Multiplexing

Multiplexing is the sharing of a medium or bandwidth. It is the process in which multiple signals coming from multiple sources are combined and transmitted over a single communication/physical line.

Types of Multiplexing

There are Five types of Multiplexing :

- Frequency Division Multiplexing (FDM)
- Time-Division Multiplexing (TDM)
- Wavelength Division Multiplexing (WDM)
- Code-division multiplexing (CDM)
- Space-division multiplexing (SDM):

1. **Frequency Division Multiplexing :**
   Frequency division multiplexing is defined as a type of multiplexing where the bandwidth of a single physical medium is divided into a number of smaller, independent frequency channels.
   Frequency Division Multiplexing is used in radio and television transmission.
   In FDM, we can observe a lot of inter-channel cross-talk, due to the fact that in this type of multiplexing the bandwidth is divided into frequency channels. In order to prevent the inter-channel cross talk, unused strips of bandwidth must be placed between each channel. These unused strips between each channel are known as guard bands.

2. **Time Division Multiplexing :**
   Time-division multiplexing is defined as a type of multiplexing wherein FDM, instead of sharing a portion of the bandwidth in the form of channels, in TDM, time is shared. Each connection occupies a portion of time in the link.
   In Time Division Multiplexing, all signals operate with the same frequency (bandwidth) at different times.

There are two types of Time Division Multiplexing :

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

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.

3. **Wavelength Division Multiplexing :**
   Wavelength Division Multiplexing (WDM) is a multiplexing technology used to increase the capacity of optical fiber by transmitting multiple optical signals simultaneously over a single optical fiber, each with a different wavelength. Each signal is carried on a different wavelength of light, and the resulting signals are combined onto a single optical fiber for transmission. At the receiving end, the signals are separated by their wavelengths, demultiplexed and routed to their respective destinations.

WDM can be divided into two categories: Dense Wavelength Division Multiplexing (DWDM) and Coarse Wavelength Division Multiplexing (CWDM).
DWDM is used to multiplex a large number of optical signals onto a single fiber, typically up to 80 channels with a spacing of 0.8 nm or less between the channels.

CWDM is used for lower-capacity applications, typically up to 18 channels with a spacing of 20 nm between the channels.

WDM has several advantages over other multiplexing technologies such as Time Division Multiplexing (TDM). WDM allows for higher data rates and capacity, lower power consumption, and reduced equipment complexity. WDM is also flexible, allowing for easy upgrades and expansions to existing networks.

WDM is used in a wide range of applications, including telecommunications, cable TV, internet service providers, and data centers. It enables the transmission of large amounts of data over long distances with high speed and efficiency.

Wavelength Division Multiplexing is used on fiber optics to increase the capacity of a single fiber. It is an analog multiplexing technique. Optical signals from the different sources are combined to form a wider band of light with the help of multiplexers. At the receiving end, the De-multiplexer separates the signals to transmit them to their respective destinations.

4. **Space-division multiplexing (SDM) :**

   Space Division Multiplexing (SDM) is a technique used in wireless communication systems to increase the capacity of the system by exploiting the physical separation of users.
   In SDM, multiple antennas are used at both the transmitter and receiver ends to create parallel communication channels. These channels are independent of each other, which allows for multiple users to transmit data simultaneously in the same frequency band without interference. The capacity of the system can be increased by adding more antennas, which creates more independent channels.

   SDM is commonly used in wireless communication systems such as cellular networks, Wi-Fi, and satellite communication systems. In cellular networks, SDM is used in the form of Multiple Input Multiple Output (MIMO) technology, which uses multiple antennas at both the transmitter and receiver ends to improve the quality and capacity of the communication link.

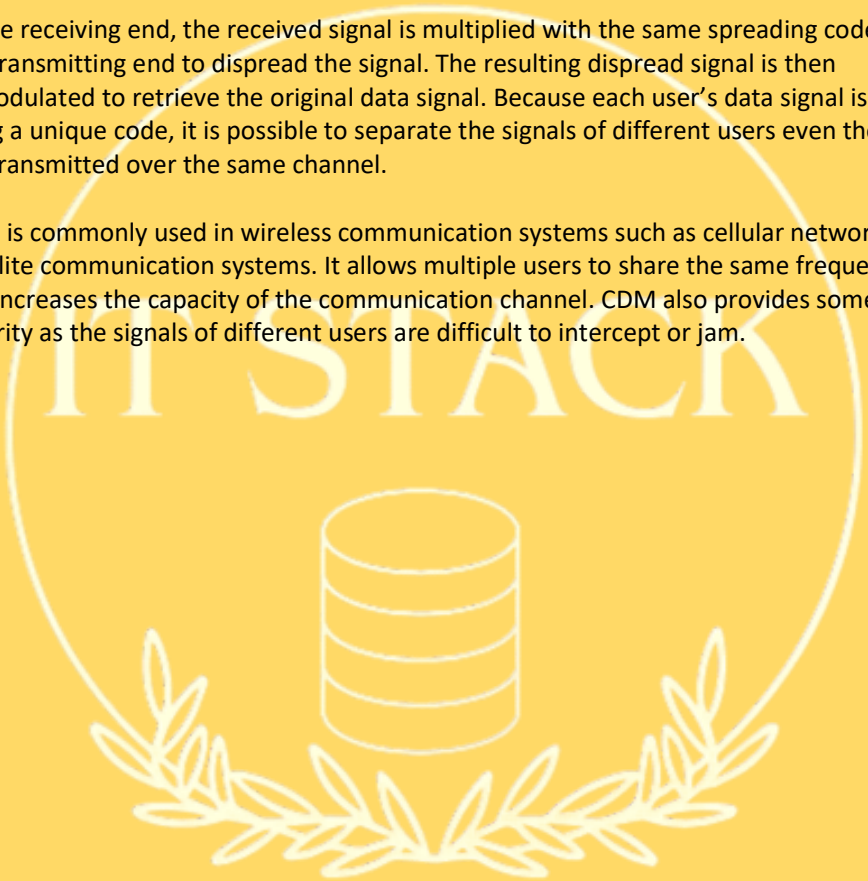
5. **Code-division multiplexing (CDM)** :

Code division multiplexing (CDM) is a technique used in telecommunications to allow multiple users to transmit data simultaneously over a single communication channel. In CDM, each user is assigned a unique code that is used to modulate their signal. The modulated signals are then combined and transmitted over the same channel. At the receiving end, each user's signal is demodulated using their unique code to retrieve their original data.

In CDM, each user is assigned a unique spreading code that is used to spread the data signal. This spreading code is typically a binary sequence that is much longer than the original data signal. The spreading code is multiplied with the data signal to generate a spread spectrum signal that has a much wider bandwidth than the original data signal. The spread spectrum signals of all users are then combined and transmitted over the same channel.

At the receiving end, the received signal is multiplied with the same spreading code used at the transmitting end to dispread the signal. The resulting dispread signal is then demodulated to retrieve the original data signal. Because each user's data signal is spread using a unique code, it is possible to separate the signals of different users even though they are transmitted over the same channel.

CDM is commonly used in wireless communication systems such as cellular networks and satellite communication systems. It allows multiple users to share the same frequency band and increases the capacity of the communication channel. CDM also provides some level of security as the signals of different users are difficult to intercept or jam.



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