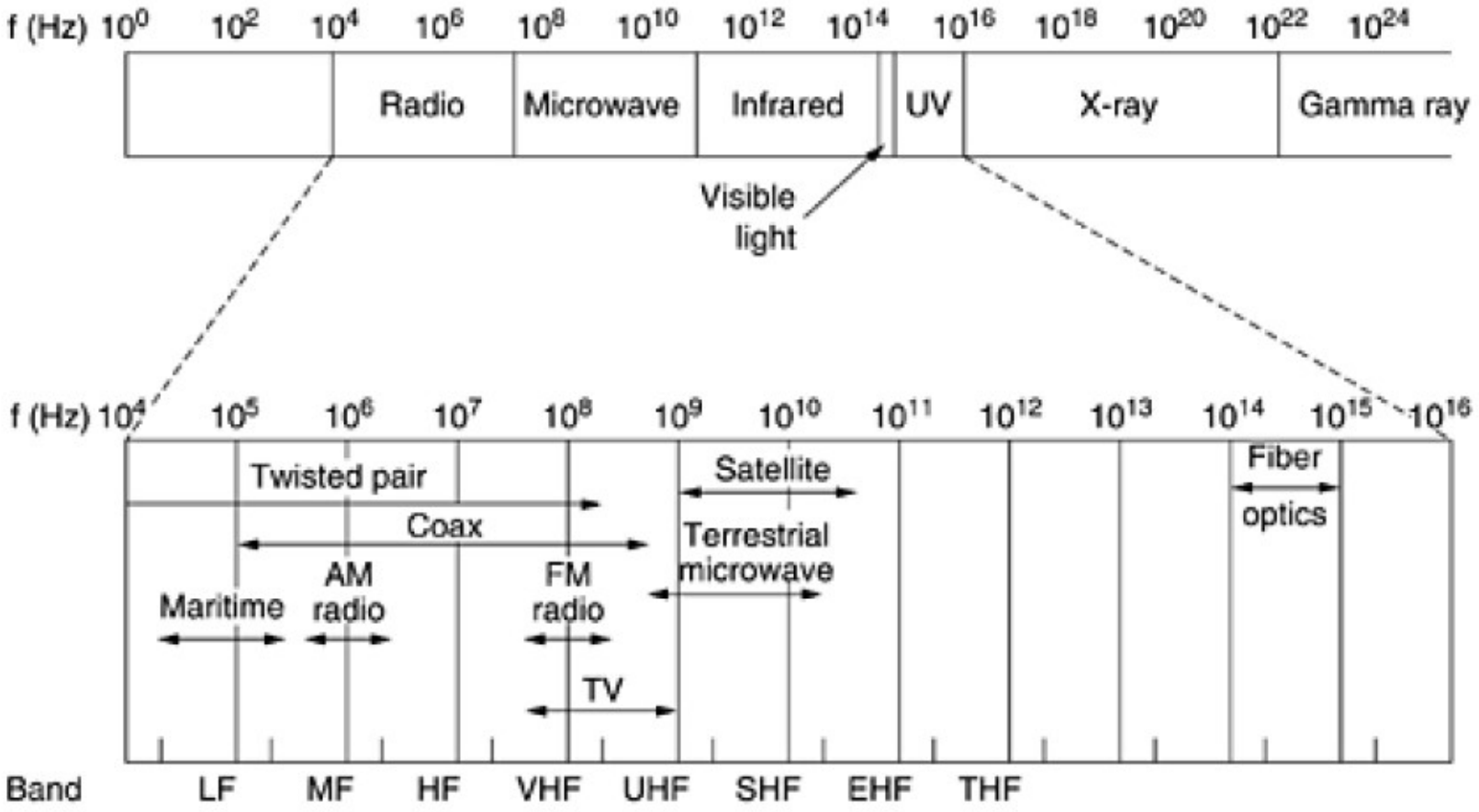
Unguided Media: Wireless Transmission

- Electromagnetic Spectrum
- Radio transmission
- Microwave Transmission
- Infrared Transmission
- Light Transmission

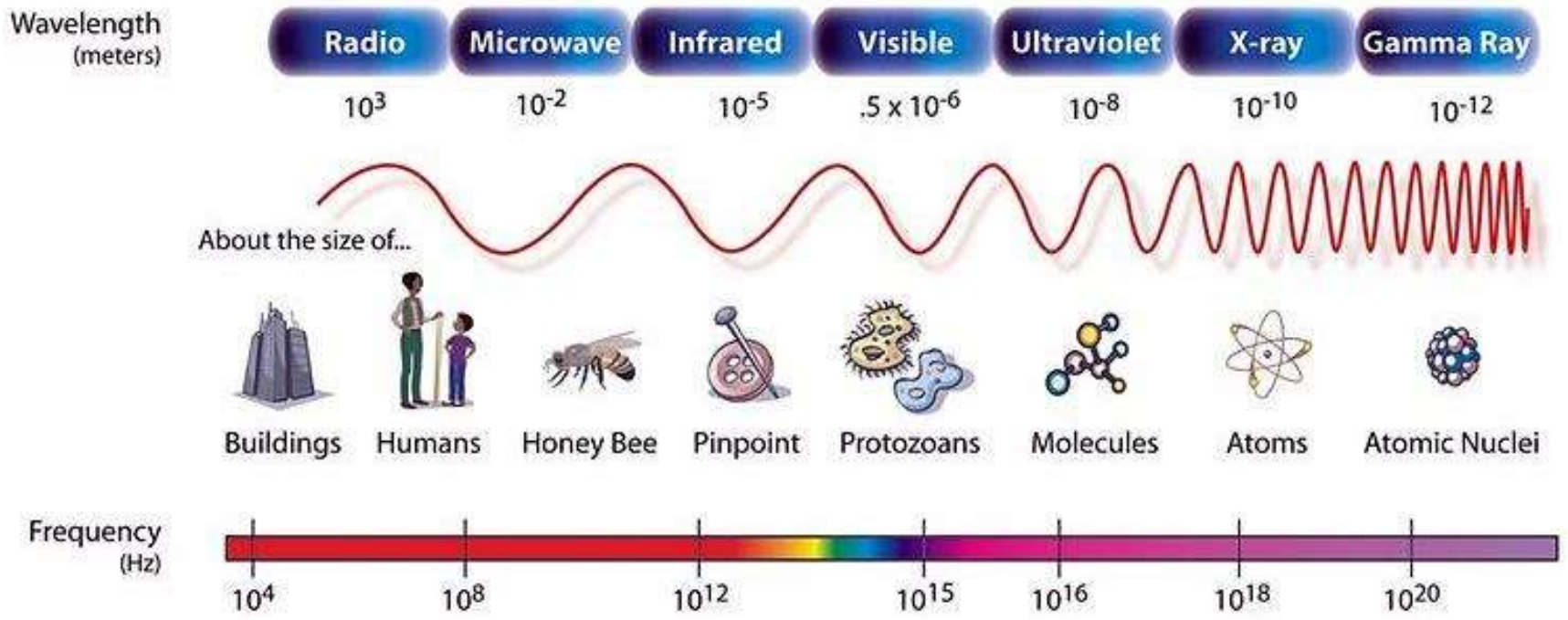
Electromagnetic Spectrum

- Electromagnetic waves, can propagate through space, were predicted by J C Maxwell in 1865 and observed by Heinrich Hertz in 1887.
- When an antenna of the appropriate size is attached to an electrical circuit, the electromagnetic waves can be broadcast efficiently and received by a receiver some distance away.
- In vacuum, all electromagnetic waves travel at the same speed, no matter what their frequency.
- In copper or fiber the speed slows to about 2/3 of this value and becomes slightly frequency dependent.

Electromagnetic spectrum and its uses for communication



Electromagnetic spectrum and its uses for communication



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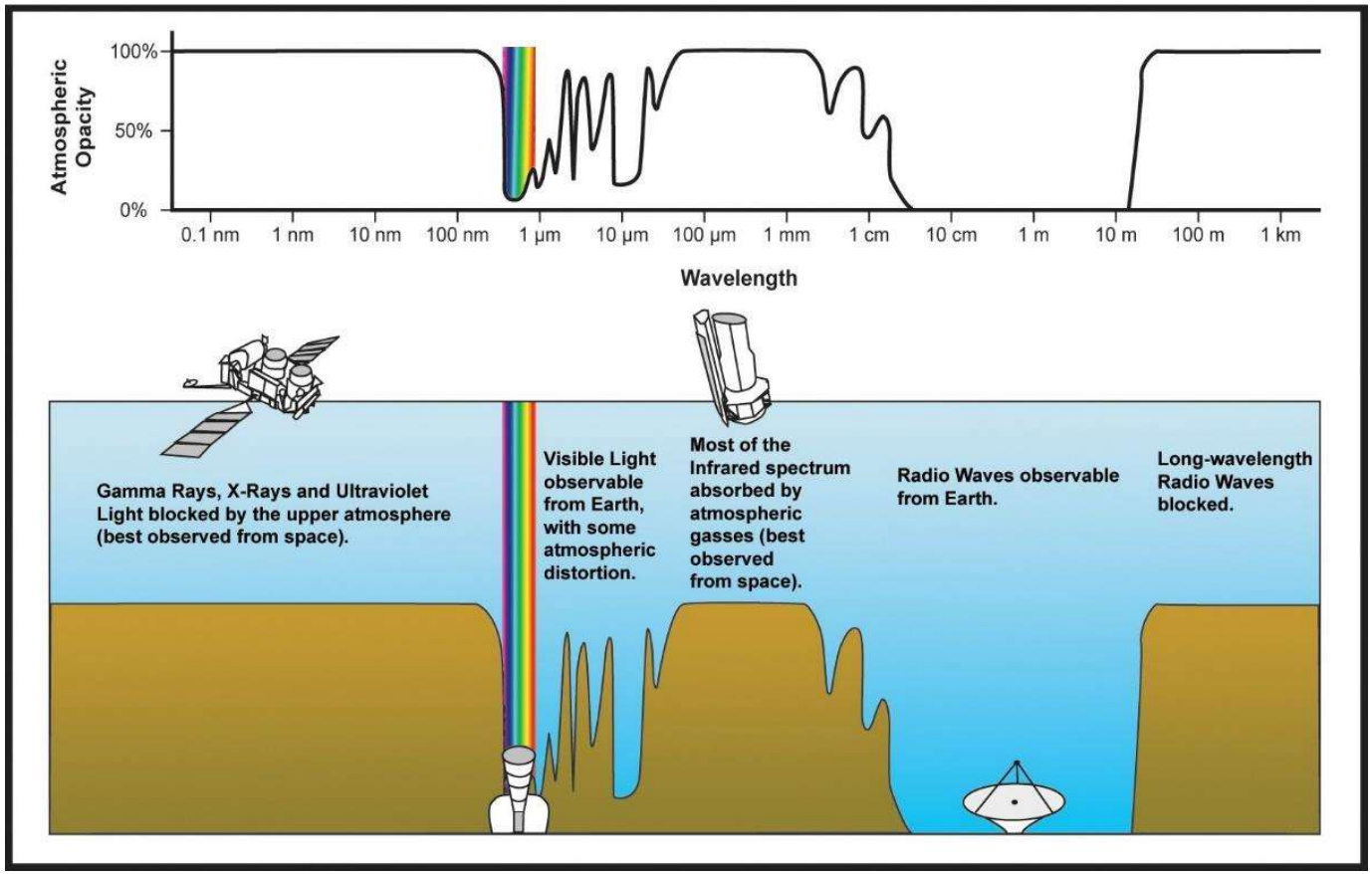


Electromagnetic spectrum and its uses for communication

- The radio, microwave, infrared, and visible light portions of the spectrum can all be used for transmitting information
- by modulating the amplitude, frequency, or phase of the waves.
- Ultraviolet light, X-rays, and gamma rays would be even better, due to their higher frequencies.
- but they are hard to produce and modulate, do not propagate well through buildings, and are dangerous to living things.

Radio Transmission (10 kHz – 300 MHz)

- easy to generate, can travel long distances, and can penetrate buildings easily, so they are widely used for communication, both indoors and outdoors.
- Radio waves also are omnidirectional, meaning that they travel in all directions from the source, so the transmitter and receiver do not have to be carefully aligned physically.
- Due to radio's ability to travel long distances, interference between users is a problem. For this reason, all governments tightly license the use of radio transmitters.
- There is a wide range of subcategories contained within radio including AM and FM radio

Radio Transmission

- **AM radio waves**: commercial radio signals (540 and 1600 kHz), information is carried by amplitude variation, while the frequency remains constant.
- **FM radio waves**: commercial radio signals (88 and 108 MHz), information is carried by frequency modulation, while the signal amplitude remains constant.
- TV broadcast: (174 – 216 MHz).

Microwave Transmission (300 MHz – 300 GHz)

- Microwaves are “small” compared to waves used in typical radio broadcasting.
- The microwave portion of the electromagnetic spectrum can be subdivided into:
  - **Extremely High Frequency (30 to 300 GHz):** wavelength range of 10 to 1 mm, so it is sometimes called the millimeter band.
  - **Super High Frequency (3 to 30 GHz):** ten to one centimeters, used for wireless LANs, cell phones, satellite communication, microwave radio relay links, and numerous short range terrestrial data links
  - **Ultra-High Frequency (300 MHz to 3 GHz):** 10 centimeters to 1 meter, used for television broadcasting, cordless phones, walkie-talkies, satellite communication, and numerous other applications

Infrared and Millimeter Wave

- Unguided infrared and millimeter waves are widely used for short-range communication (The remote controls used on televisions, VCRs, and stereos all use infrared communication).
- They are relatively directional, cheap, and easy to build but have a major drawback: they do not pass through solid objects.
- In general, as we go from long-wave radio toward visible light, the waves behave more and more like light and less and less like radio.
- On the other hand, infrared system in one room of a building will not interfere with a similar system in adjacent rooms or buildings.
- Infrared communication has a limited use on the desktop, for example, connecting notebook computers and printers, it is not a major player in the communication.

Light Wave Transmission

- A more modern application is to connect the LANs in two buildings lasers mounted on their rooftops.
- Coherent optical signaling using lasers is inherently unidirectional, so each building needs its own laser and its own photodetector. This scheme offers very high bandwidth and very low cost.
- It is also relatively easy to install and, unlike microwave, does not require an FCC license.

Multiplexing

- **Definition**: Multiplexing is a technique which combines multiple signals into one signal, suitable for transmission over a communication channel such as coaxial cable or optical fiber.

- **By doing multiplexing**, large amount bandwidth can be saved, cost can be reduced, circuit complexity can be reduced and multiple signals can be sent simultaneously over a single communication channel.

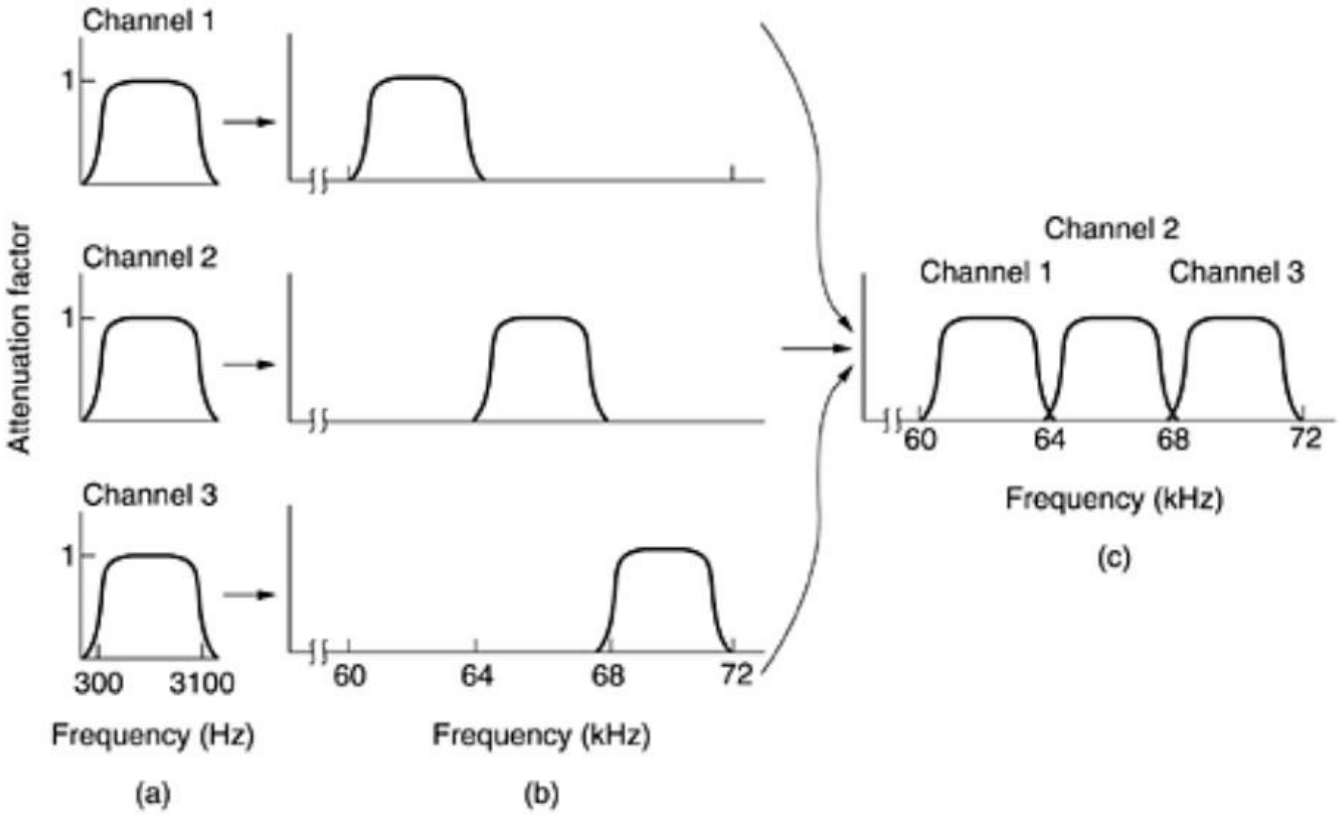
- **Analog**: Frequency Division Multiplexing and Wavelength Division Multiplexing

- **Digital**: Time Division Multiplexing

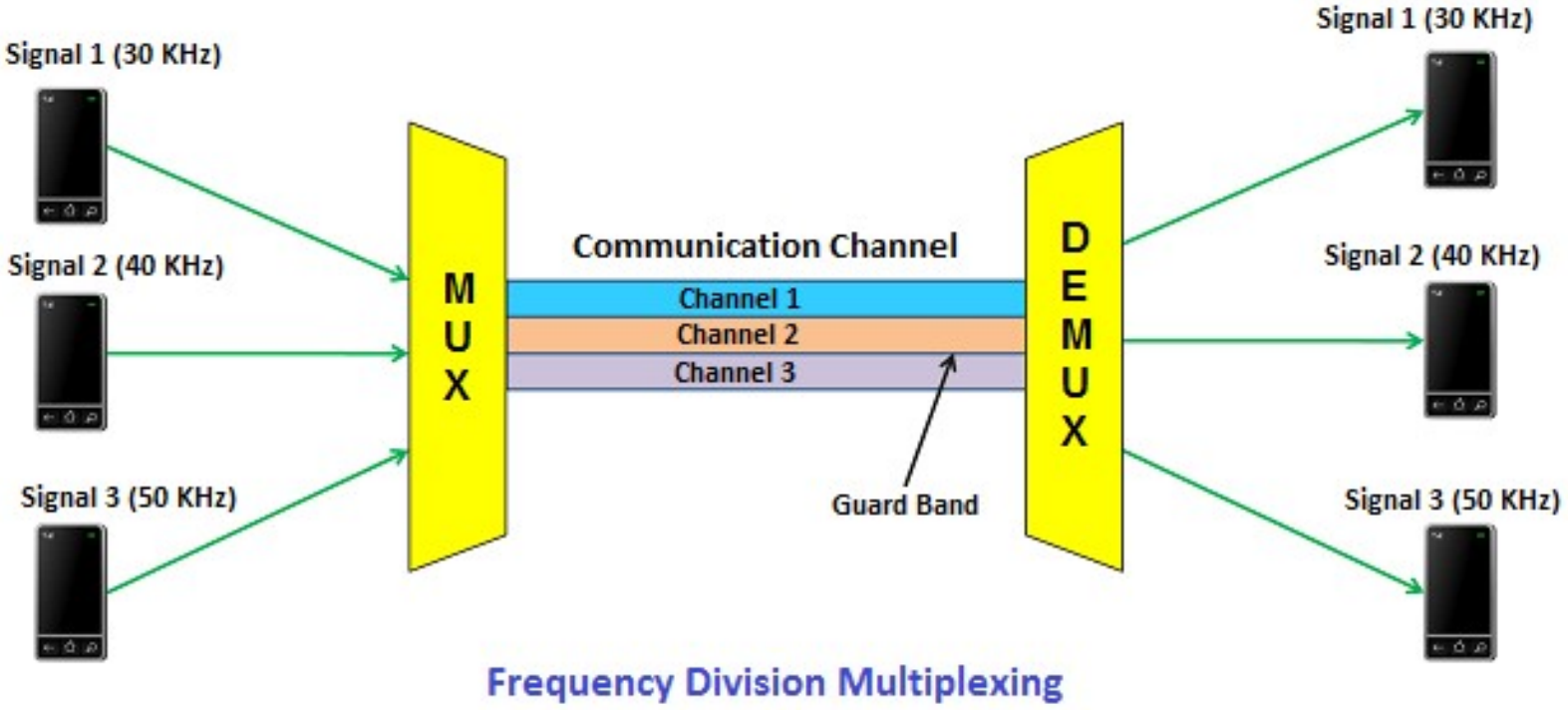
Frequency Division Multiplexing (FDM)

- popular multiplexing technique in TV and radio.
- combines multiple signals into one signal → transmitted over the communication channel.
- bandwidth of the communication channel should be greater than the combined bandwidth of individual signals.
- divides the bandwidth of a channel into several logical sub-channels and each logical sub-channel is separated by an unused bandwidth called Guard Band to prevent overlapping of signals.
- A guard band is a narrow frequency range that separates two signal frequencies.

FDM Operation



FDM Operation



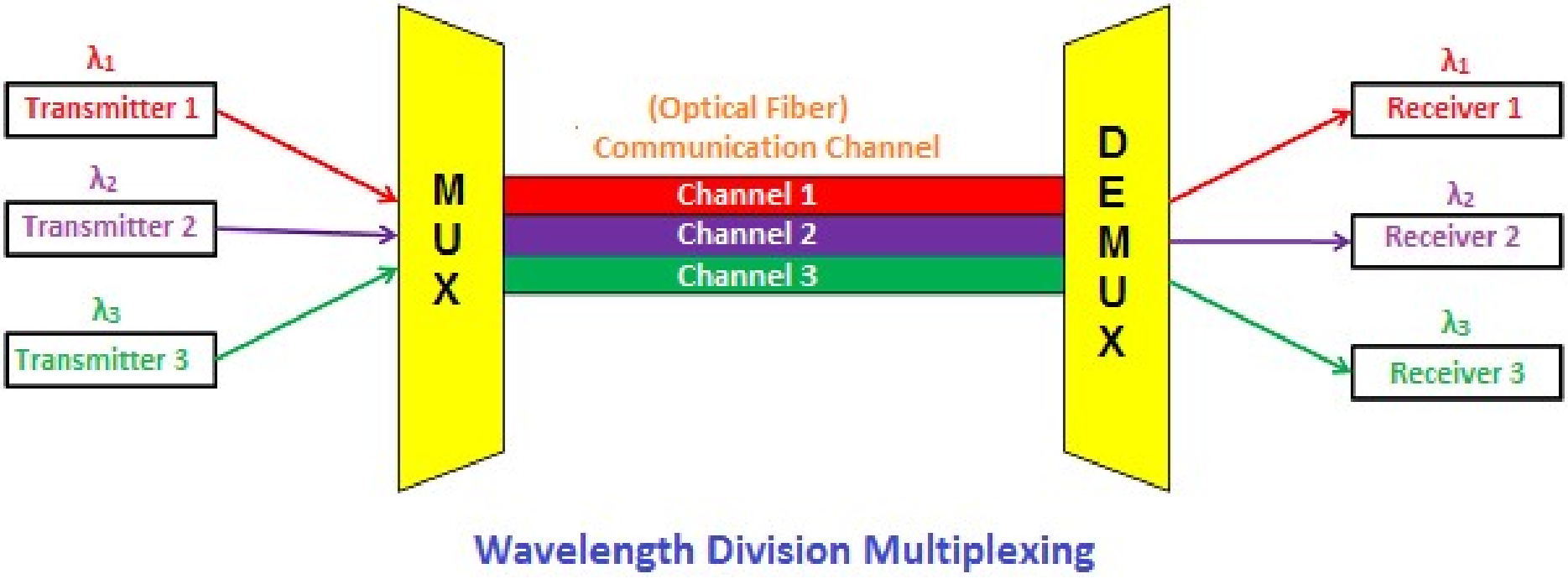
FDM

- **Advantages of Frequency Division Multiplexing (FDM)**
  - It transmits multiple signals simultaneously.
  - In frequency division multiplexing, the demodulation process is easy.
  - It does not need Synchronization between transmitter and receiver.
- **Disadvantages of Frequency Division Multiplexing (FDM)**
  - It needs a large bandwidth communication channel.
- **Applications of Frequency Division Multiplexing (FDM)**
  - Frequency division multiplexing is used for FM and AM radio broadcasting.
  - It is used in first generation cellular telephone.
  - It is used in television broadcasting.

Wavelength Division Multiplexing (WDM)

- Wavelength division multiplexing is a technology that increases the bandwidth of a communication channel (optical fiber) by simultaneously allowing multiple optical signals through it.
- the working principle of wavelength division multiplexing is similar to frequency division multiplexing. The only difference is in wavelength division multiplexing optical signals are used instead of electrical signals.
- The main advantage of WDM system is that only need to upgrade the multiplexer and demultiplexer at each end; no need to buy more fibers which are more expensive.

WDM



Wavelength Division Multiplexing

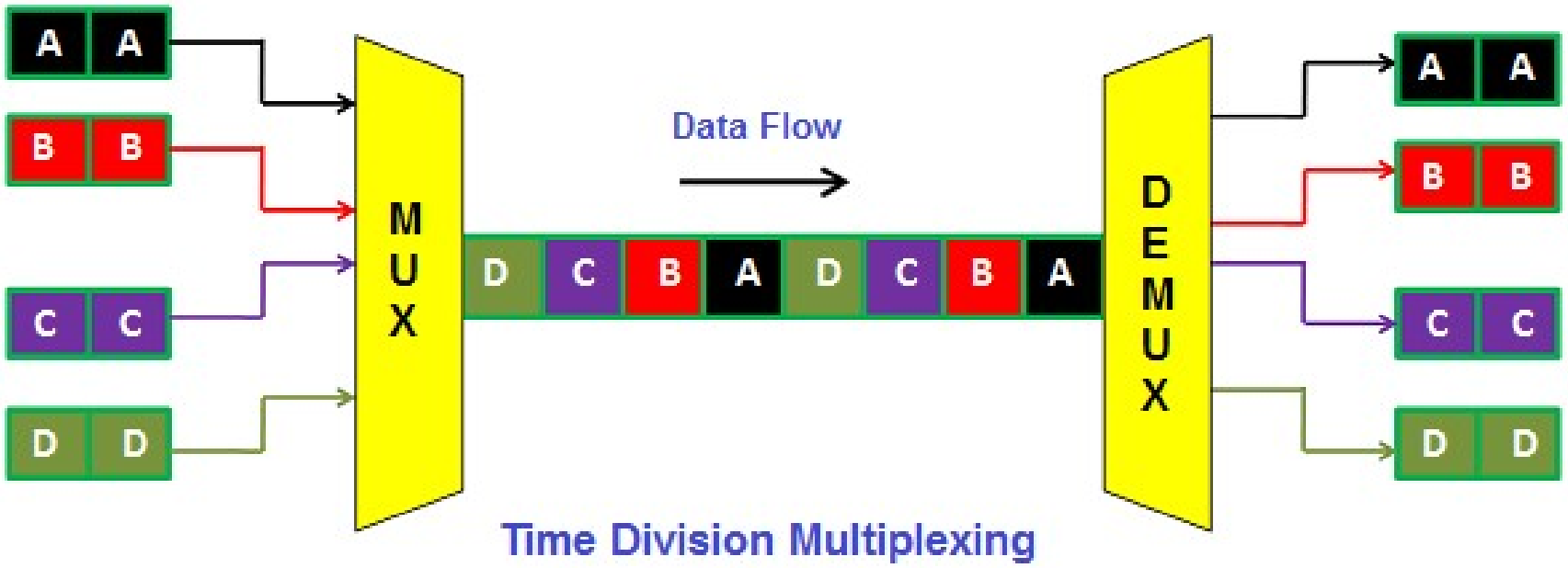
WDM

- WDM techniques are of two types:
  - Dense Wavelength Division Multiplexing (longer distances)
  - Coarse Wavelength Division Multiplexing (Shorter distances)
- **Advantages of Wavelength Division Multiplexing (WDM)**
  - WDM allows transmission of data in two directions simultaneously
  - Low cost
  - Greater transmission capacity
  - High security
  - Long distance communication with low signal loss

Time Division Multiplexing (digital)

- multiple signals are combined and transmitted one after another on the same communication channel.
- in time division multiplexing, all signals operate with the same frequency are transmitted at different times.

TDM

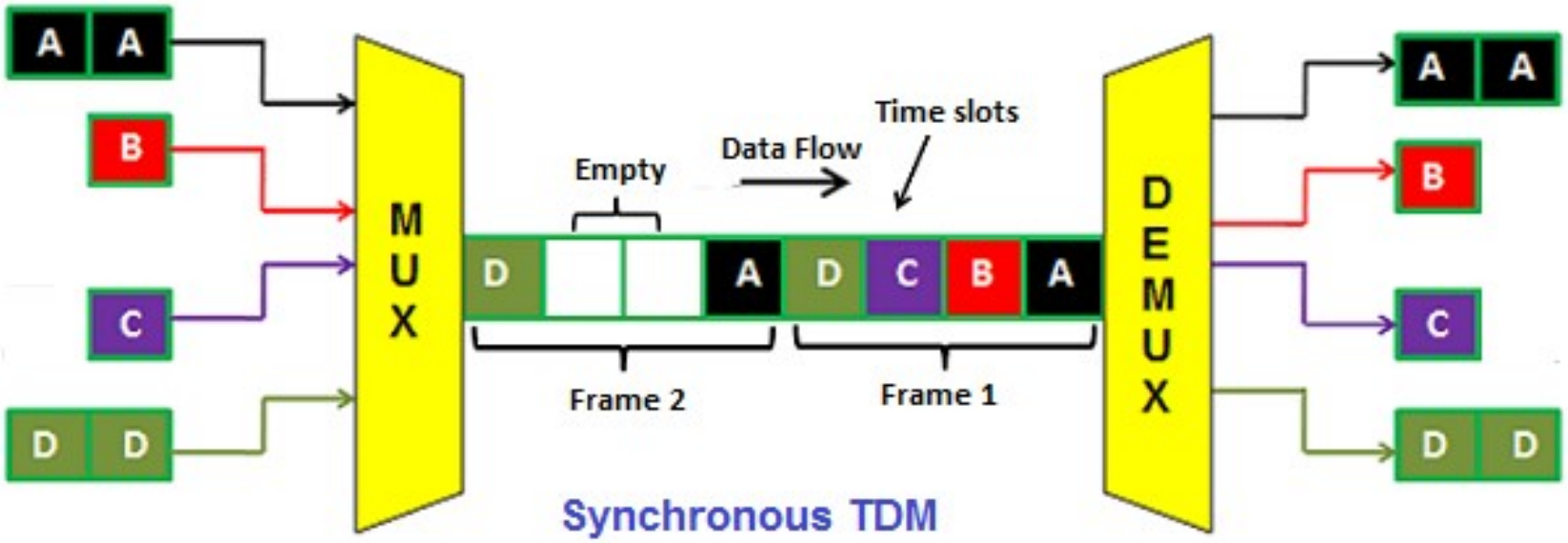

A A
B B
C C
D D
MUX
Data Flow
D C B A D C B A
DEMUX
A A
B B
C C
D D
Time Division Multiplexing

TDM

- Time Division Multiplexing is mainly classified into two types:
  - Synchronous TDM (fixed time slots)
  - Asynchronous TDM (no fixed time slots they are flexible).
- **Advantages of Time Division Multiplexing (TDM)**
  - Full bandwidth is utilized by a user at a particular time.
  - The time division multiplexing technique is more flexible than frequency division multiplexing.
  - In time division multiplexing, the problem of crosstalk is very less.
- **Disadvantages of Time Division Multiplexing (TDM)**
  - In time division multiplexing, synchronization is required.

Synchronous TDM

synchronous TDM, the number of time slots is equal to the number of transmitters.



Asynchronous TDM

in Asynchronous TDM, the number of time slots is not equal to the number of devices (transmitters). The time slots in asynchronous TDM are always less than the number of devices (transmitter)