UNIT I

MULTIPLEXING

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.

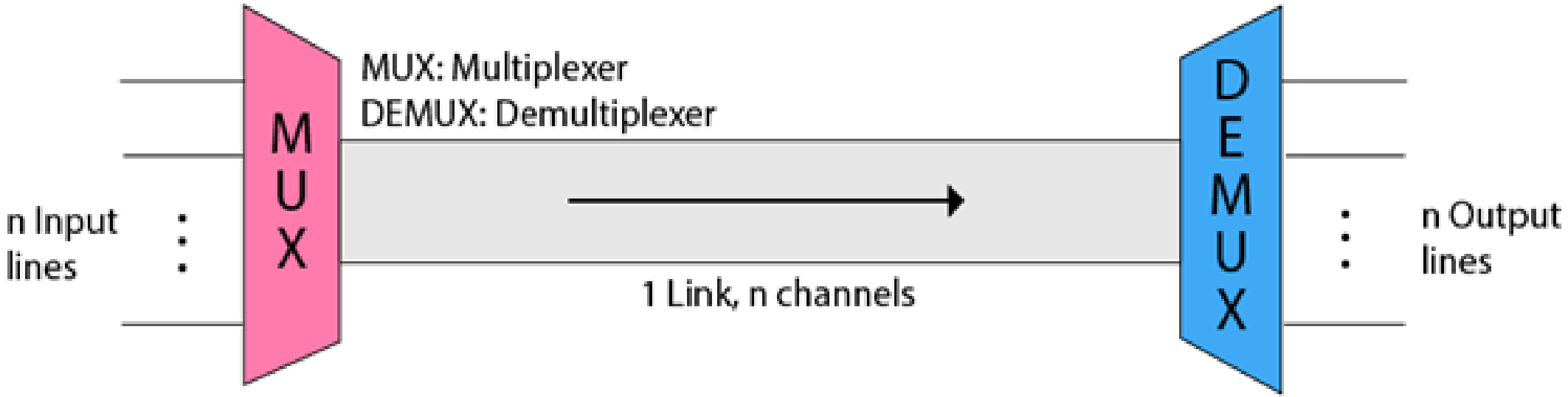
- If there are multiple signals to share one medium, then the medium must be divided in such a way that each signal is given some portion of the available bandwidth.

- For example: If there are 10 signals and bandwidth of medium is100 units, then the 10 unit is shared by each signal.

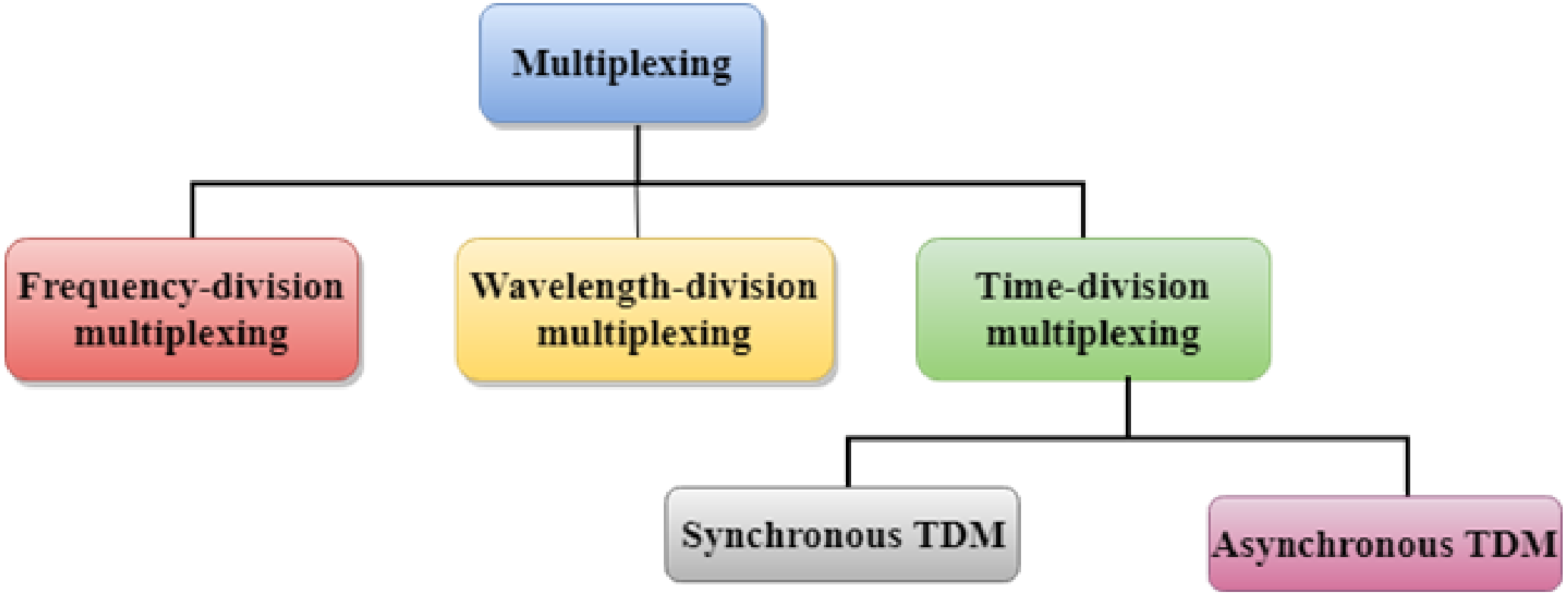
- When multiple signals share the common medium, there is a possibility of collision. Multiplexing concept is used to avoid such collision.

- Transmission services are very expensive.

Concept of Multiplexing

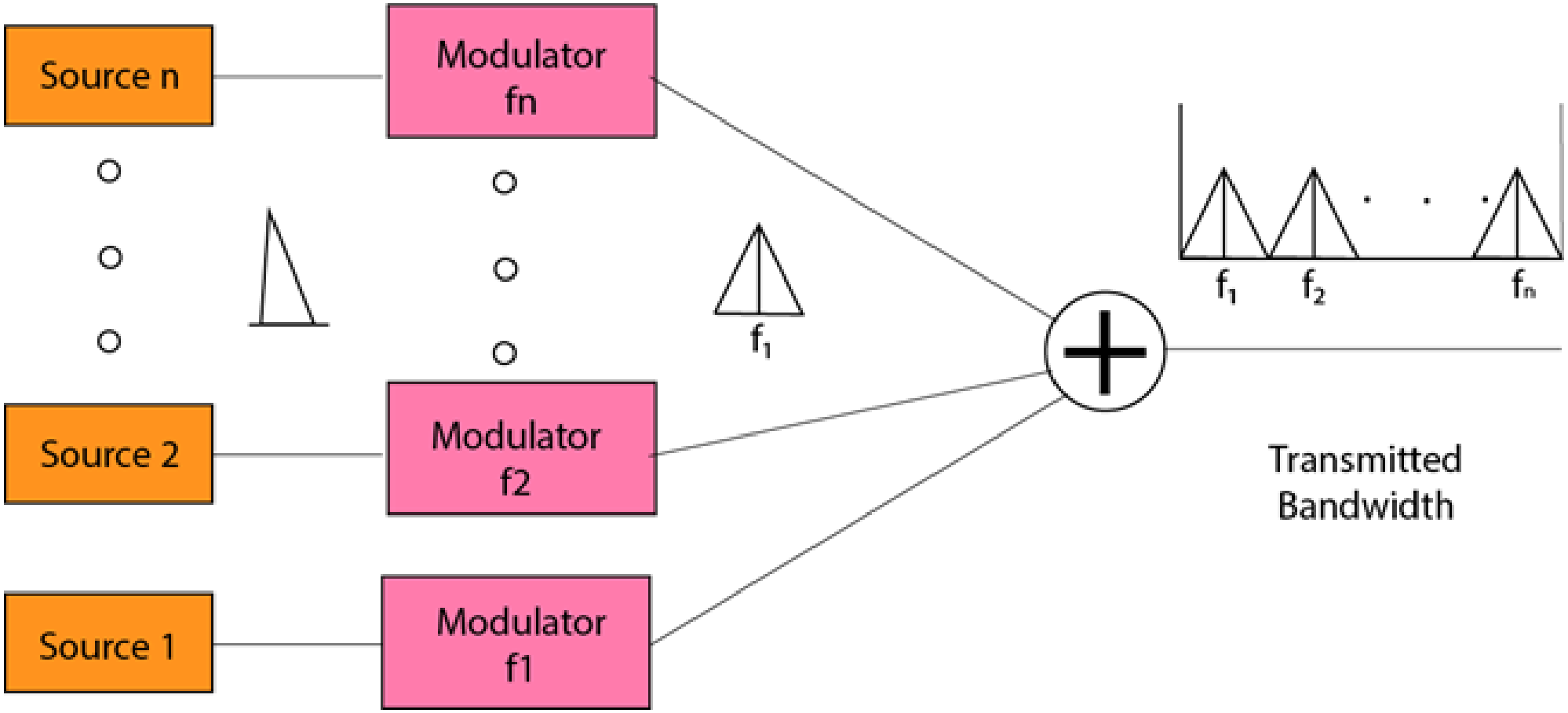


Multiplexing Techniques



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.
- 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.


Source n
Source 2
Source 1
Modulator fn
Modulator f2
Modulator f1
f1
f1
f2
fn
Transmitted Bandwidth

Advantages Of FDM:

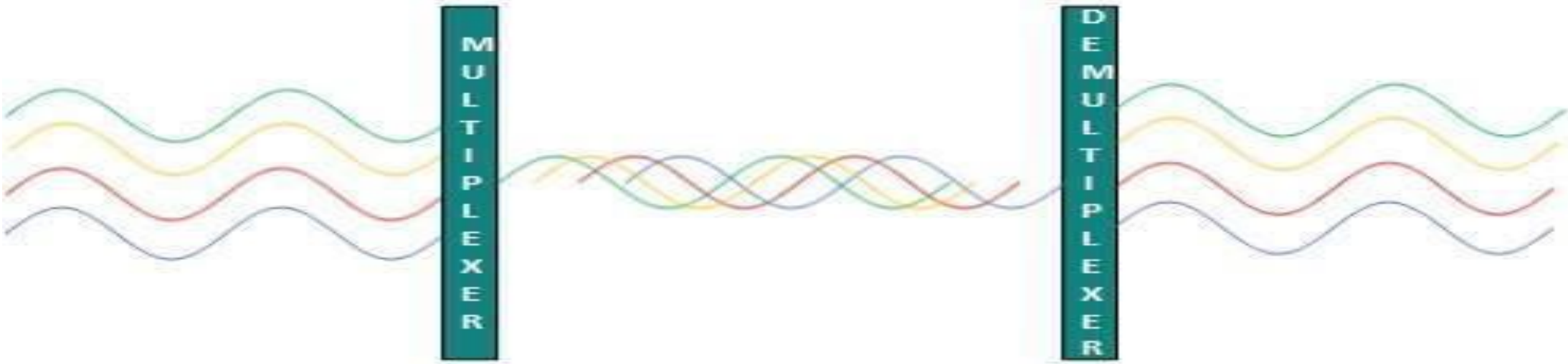
- FDM is used for analog signals.
- FDM process is very simple and easy modulation.
- A Large number of signals can be sent through an FDM simultaneously.
- It does not require any synchronization between sender and receiver.

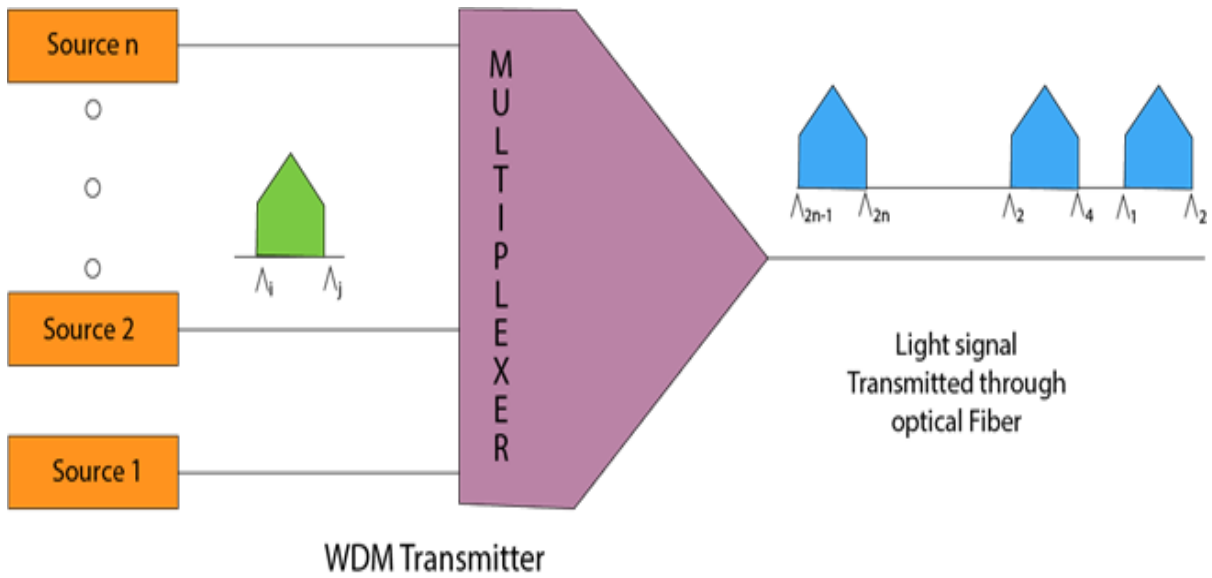
Disadvantages Of FDM:

- 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

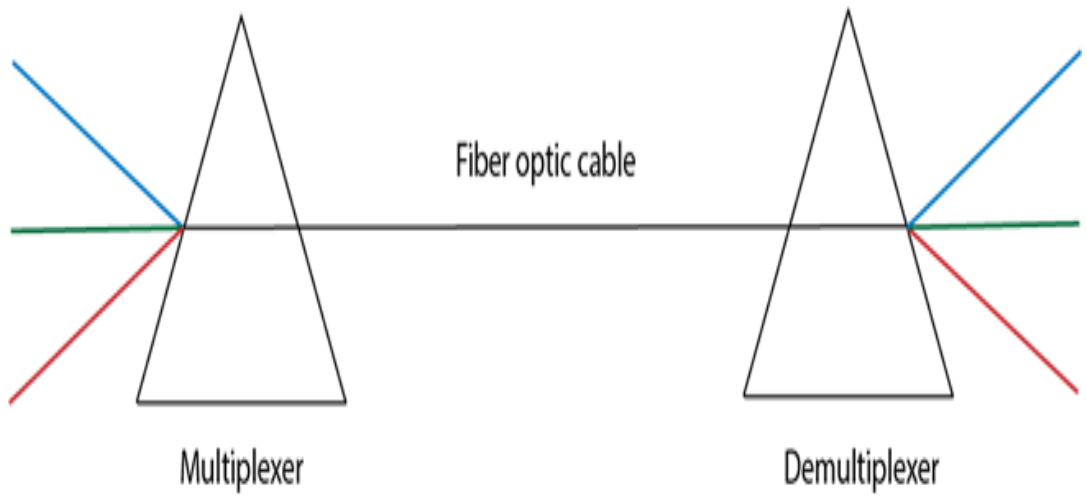
Wavelength Division Multiplexing

- 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.





WDM Transmitter

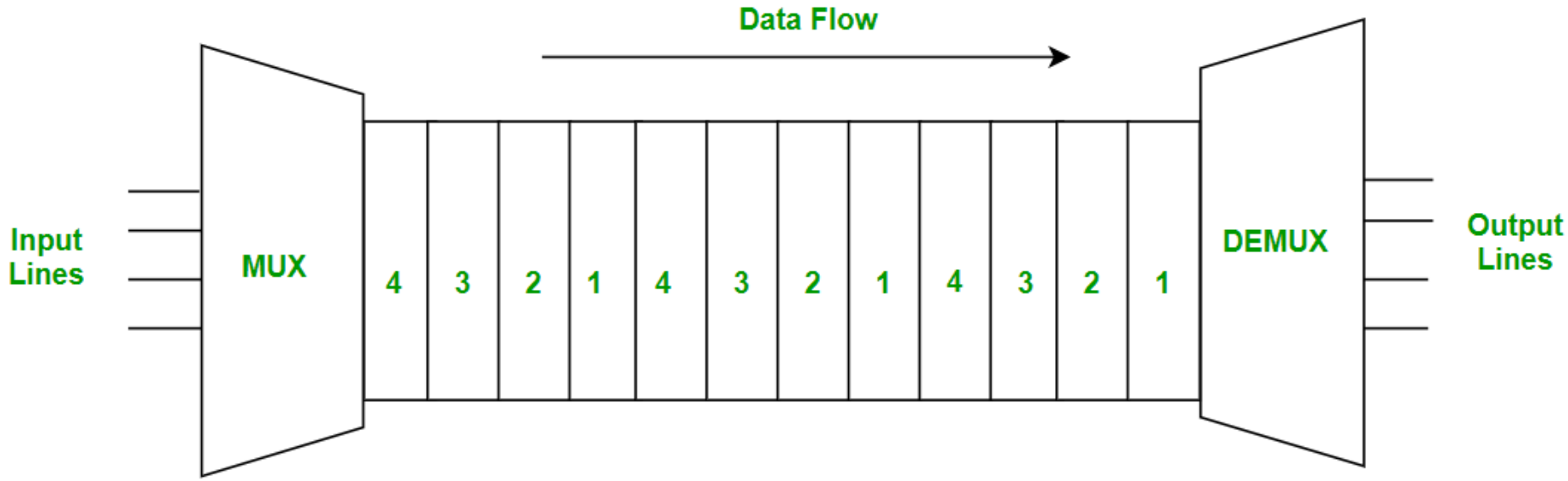


Time Division Multiplexing

- 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.
- Digital signals are divided in frames, equivalent to time slot i.e. frame of an optimal size which can be transmitted in given time slot.
- TDM works in synchronized mode. Both ends, i.e. Multiplexer and De-multiplexer are timely synchronized and both switch to next channel simultaneously.

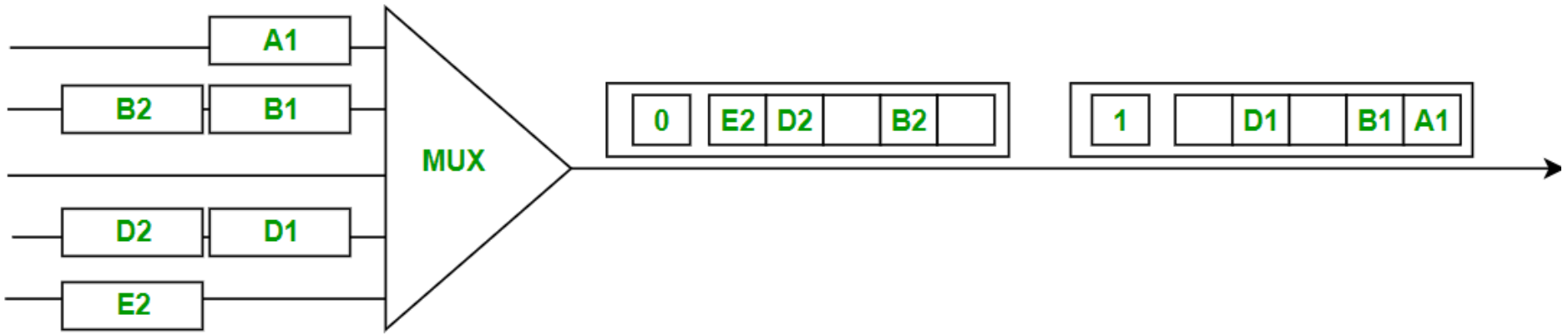
There are two types of Time Division Multiplexing :

- Synchronous Time Division Multiplexing
- Statistical (or Asynchronous) Time Division Multiplexing


Data Flow
Input Lines
MUX
4
3
2
1
4
3
2
1
4
3
2
1
DEMUX
Output Lines

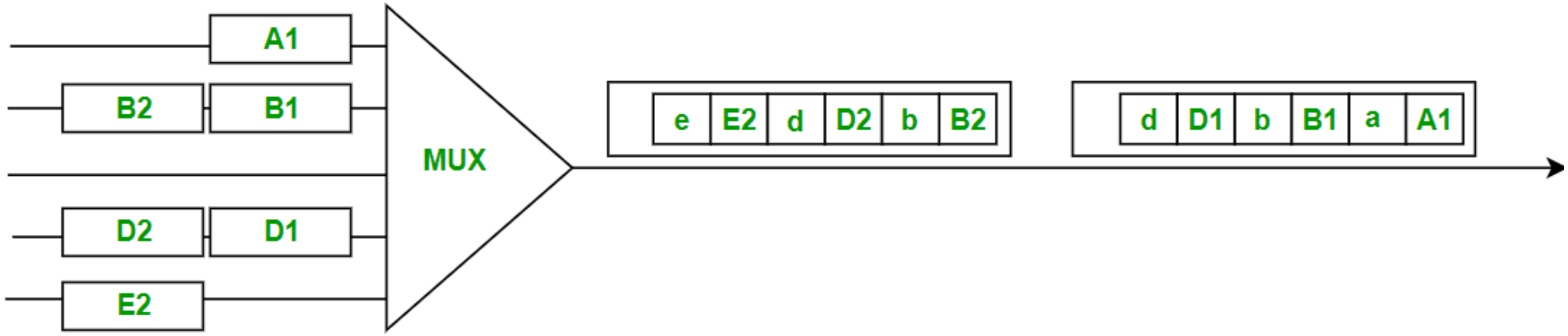
Synchronous TDM :

- Synchronous TDM is a type of Time Division Multiplexing where the input frame already has a slot in the output frame. Time slots are grouped into frames. One frame consists of one cycle of time slots.
- Synchronous TDM is not efficient because if the input frame has no data to send, a slot remains empty in the output frame.
- In synchronous TDM, we need to mention the synchronous bit at the beginning of each frame



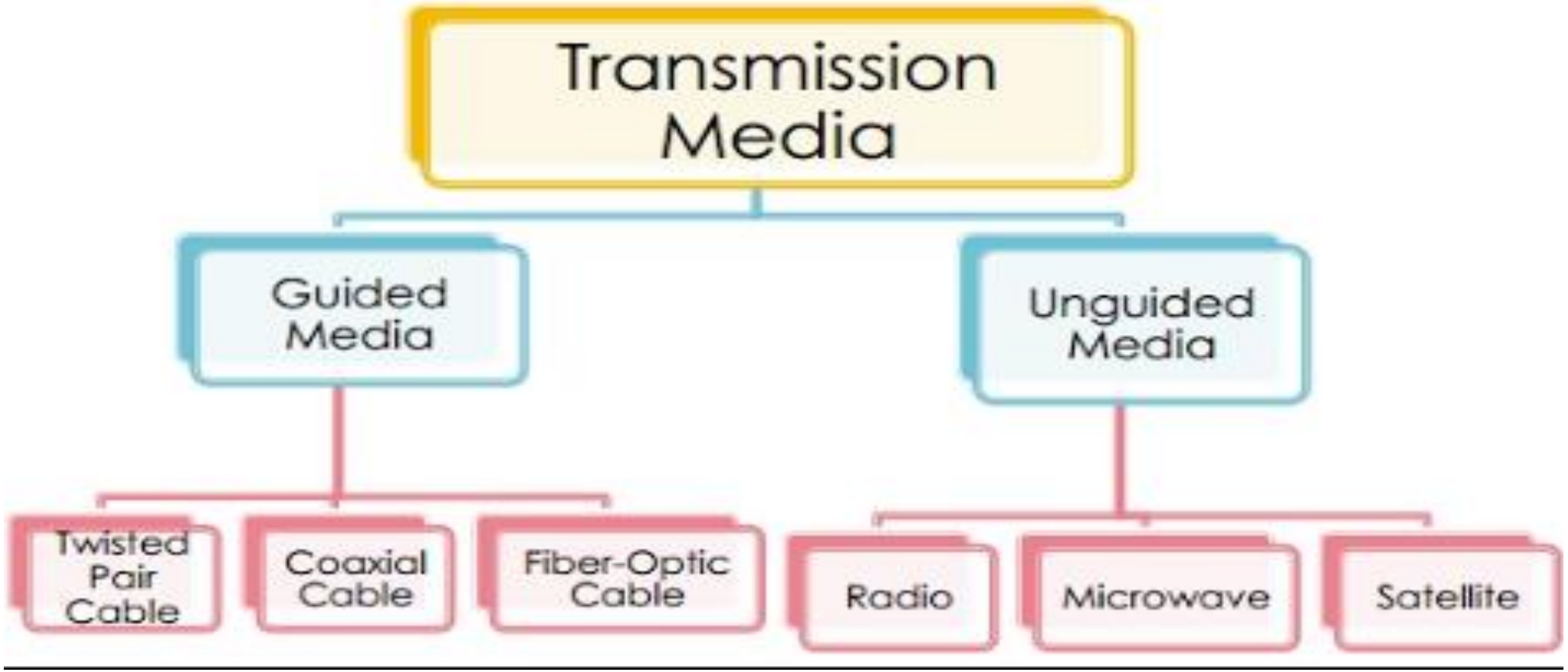
Statistical TDM :

- Statistical TDM is a type of Time Division Multiplexing where the output frame collects data from the input frame till it is full, not leaving an empty slot like in Synchronous TDM.
- In statistical TDM, we need to include the address of each particular data in the slot that is being sent to the output frame.
- Statistical TDM is a more efficient type of time division multiplexing as the channel capacity is fully utilized and improves the bandwidth efficiency.



Transmission Media

- In data communication terminology, a transmission medium is a physical path between the transmitter and the receiver i.e it is the channel through which data is sent from one place to another.
- Transmission Media is broadly classified into the following types:



BASIS FOR COMPARISON	GUIDED MEDIA	UNGUIDED MEDIA
Basic	The signal requires a physical path for transmission.	The signal is broadcasted through air or sometimes water.
Alternative name	It is called wired communication or bounded transmission media.	It is called wireless communication or unbounded transmission media.
Direction	It provides direction to signal for travelling.	It does not provide any direction.
Types	Twisted pair cable, coaxial cable and fibre optic cable.	Radio wave, microwave and infrared.

Twisted Pair Cable

- Copper wires are the most common wires used for transmitting signals because of good performance at low costs.

- They are most commonly used in telephone lines. However, if two or more wires are lying together, they can interfere with each other’s signals.

- To reduce this electromagnetic interference, pair of copper wires are twisted together in helical shape like a DNA molecule. Such twisted copper wires are called **twisted pair**.

- To reduce interference between nearby twisted pairs, the twist rates are different for each pair.

- Up to 25 twisted pair are put together in a protective covering to form twisted pair cables that are the backbone of telephone systems and Ethernet networks.

Shielding twisted pair cable

- To counter the tendency of twisted pair cables to pick up noise signals, wires are shielded in the following three ways −

➢Each twisted pair is shielded.

➢Set of multiple twisted pairs in the cable is shielded.

➢Each twisted pair and then all the pairs are shielded.

- Such twisted pairs are called **shielded twisted pair (STP) cables**.

- The wires that are not shielded but simply bundled together in a protective sheath are called **unshielded twisted pair (UTP) cables**. These cables can have maximum length of 100 metres.

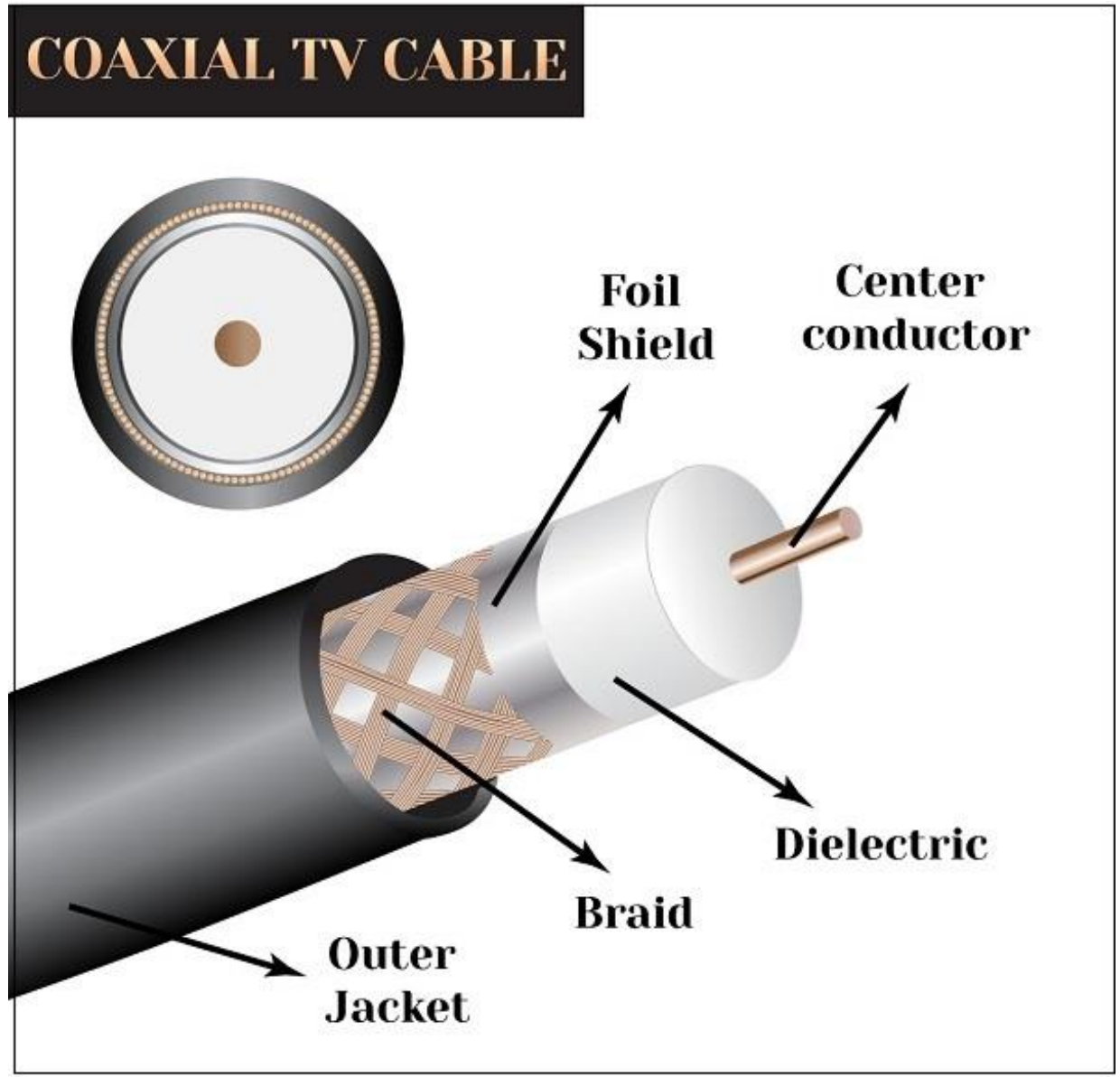
- Shielding makes the cable bulky, so UTP are more popular than STP. UTP cables are used as the last mile network connection in homes and offices.

Coaxial Cable

- **Coaxial cables** are copper cables with better **shielding** than twisted pair cables, so that transmitted signals may travel longer distances at higher speeds. A coaxial cable consists of these layers, starting from the innermost −

  - Stiff copper wire as **core**
  - **Insulating material** surrounding the core
  - Closely woven braided mesh of **conducting material** surrounding the **insulator**
  - Protective **plastic sheath** encasing the wire

- Coaxial cables are widely used for **cable TV** connections and **LANs**.


COAXIAL TV CABLE
Foil
Shield
Center
conductor
Dielectric
Braid
Outer
Jacket

Optical Fibre

- Thin glass or plastic threads used to transmit data using light waves are called **optical fibre**. Light Emitting Diodes (LEDs) or Laser Diodes (LDs) emit light waves at the **source**, which is read by a **detector** at the other end.

- **Optical fibre cable** has a bundle of such threads or fibres bundled together in a protective covering. Each fibre is made up of these three layers, starting with the innermost layer −

➢ **Core** made of high quality **silica glass** or **plastic**

➢ **Cladding** made of high quality **silica glass** or **plastic**, with a lower refractive index than the core

➢ Protective outer covering called **buffer**

- Note that both core and cladding are made of similar material. However, as **refractive index** of the cladding is lower, any stray light wave trying to escape the core is reflected back due to **total internal reflection**.

OPTICAL FIBER