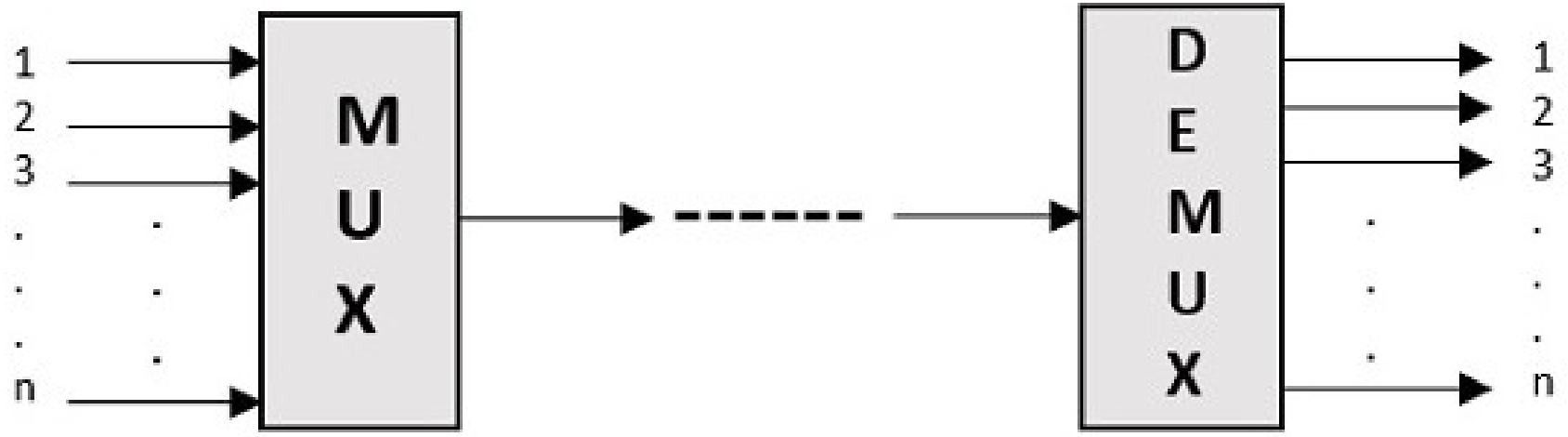
Multiplexing and Demultiplexing

- Multiplexing is the process of combining multiple signals into one signal, over a shared medium. It divides the physical line or medium into logical segments called channels.
- Multiplexing is done by using a device called multiplexer (MUX) that combines n input lines to generate one output line i.e. (many to one). Therefore multiplexer (MUX) has several inputs and one output.
- At the receiving end, a device called demultiplexer (DEMUX) is used that separates signal into its component signals. So demultiplexer has one input and several outputs.
- **HISTORY:**
  - Multiplexing was first developed in telephony. A number of signals were combined to send through a single cable. **The process of multiplexing divides a communication channel into several number of logical channels, allotting each one for a different message signal or a data stream to be transferred.** The device that does multiplexing, can be called as a MUX.
  - The reverse process, i.e., extracting the number of channels from one, which is done at the receiver is called as demultiplexing. The device which does demultiplexing is called as DEMUX.

Multiplexing and Demultiplexing

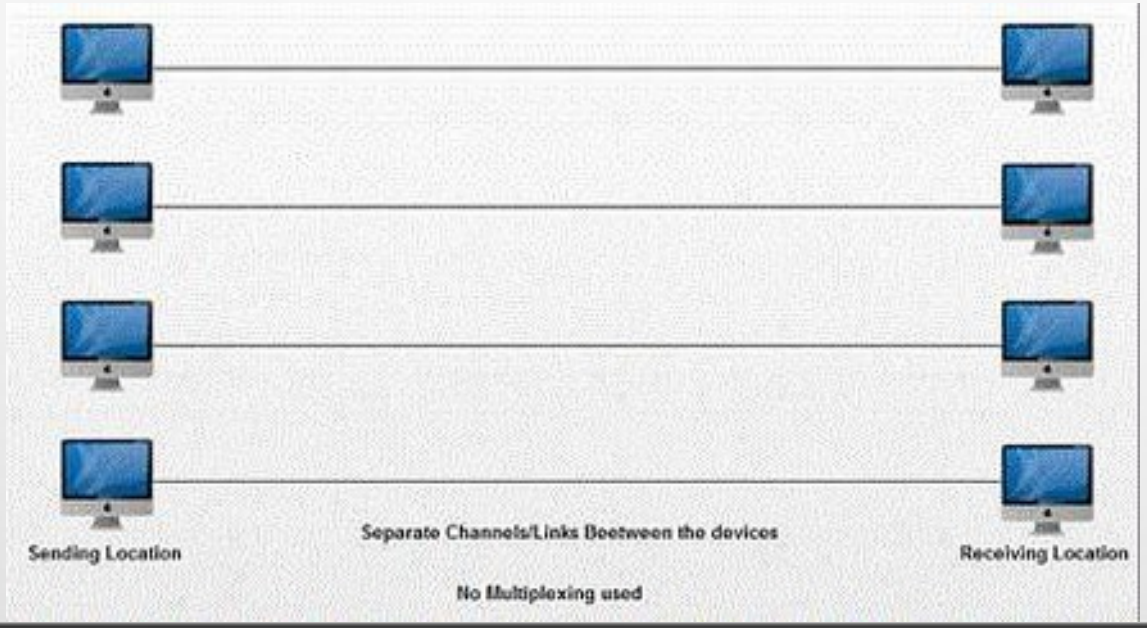
- The following figures illustrates the concept of MUX and DEMUX. Their primary use is in the field of communications.



Multiplexing and Demultiplexing

Multiplexing and Demultiplexing

- **Advantages of Multiplexing**
- If no multiplexing is used between the users at two different sites that are distance apart, then separate communication lines would be required as shown in fig.
- This is not only costly but also become difficult to manage. If multiplexing is used then, only one line is required. This leads to the reduction in the line cost and also it would be easier to keep track of one line than several lines. Multiplexing efficient for utilization of bandwidth.



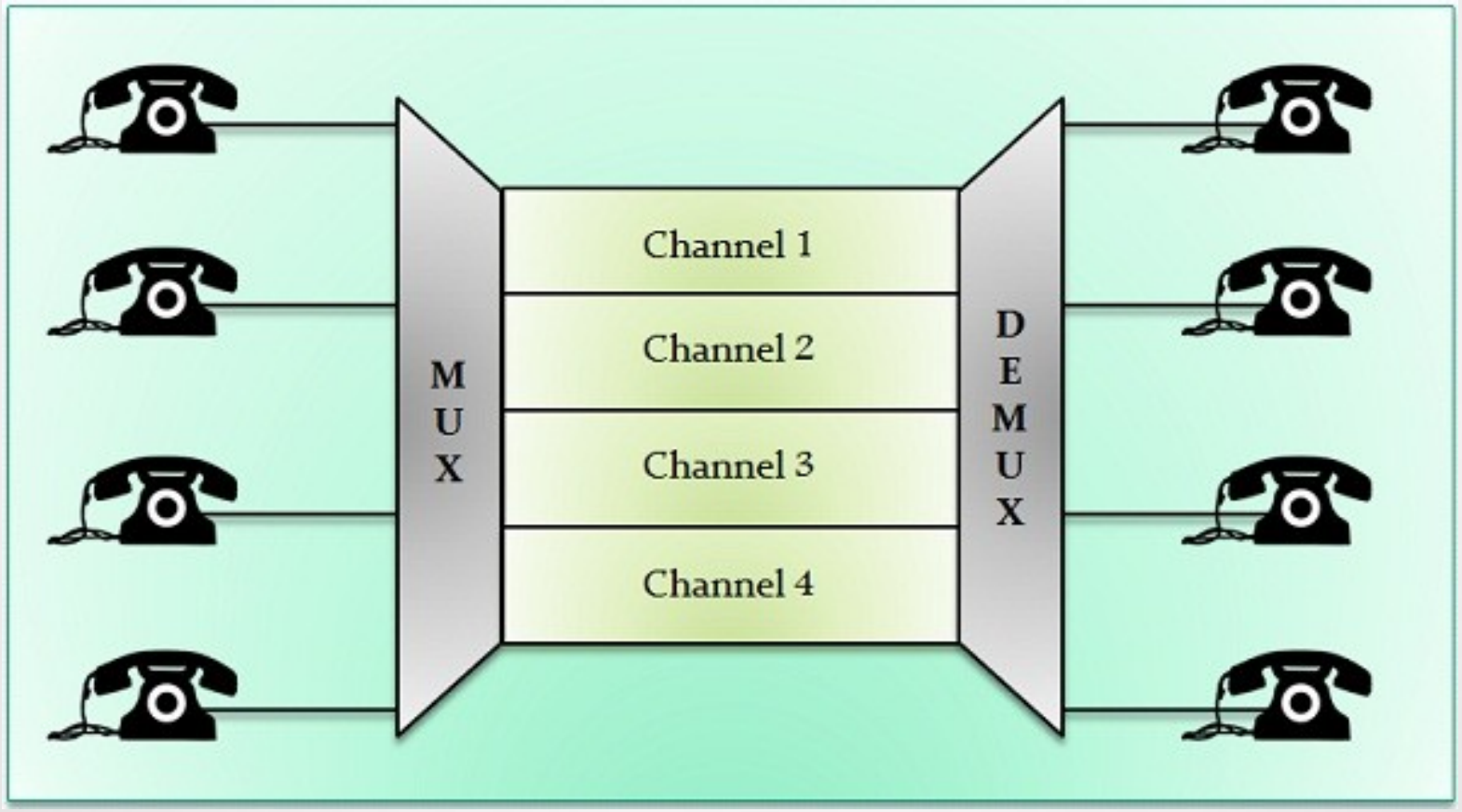
Analog Multiplexing

- The signals used in analog multiplexing techniques are analog in nature. The analog signals are multiplexed according to their frequency (FDM) or wavelength (WDM).

FDM – Frequency Division Multiplexing

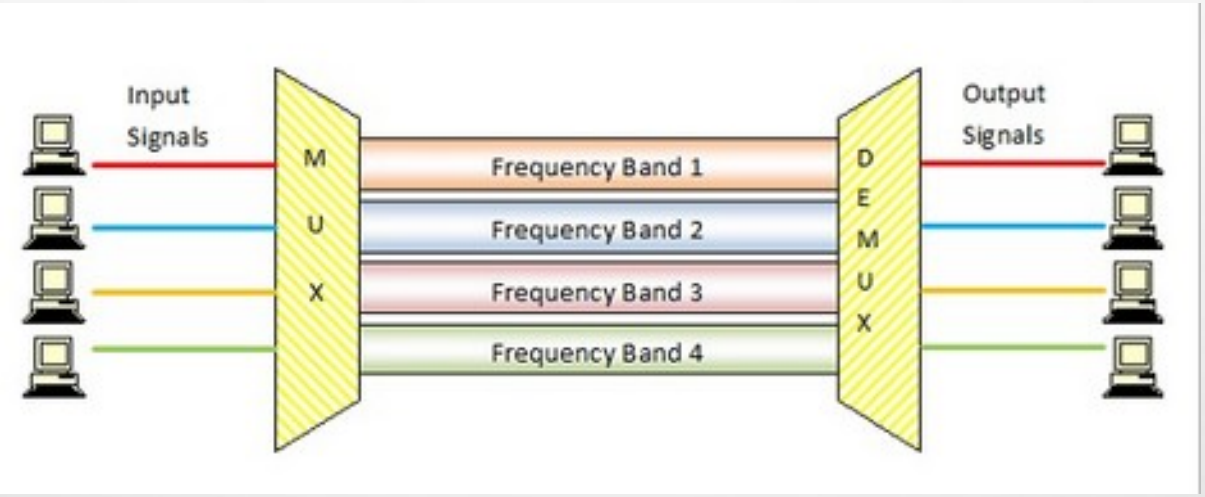
- FDM used in public telephones and cable **TV systems,** where a single cable carries multiple video signals from different channels to the TV set.
- With the remote control, we essentially activate the electronic circuits in the television to select a specific frequency band or channel and our program on TV set is set(visualize).
- The signals from other programs also actually traverse to your TV set on the same cable, but they lie idle at your TV set for you to choose from.
- In FDM , the medium is divided into number of channels, each with a frequency bandwidth. Though the composite signal ultimately carried by the medium in analog the input signals can be analog or digital. If the input signals are analog, multiplexers at both the ends are sufficient as shown in fig.

FDM – Frequency Division Multiplexing



FDM – Frequency Division Multiplexing

- Frequency division multiplexing (FDM) is a technique of multiplexing which means combining more than one signal over a shared medium. In FDM, signals of different frequencies are combined for concurrent transmission.
- In FDM, the total bandwidth is divided to a set of frequency bands that do not overlap. Each of these bands is a carrier of a different signal that is generated and modulated by one of the sending devices. The frequency bands are separated from one another by strips of unused frequencies called the guard bands, to prevent overlapping of signals.



FDM – Frequency Division Multiplexing

- **Advantages:**
  - It does not need synchronization between its transmitter and receiver.
  - Frequency division multiplexing (FDM) is simpler and easy demodulation.
  - It is used for analog signals.
  - A large number of signals (channels) can be transmitted simultaneously.

- **Disadvantages:**
  - It suffers problem of cross-talk.
  - It is used only when a few low speed channels are desired.
  - Intermodulation distortion takes place.
  - The communication channel must have a very large bandwidth.
  - Large number of modulators and filters are required.

FDM – Frequency Division Multiplexing

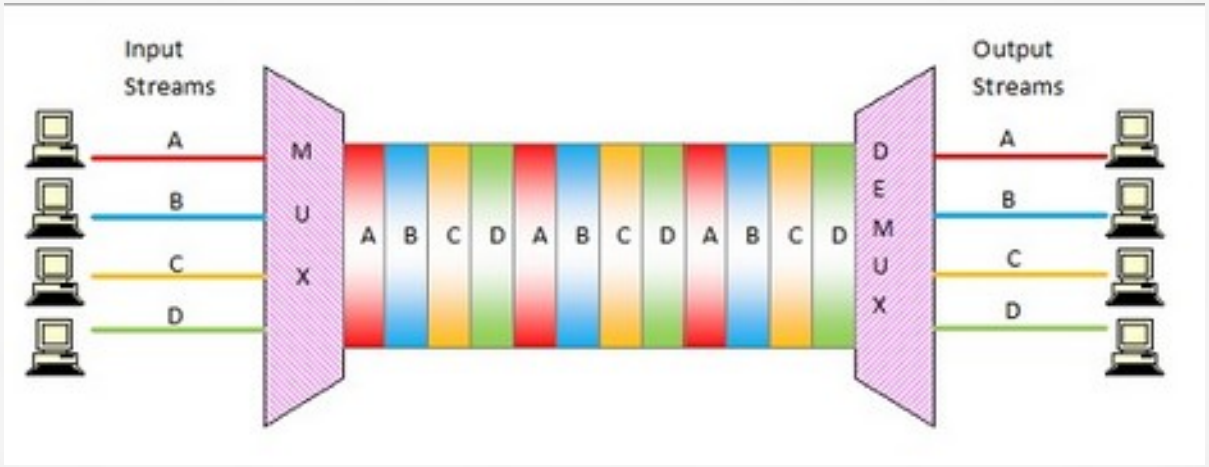
- **Applications:**
  - It is used in public telephones.
  - In cable TV systems. A multiplexor is used to combine many channels to maximize the use of the available bandwidth and a Demultiplexer built into the television or set top box will separate the channel that the viewer wants to watch.
  - It is used in broad casting.
  - It is used in AM and FM radio broadcasting.

TDM – Time Division Multiplexing

- Time division multiplexing (TDM) is a technique of multiplexing, where the users are allowed the **total available bandwidth on time sharing basis.** Here the time domain is divided into several **recurrent slots of fixed length,** and each signal is allotted a time slot on a round-robin basis.
- In TDM, the data flow of each input stream is divided into units. One unit may be 1 bit, 1 byte, or a block of few bytes. Each input unit is allotted an input time slot. One input unit corresponds to one output unit and is allotted an output time slot. During transmission, one unit of each of the input streams is allotted one-time slot, periodically, in a sequence, on a rotational basis. This system is popularly called round-robin system.
  - **Synchronous TDM (also known as TDM)**
  - **Statistical TDM**

TDM – Time Division Multiplexing

Consider a system having four input streams, A, B, C and D. Each of the data streams is divided into units which are allocated time slots in the round – robin manner. Hence, the time slot 1 is allotted to A, slot 2 is allotted to B, slot 3 is allotted to C, slot 4 is allotted to D, slot 5 is allocated to A again, and this goes on till the data in all the streams are transmitted.



- **Statistical Time Division Multiplexing (STDM)**

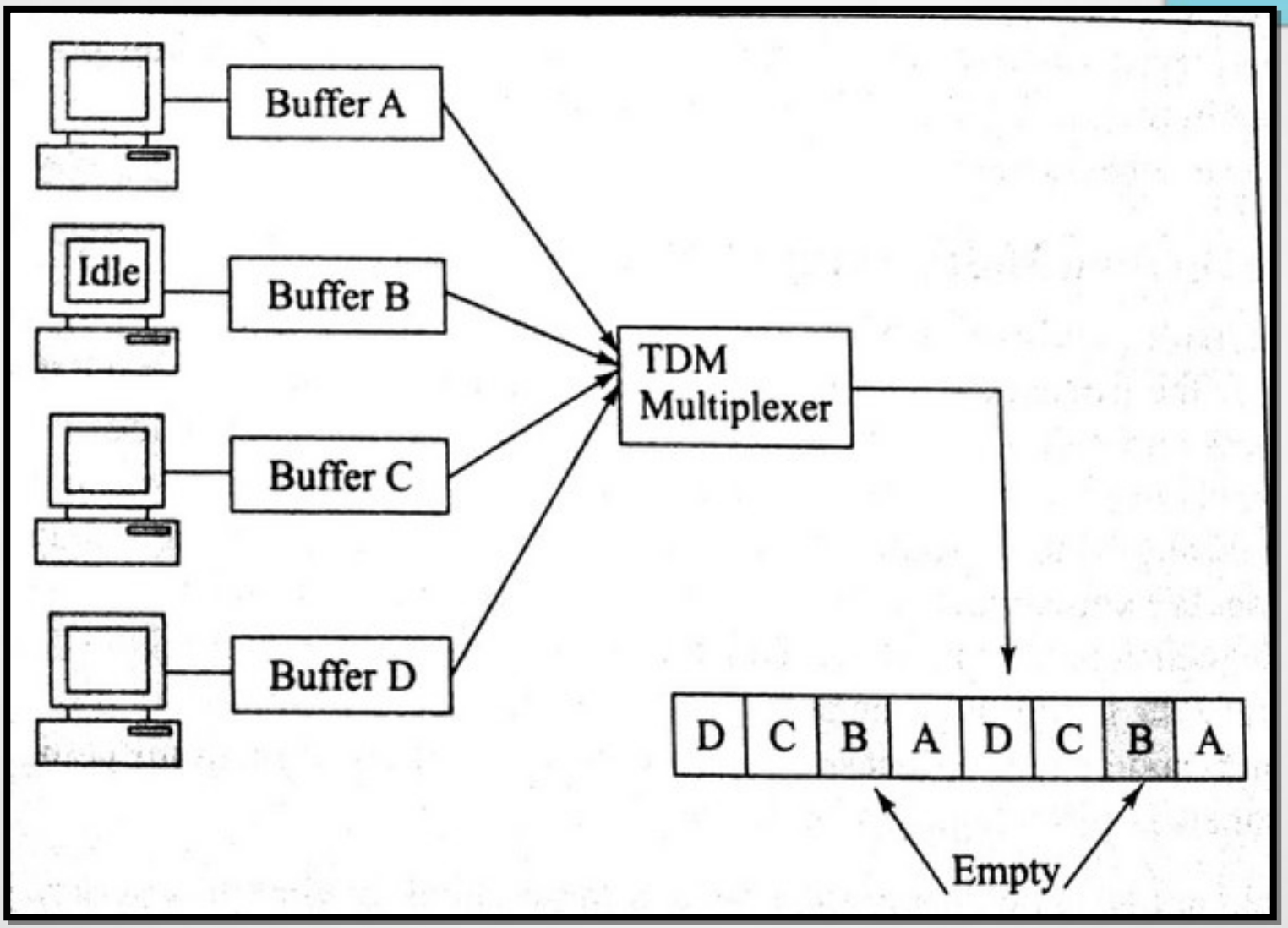
- In STDM, the time slots are dynamically allocated to the slots according to demand. The multiplexer checks each input stream in a round – robin manner and allocates a slot to an input line only if data is present there, otherwise, it skips to the next stream and checks it.

TDM – Time Division Multiplexing

Synchronous TDM (also known as TDM)

- In synchronous TDM, each device is given same time slot to transmit the data over the link, irrespective of the fact that device has any data to transmit or not.
- The time slice is allocated to a source node regardless of whether it wants to send some data or not.
- 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.
- If any device does not have data to send then its time slot remains empty.
- The various time slots are organized into frames and each frame consists of one or more time slots dedicated to each sending device.
- If there are n sending devices, there will be n slots in frame i.e. one slot for each device.
- A small buffer is associated with every source node. At any time, note all nodes may want to send some data.
- If there was no data to be transmitted, the buffer will be empty, but it will still be sent.
- **Hence it can be a very wasteful scheme, because the time slot is allotted to a source node even if it has nothing to send.**

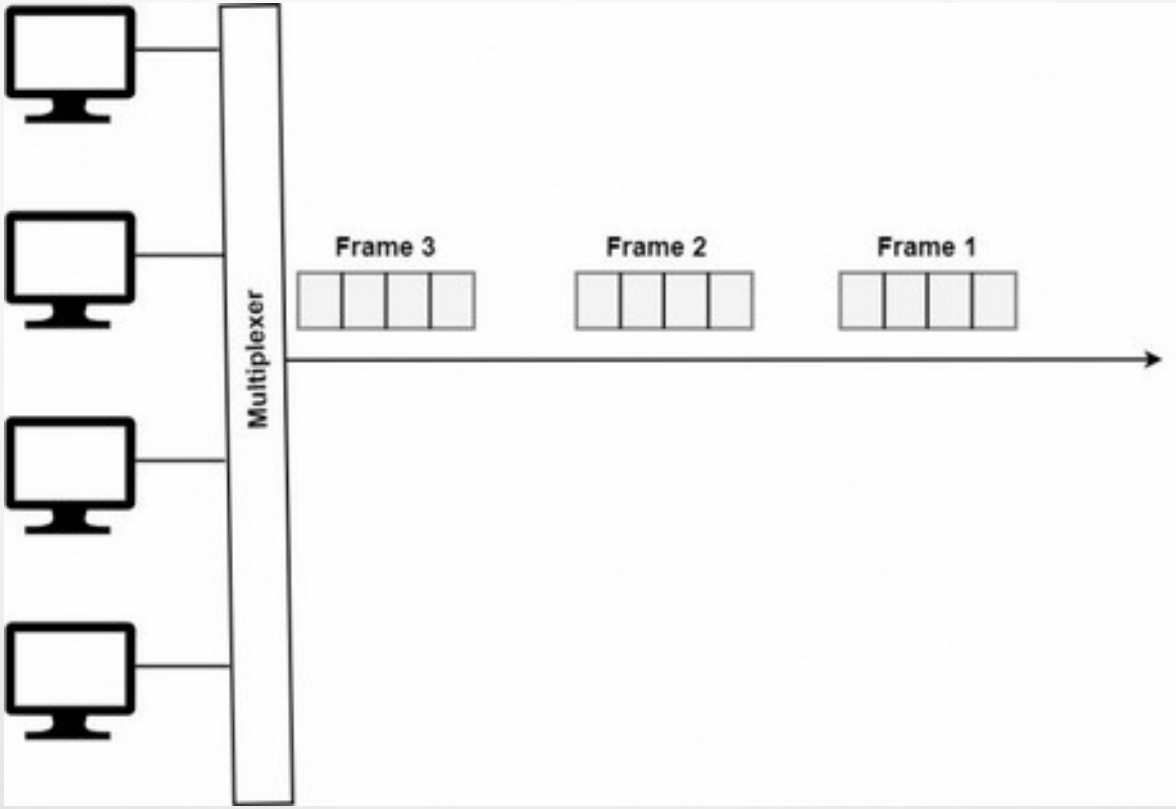
TDM – Time Division Multiplexing



TDM – Time Division Multiplexing

Asynchronous/Statistical TDM (also known as STDM)

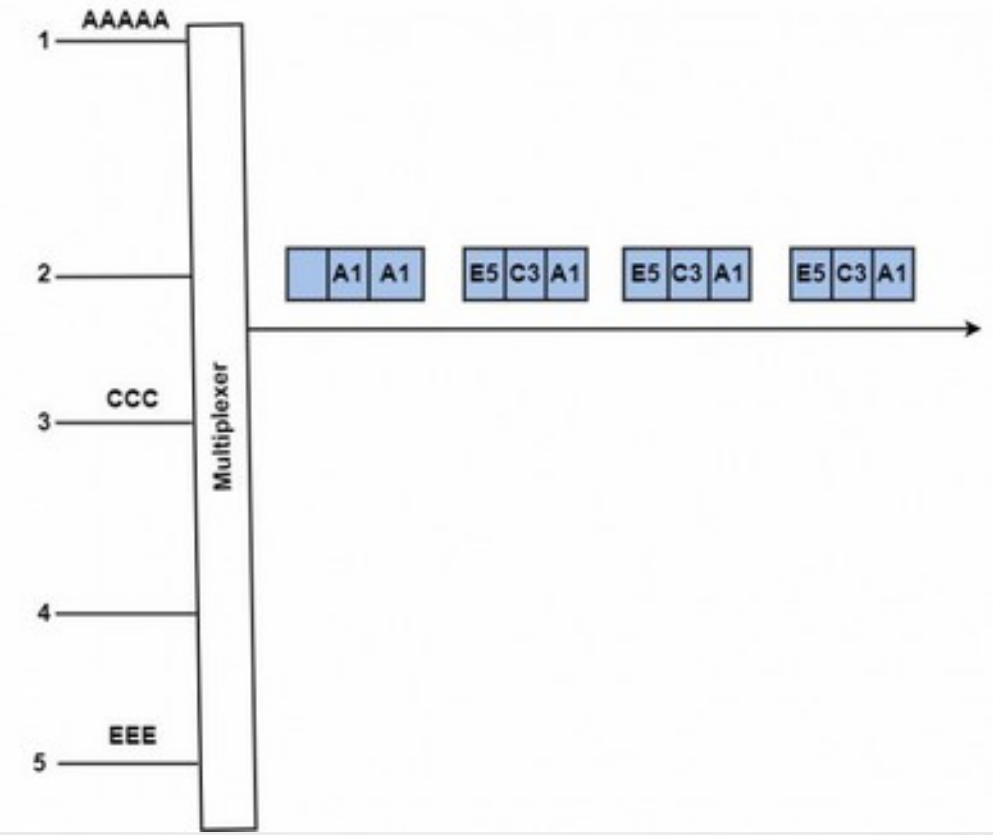
- An asynchronous TDM is also called as a Statistical TDM. ATDM has been designed to solve the problem of wastage of the multiplexed channels in synchronous TDM.
- In ATDM, if there are n input lines, then each slot can contain m frames, where m is less than n, as shown in the figure below.



TDM – Time Division Multiplexing

Asynchronous/Statistical TDM (also known as STDM)

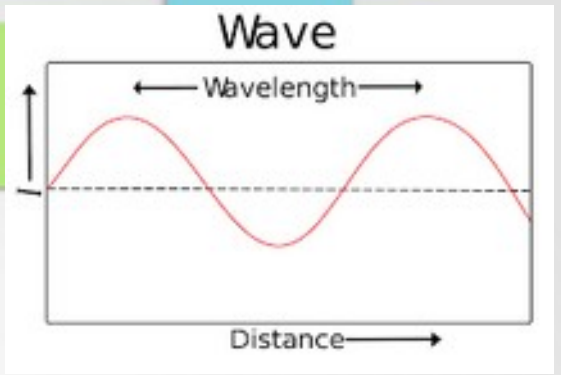
- In ATDM, the multiplexer scans all the input lines and accepts the portions of data till the frame is filled. When the frame is filled, it is sent across the link. If the senders don't have enough data to fill the frame, it is transmitted as partially filled. This is depicted in the figure below.



TDM – Time Division Multiplexing

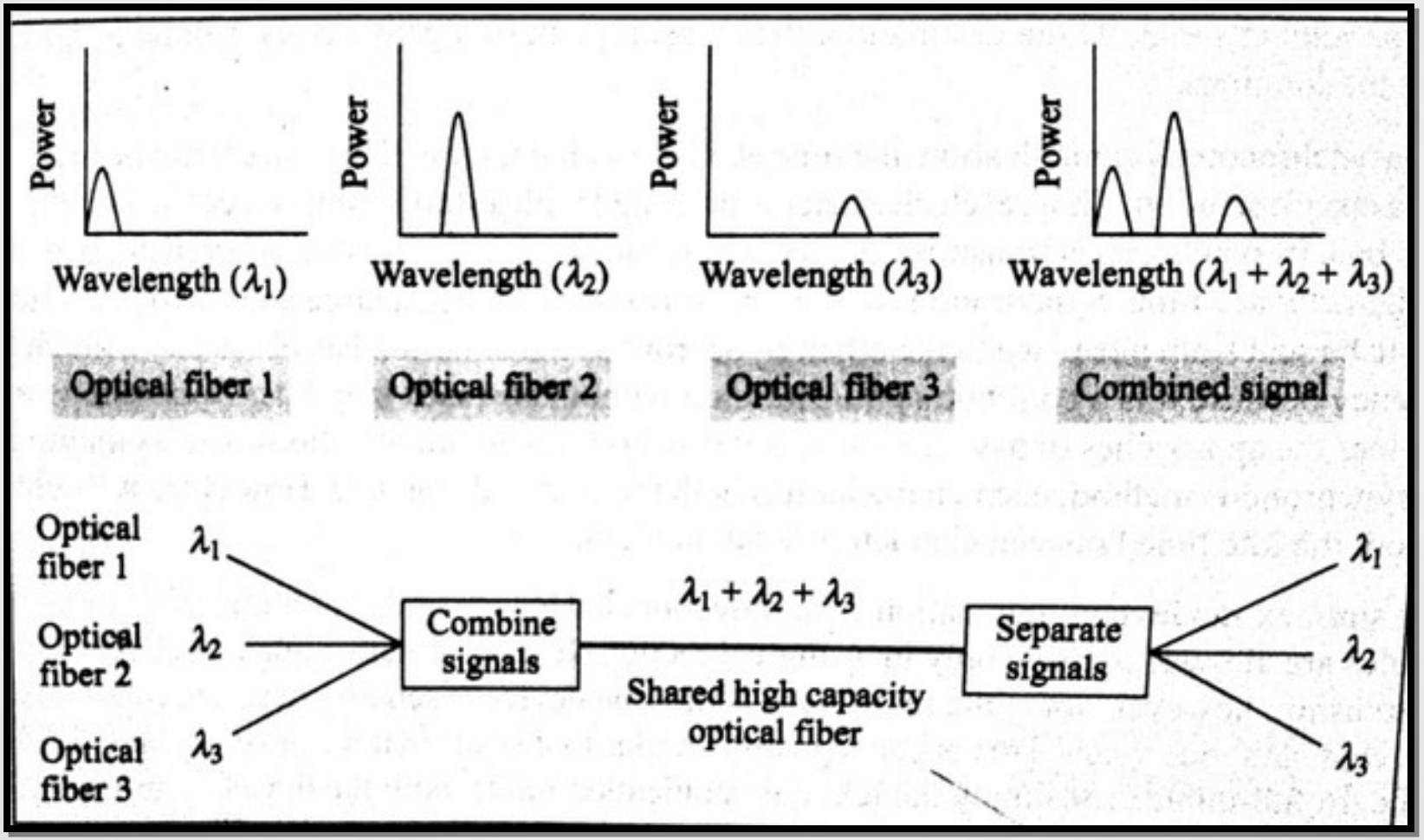
- **Advantages:**
  - Time division multiplexing systems are more flexible than frequency division multiplexing.
  - Time division multiplexing circuitry is not complex.
  - Problem of cross talk is not severe.
  - Full available channel bandwidth can be utilized for each channel.
  - No Intermodulation Disruption
  - Absence of external impedance
  - high transmission speed
- **Disadvantages:**
  - Synchronization is essential for proper operation.
  - Major modifications are needed.
  - Problem of memory space distribution.
- **Applications:**
  - It used in ISDN (Integrated Services Digital Network) telephone lines.
  - It is used in PSTN (public switched telephone network).
  - It is used for some telephone system.

WDM – Wavelength Division Multiplexing



- In this transmission medium, copper wire is not used but it uses optical fiber. Also it is variation of the basic FDM scheme.
- In WDM transmission multiple optical fibers are combined and sent together.
- In FDM the transmission from various sources are combined and sent together on the basis of their **frequencies,** here in WDM transmissions are combined on the basis of the difference between the **wavelengths**.
- The transmissions from various optical fibers are combined on the sender's side. These transmissions have different wave lengths. The combined transmission is sent to the other side via a single and more powerful optical fibers.
- At the receiver's end, the individual transmissions are retrieved by filtering out the individual source signals on the basis of their wavelengths.
- WDM is similar to FDM, exccept that very high frequencies are used in WDM.
- When there are more than 200 different channels to share a single high capacity optical fiber line. In such a case, where a significant number of input sources are combined into a single channel, we call it as **Dense WDM(DWDM).**

TDM – Time Division Multiplexing



S.NO	TDM	FDM
1.	TDM stands for Time division multiplexing.	FDM stands for Frequency division multiplexing.
2.	TDM works with digital signals as well as analog signals.	While FDM works with only analog signals.
3.	TDM has low conflict.	While it has high conflict.
4.	Wiring or chip of TDM is simple.	While it's wiring or chip is complex rather than simple.
5.	TDM is efficient.	While it is inefficient.
6.	In TDM, time sharing takes place.	While in this, frequency sharing takes place.
7.	In TDM, synchronization pulse is necessary.	While in it Guard band is necessary.