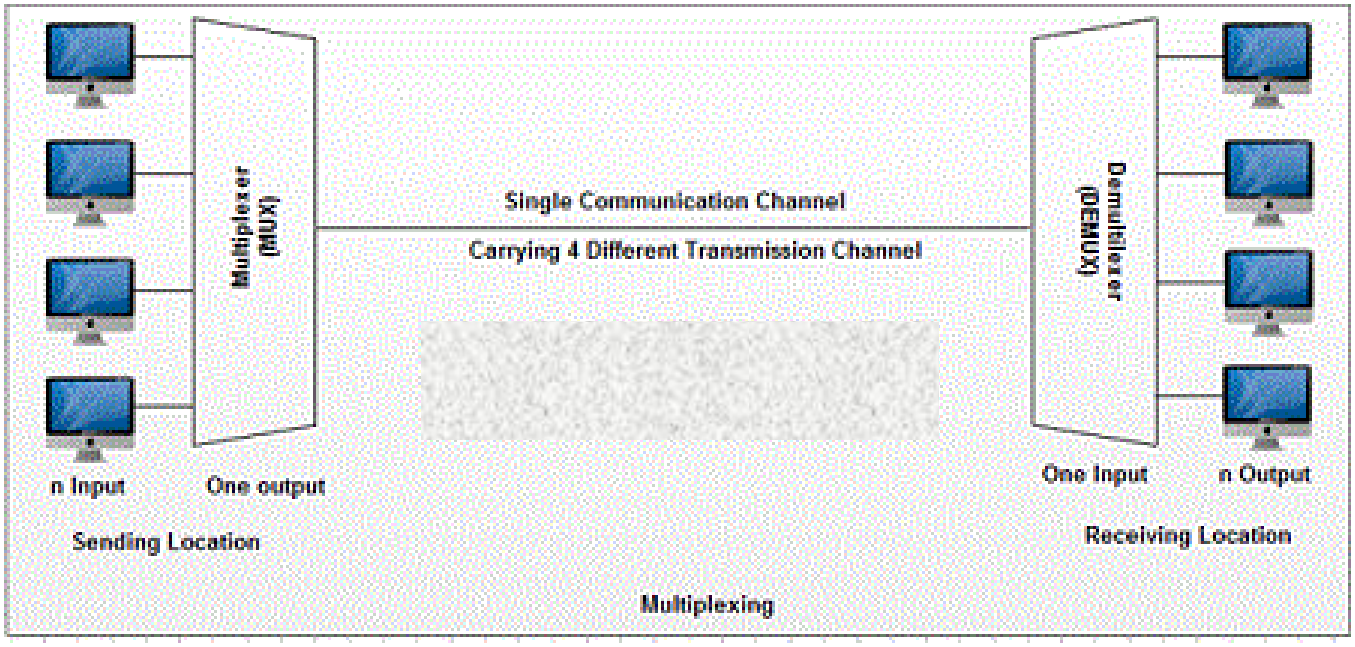
Communication is possible over the air (radio frequency), using a physical media (cable), and light (optical fiber). All mediums are capable of multiplexing.

What is demultiplexing?

Demultiplexing (Demuxing) is a term relative to multiplexing. It is the reverse of the multiplexing process. Demultiplex is a process reconverting a signal containing multiple analog or digital signal streams back into the original separate and unrelated signals.

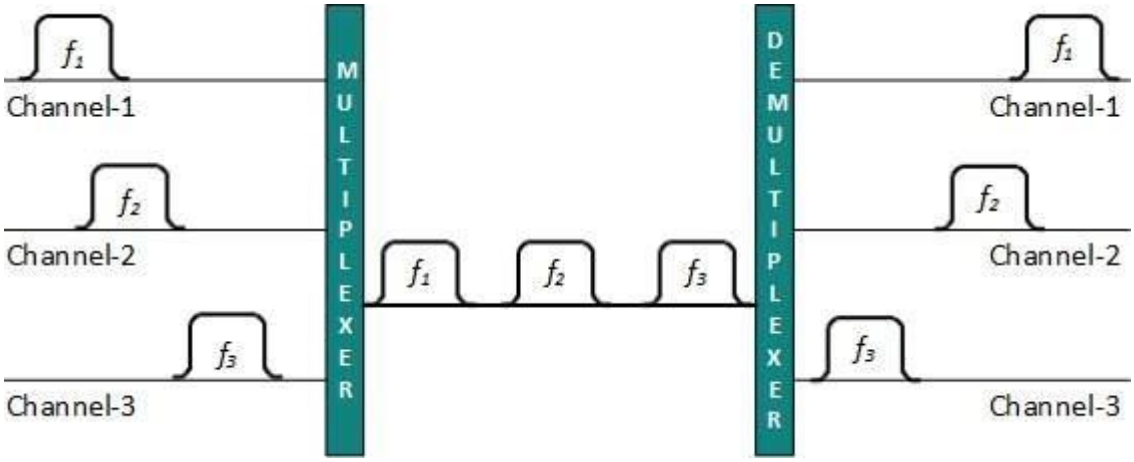
Although demultiplexing is the reverse of the multiplexing process, it is not the opposite of multiplexing. The opposite of multiplexing is inverse multiplexing (iMuxing), which breaks one data stream into several related data streams. Thus, the difference between demultiplexing and inverse multiplexing is that the output streams of demultiplexing are unrelated, while the output streams of inverse multiplexing are related.

Demultiplexer (Demux) is a device that performs the reverse process of multiplexer.



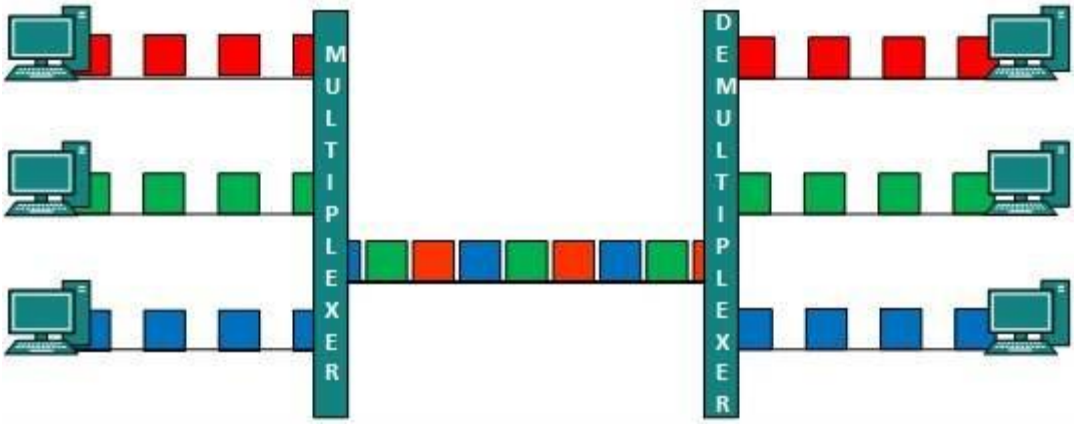
Frequency Division Multiplexing

When the carrier is frequency, FDM is used. FDM is an analog technology. FDM divides the spectrum or carrier bandwidth in logical channels and allocates one user to each channel. Each user can use the channel frequency independently and has exclusive access of it. All channels are divided in such a way that they do not overlap with each other. Channels are separated by guard bands. Guard band is a frequency which is not used by either channel.



Time Division Multiplexing

TDM is applied primarily on digital signals but can be applied on analog signals as well. In TDM the shared channel is divided among its user by means of time slot. Each user can transmit data within the provided time slot only. TDM works in synchronized mode. Both ends, i.e. Multiplexer and De-multiplexer are timely synchronized and both switch to next channel simultaneously.



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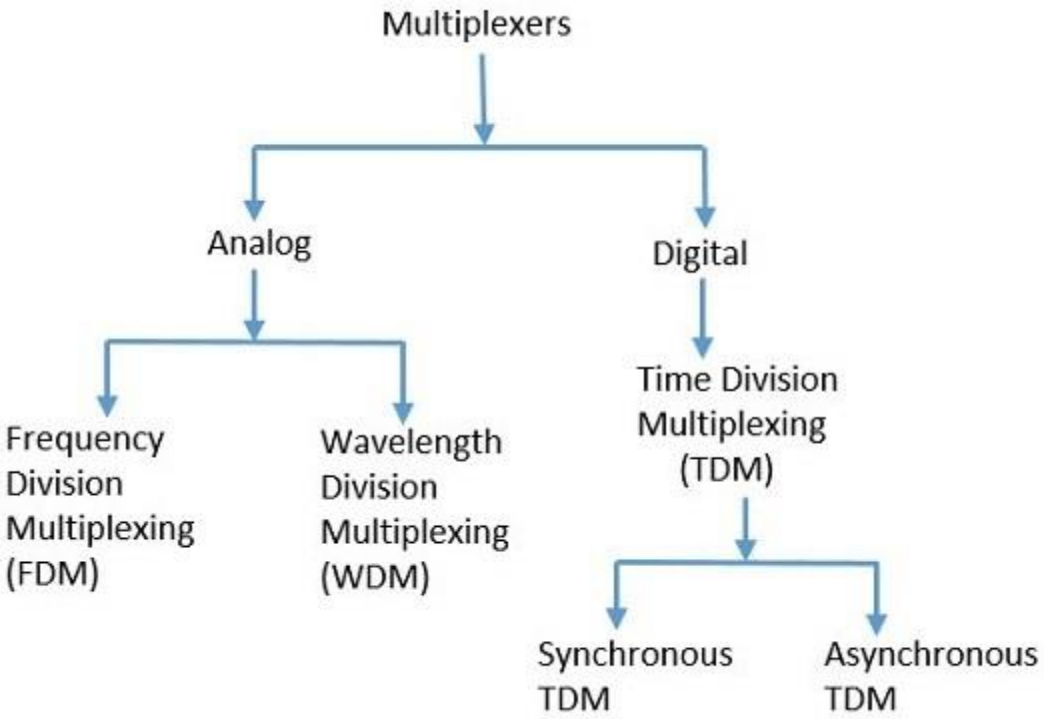
Wavelength Division Multiplexing

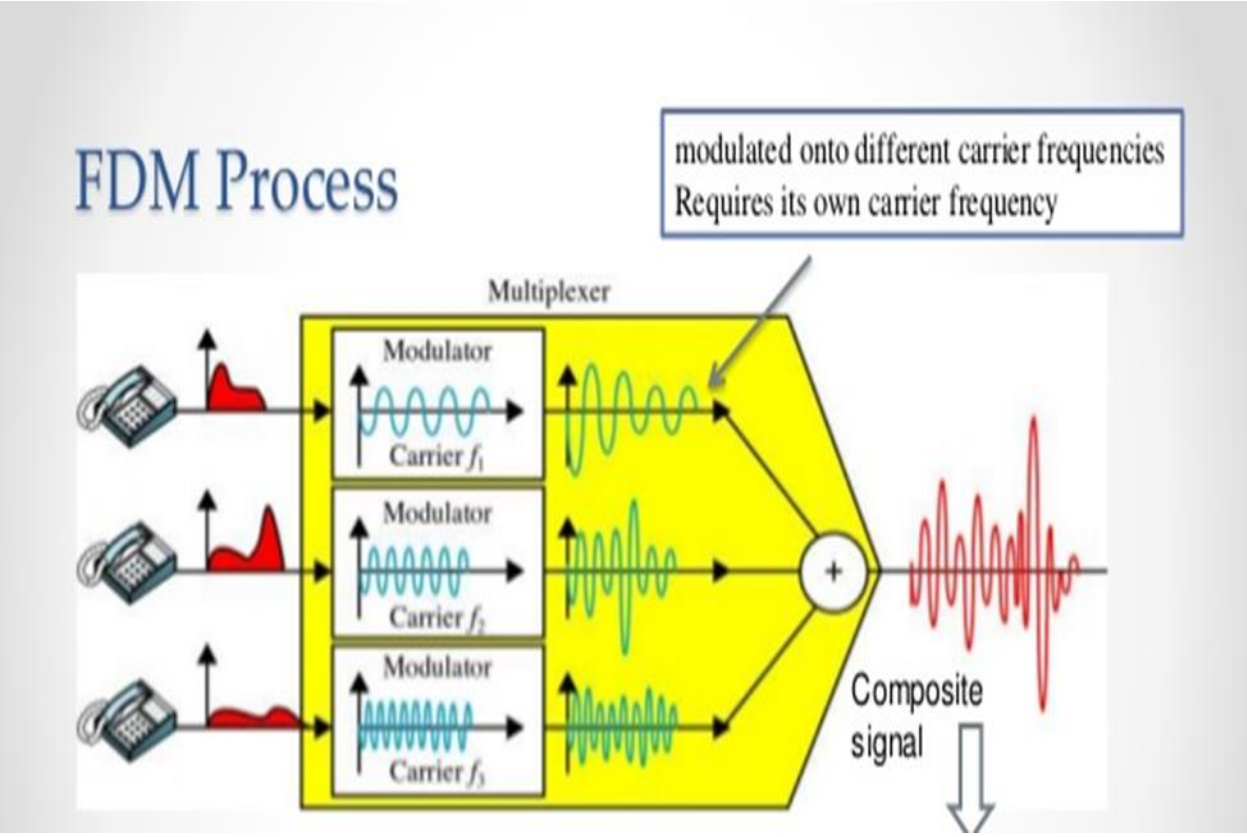
Light has different wavelength (colors). In fiber optic mode, multiple optical carrier signals are multiplexed into an optical fiber by using different wavelengths. This is an analog multiplexing technique and is done conceptually in the same manner as FDM but uses light as signals.

CATEGORIES OF MULTIPLEXING:

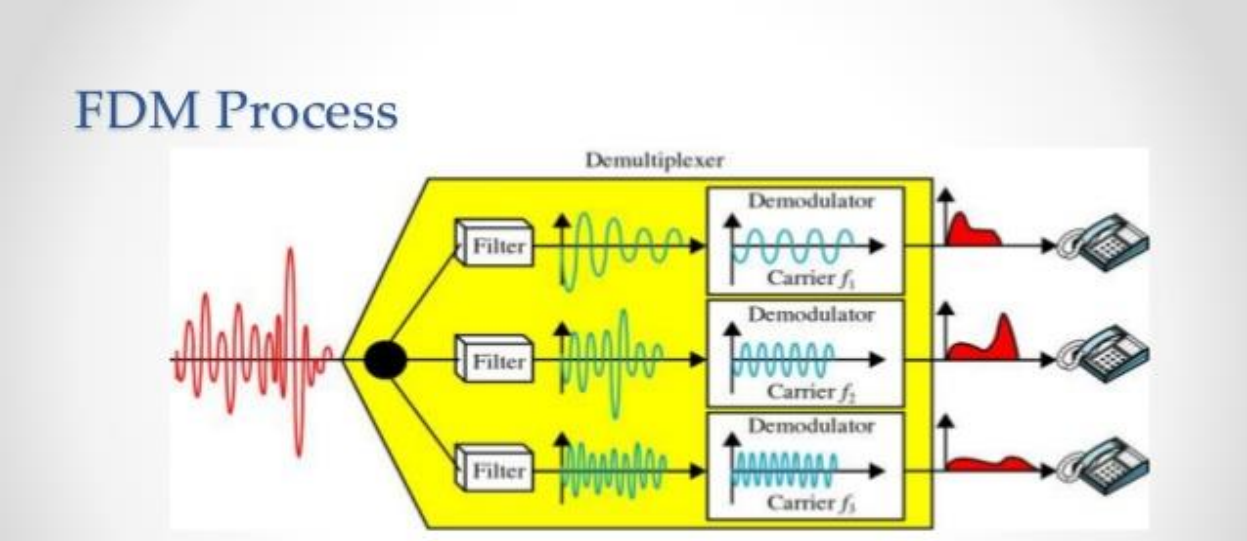


FREQUENCY DIVISION MULTIPLEXING:

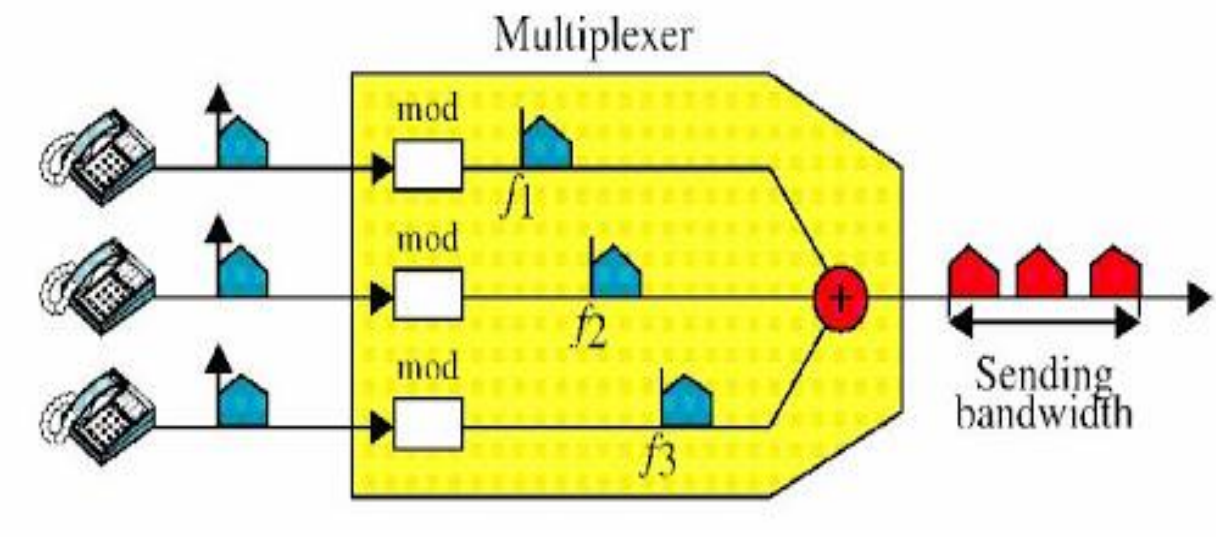
In the 20th century, many telephone companies used frequency-division multiplexing for long distance connections to multiplex thousands of voice signals through a coaxial cable system. For shorter distances, cheaper balanced cables were used, but they didn't allow large bandwidths. The FDM is an analog multiplexing that combines analog signals. Frequency division multiplexing is applied when the bandwidth of the link is greater than the combined bandwidth of the signals to be transmitted.

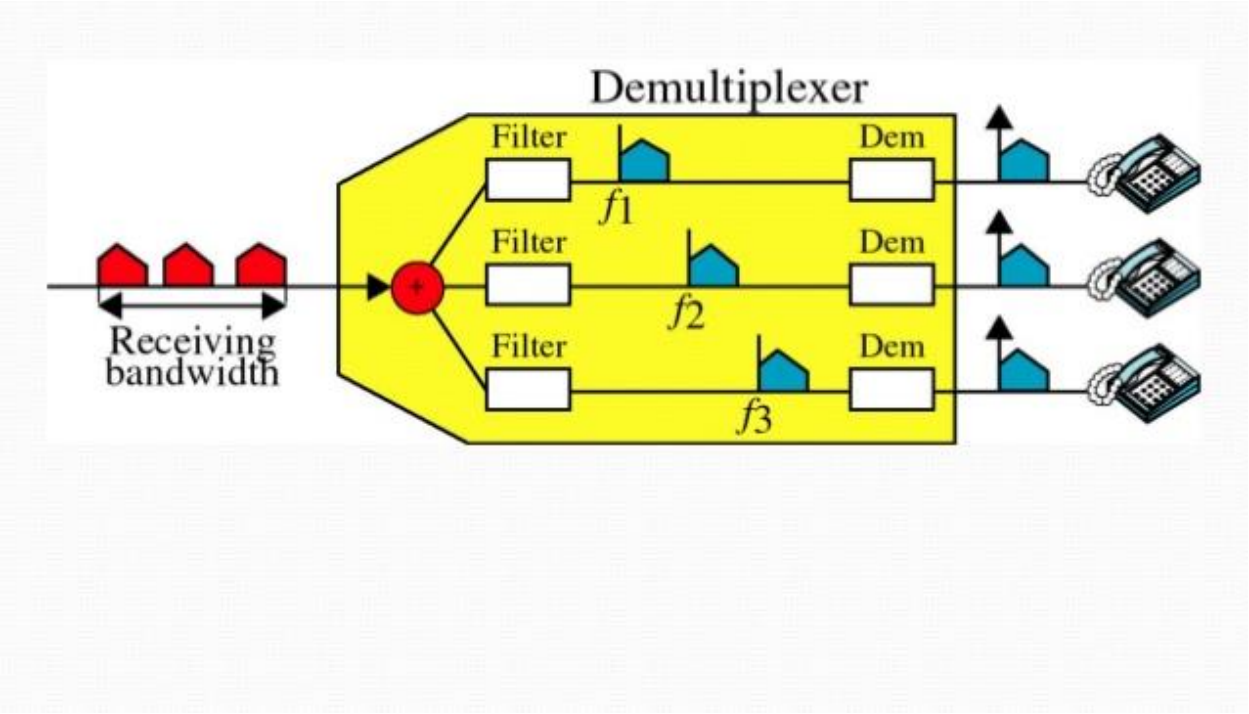


In this type of multiplexing, signals are generated by sending different device-modulated carrier frequencies, and these modulated signals are then combined into a single signal that can be transported by the link. To accommodate the modulated signal, the carrier frequencies are separated with enough bandwidth, and these bandwidth ranges are the channels through which different signals travel. These channels can be separated by unused bandwidth. Some of the examples for the time division multiplexing include radio and television signal transmission.



The same can be shown in frequency domain like this -





Advantages:

There are some advantages of frequency division multiplexing (FDM) which are given below,

- It does not need synchronization between its transmitter and receiver.
- Frequency division multiplexing (FDM) is simpler and easy demodulation.
- Due to slow narrow band fading only one channel gets affected.
- It is used for analog signals.
- A large number of signals (channels) can be transmitted simultaneously.

Disadvantages:

There are some disadvantages of frequency division multiplexing (FDM) which are given below,

- It is suffers problem of cross-talk.
- It is used only when a few low speed channels are desired.
- Intermodulation distortion takes place.

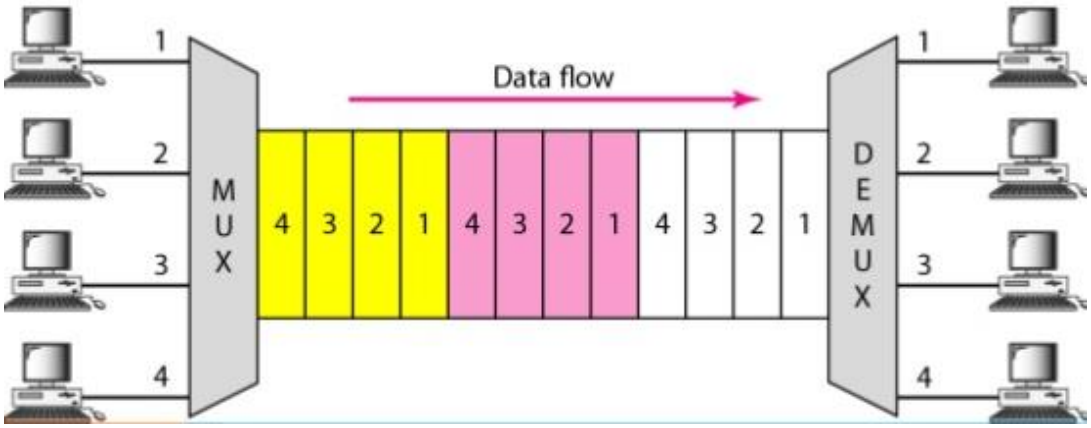
Applications:

- It is used to public telephones and in cable TV systems.
- It is used in broad casting.
- It is used in AM and FM broadcasting.

TIME DIVISION MULTIPLEXING

Time Division Multiplexing (TDM) –

This happens when data transmission rate of media is greater than that of the source, and each signal is allotted a definite amount of time. These slots are so small that all transmissions appear to be parallel. In frequency division multiplexing all the signals operate at the same time with different frequencies, but in time division multiplexing all the signals operate with same frequency at different times.

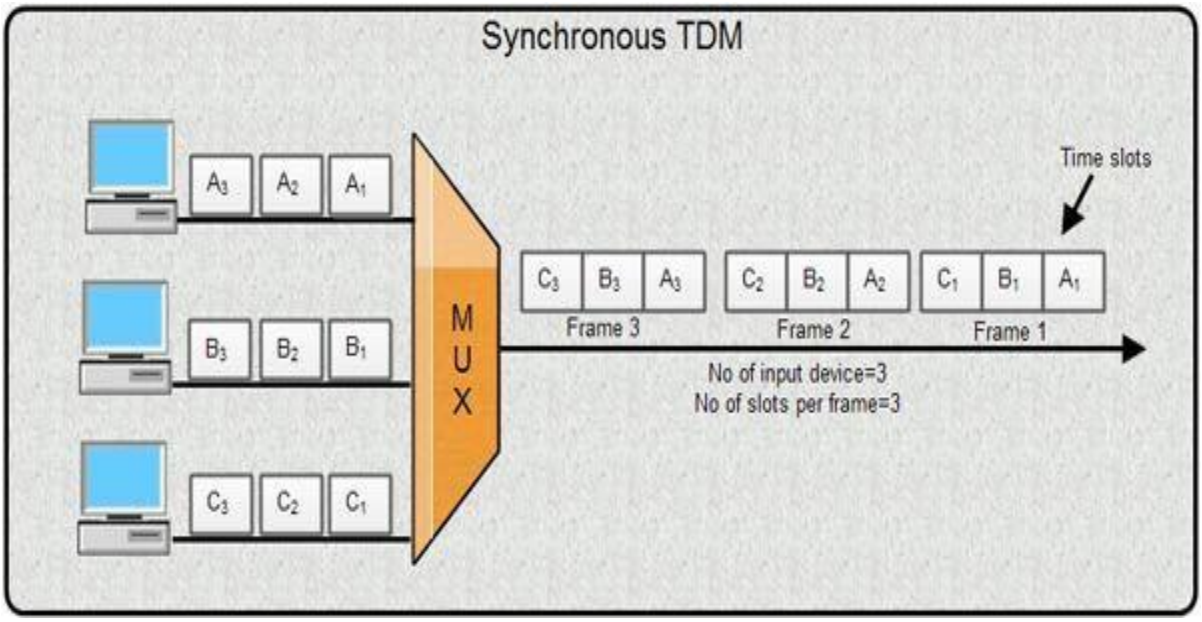


Synchronous TDM –

The time slots are pre-assigned and fixed. This slot is even given if the source is not ready with data at this time. In this case the slot is transmitted empty. It is used for multiplexing digitized voice stream.

1. In synchronous TDM, each device is given same **time slot** to transmit the data over the link, irrespective of the fact that the device has any data to transmit or not. Hence the name Synchronous TDM. Synchronous TDM requires that the total speed of various input lines should not exceed the capacity of path.
2. Each device places its data onto the link when its **time slot** arrives *i.e.* each device is given the possession of line turn by turn.

3. If any device does not have data to send then its time slot remains empty.
4. The various time slots are organized into **frames** and each frame consists of one or more time slots dedicated to each sending device.
5. If there are *n* sending devices, there will be *n* slots in frame *i.e.* one slot for each device.



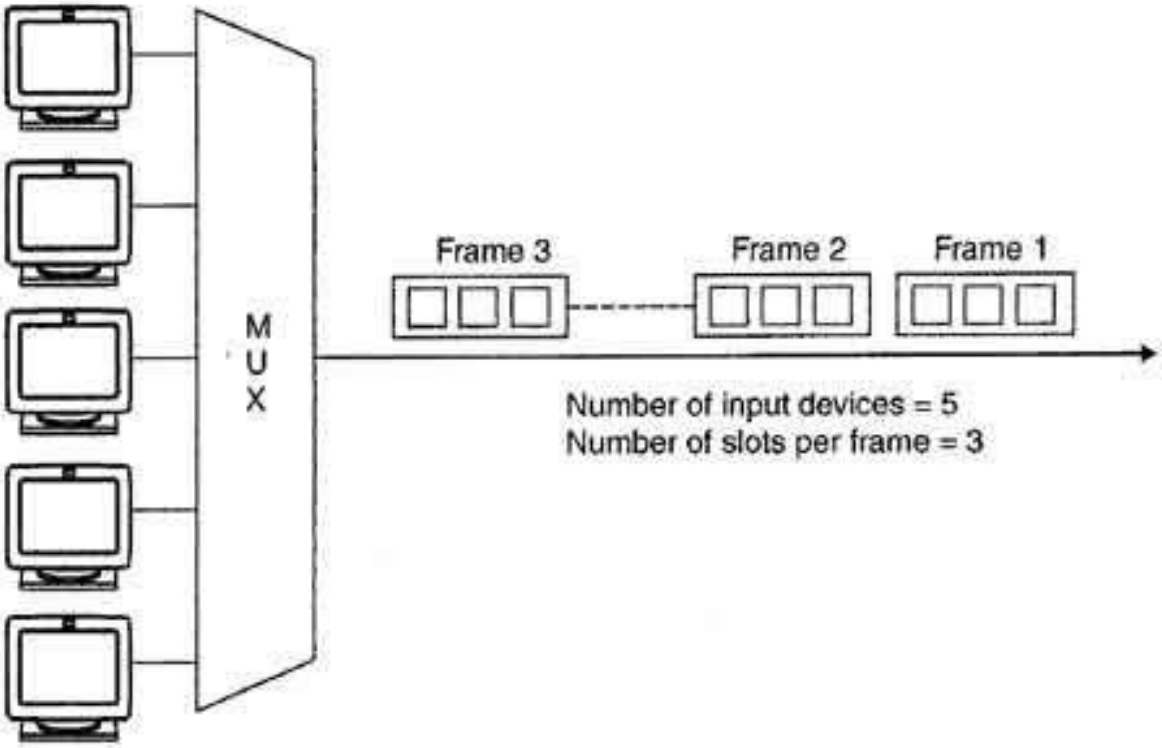
Disadvantages of Synchronous TDM

1. The channel capacity cannot be fully utilized. Some of the slots go empty in certain frames. As shown in fig only first two frames are completely filled. The last three frames have 6 empty slot. It means out of 20 slots in all, 6 slots are empty. This wastes the l/4th capacity of links.

2. The capacity of single communication line that is used to carry the various transmission should be greater than the total speed of input lines.

Asynchronous (or statistical) TDM –
The slots are allocated dynamically depending on the speed of source or their ready

state. It dynamically allocates the time slots according to different input channel's needs, thus saving the channel capacity.



1. It is also known as statistical time division multiplexing.

2. Asynchronous TDM is called so because is this type of multiplexing, time slots are not fixed *i.e.* the slots are flexible.

3. Here, the total speed of input lines can be greater than the capacity of the path.

4. In synchronous TDM, if we have *n* input lines then there are *n* slots in one frame. But in asynchronous it is not so.

5. In asynchronous TDM, if we have *n* input lines then the frame contains not more than *m* slots, with *m* less than *n (m < n).*

7. In this system slots are not predefined, the slots are allocated to any of the device that has data to send.

8. The multiplexer scans the various input lines, accepts the data from the lines that have data to send, fills the frame and then sends the frame across the link.

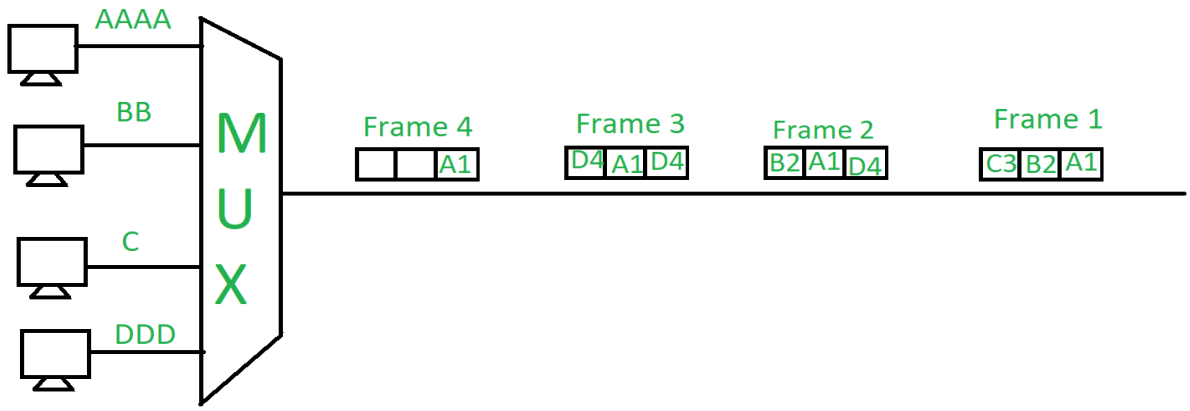
9. If there are not enough data to fill all the slots in a frame, then the frames are transmitted partially filled.

Advantages of TDM:

1Full available channel bandwidth can be utilized for each channel.

Disadvantages of TDM:

Synchronization is essential for proper operation.

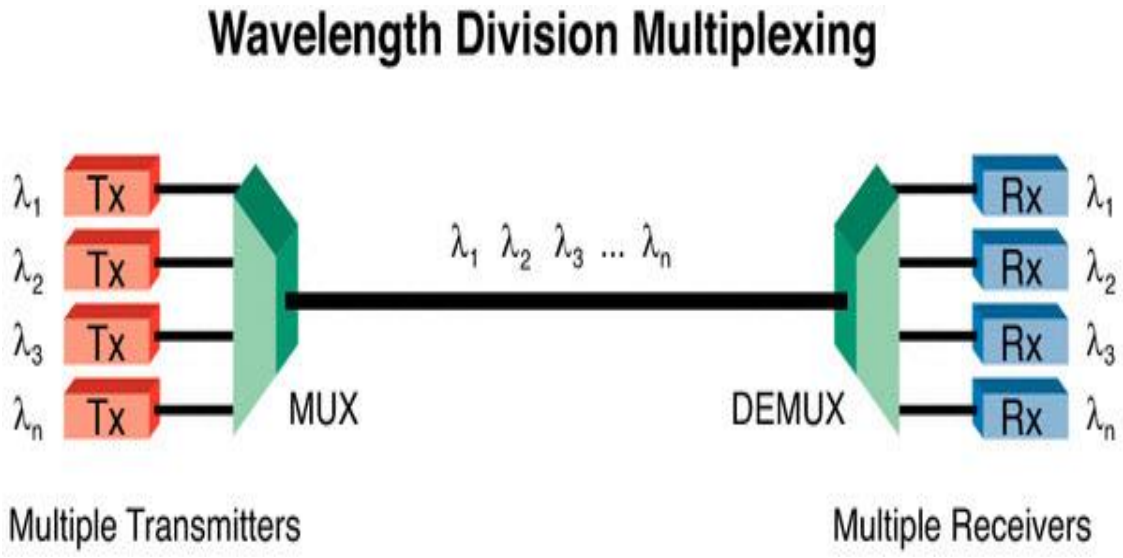


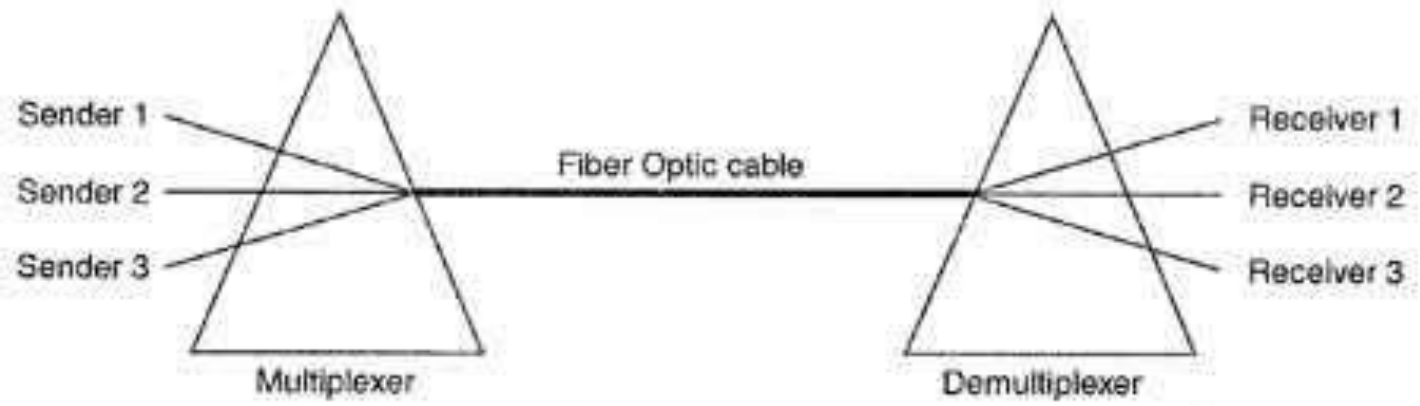
WAVE- DIVISION MULTIPLEXING (WDM)

Wavelength division multiplexing (WDM) is a technology in fiber optic communications and, for the high capacity communication systems, wavelength division multiplexing is the most promising concept. This system uses multiplexer at transmitter to join signals and demultiplexer to split the signals apart, at the receiver end. The purpose of WDM is to combine multiple light sources into a single light source at the multiplexer; and, at the demultiplexer the single light is converted into multiple light sources.

WDM is designed to use the high data rate capability of the fiber optic cable. The data rate of this cable is higher than the metallic transmission cable's data rate. Conceptually, the wavelength division multiplexing is same as the frequency division

multiplexing, except for the transmission through the fiber optic channels wherein the multiplexing and demultiplexing involves optical signals.





Usage of prisms in WDM