WMC (Unit 2)

(*). Cellular Concept:

→ Mobile Networks are also called Cellular Networks because the consist of large number of interconnected cells.

→ These cells are placed in a pattern which is dependent on land and reception characteristics.

→ These cells patterns roughly take the form of regular shapes, such as hexagons, squares, circles, etc. (Mostly Hexagon).

→ Each of these cells is assigned with multiple frequencies which have corresponding base stations.

→ These frequencies can be reused in other cells provided that the same frequencies are not reused in adjacent cells, that can cause co-channel interference.

→ A cell typically uses different set of frequencies from neighbouring cells to avoid interference and provide guaranteed service quality within each cell.

→ Each cell has a base station. Mobile terminals in a cell communicate via the base station of that cell.

→ Cellular technology needs to offer very efficient use of the available frequency spectrum.

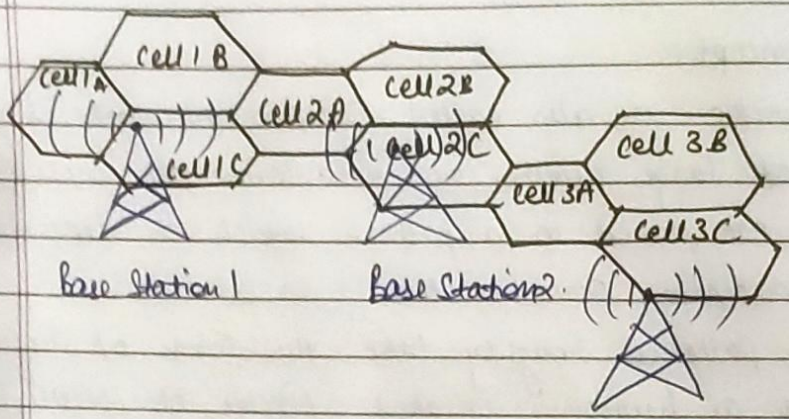
→ Limit the coverage area of each base station to a small area.

(*). Cell Area:

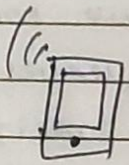
→ A cellular network is a radio network distributed over a geographic area called cells and the area it covers is called cell area.

→ Each cell station is served by atleast one fixed location and this fixed location is called base station or cell site.

→ When three cell sites are joined together, they provide coverage over a large geographical area. This process helps a large no. of mobile phones to communicate with each other.



Cellphone 1



Cellphone 2

(*) Signal Strength:

→ Signal strength is the wireless signal power level that is received by the wireless client.

→ Strong signal strength results in more reliable connections and higher speeds.

→ Signal strength can vary depending on the cellular network, the technology used (2G, 3G, 4G, 5G) and the specific location you are in.

→ It is represented in -dBm format (0 to -100).

→ The closer the value is to 0, the stronger is the signal. For example, -41 dBm is better than -61 dBm.

(*) Cell Parameter:

→ Cell parameters refer to the various settings and configurations that define the behaviour and characteristics of a cellular network's individual cells.

Here are some important cell parameters:

1. Cell ID: A unique number used to identify each cell within an area.
2. Cell Coverage Area: The geographical area that defines the cellular coverage zone created by the base station of a mobile network.
3. Transmit power: Key degree of freedom in the management of interference, energy and connectivity.
4. Frequency Band: The range or interval of radio frequencies used to transmit a signal over a network. Different frequency bands are alloted for different applications.
5. Cell Radius: Radius of a cell.
6. Traffic Management: Combination of measures that serve to preserve traffic capacity and improve the security, safety and reliability of the network.

(*) Cell Capacity:

→ The explosion of mobile traffics puts immense pressure on mobile networks to deliver the necessary capacity and performance.

→ Mobile network operators and their suppliers will require a variety of strategies to satisfy demands.

→ The aim of the capacity is to provide more channels per unit coverage area.

→ Cell capacity refers to the maximum number of users or devices that a cell or base station can support.

→ 3 techniques to improve capacity: sectoring, splitting and coverage zone approach.

→ The factors affecting cell capacity include:

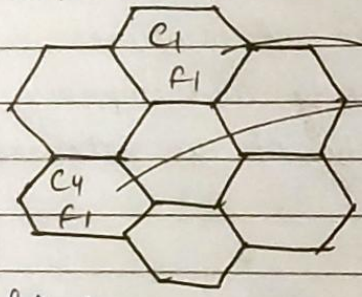
- Spectrum Availability
- Channel Bandwidth
- Signal to Noise Ratio
- Interference
- Cell size and density.

(*) Co-channel Interference (CCI):

→ Refers to interference that occurs when multiple cells in a cellular network use the same frequency to transmit and receive signals.

→ Co-channel cells are those cells that use same frequency in a given coverage area.

→ Interference from these cells is called as CCI.



Frequency Reuse

Since C_1 and C_4 are using same frequency (f_1), C_1 and C_4 are co-channels.

→ Interference occurs because the radio transmitter is operating on same frequency.

(*) Reasons for co-channel interference:

→ Cells operating at same frequency.

→ Bad weather conditions: Signals can overlap.

→ Poor frequency planning.

(*) Frequency Reuse:

→ Core concept of cellular mobile communication

→ The total available channels are divided into number of channel sets and each channel set is assigned to the cell.

→ Cells are assigned frequencies that are completely different

from the neighbouring cells.

→ In the diagram, the cells with same alphabets will use the same frequencies.

→ Some frequencies can be reused by another cell if the cell is at a distance 'D' where D = reuse distance.

→ Reuse distance $D = \sqrt{3N}\,R$

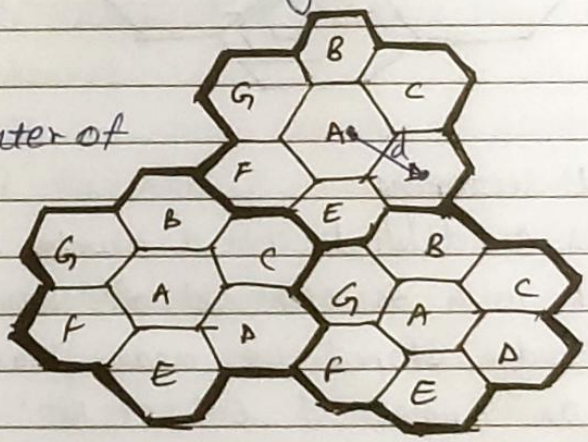
D = minimum distance b/w the center of the cells that use same frequency.

R = Radius of cell.

N = Number of cells in a repeating pattern.

d = distance b/w center of adjacent cells.

$d = \sqrt{3}\,R$



Frequencies cannot be reused by the neighbouring cells.

(*) Cell Splitting:

→ Process of subdividing a cell into smaller cells each with its own Base Station.

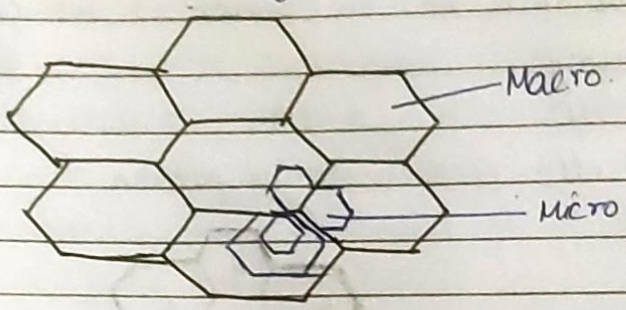
→ On splitting, new cells with smaller radius are added called microcells.

→ Each new cell created is independent.

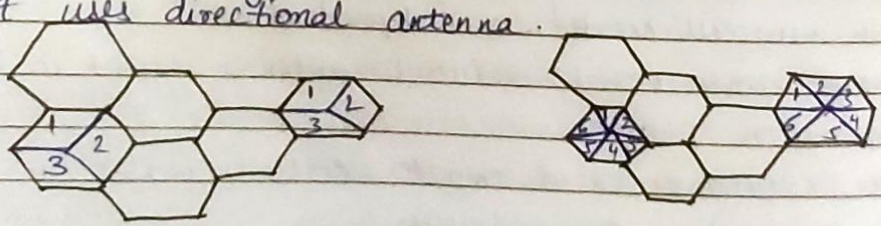
→ Every new cell has reduced antenna height and transmitter power.

→ The creation of new smaller cells increases the capacity of the system as a whole.

→ It increases frequency reuse factor.
→ A higher frequency factor increases the cell capacity.
→ It increases signal to noise ratio.
→ It reduces interference.
→ Disadvantages: (a) Huge Number of base stations are required
(b) Assigning channels is difficult.

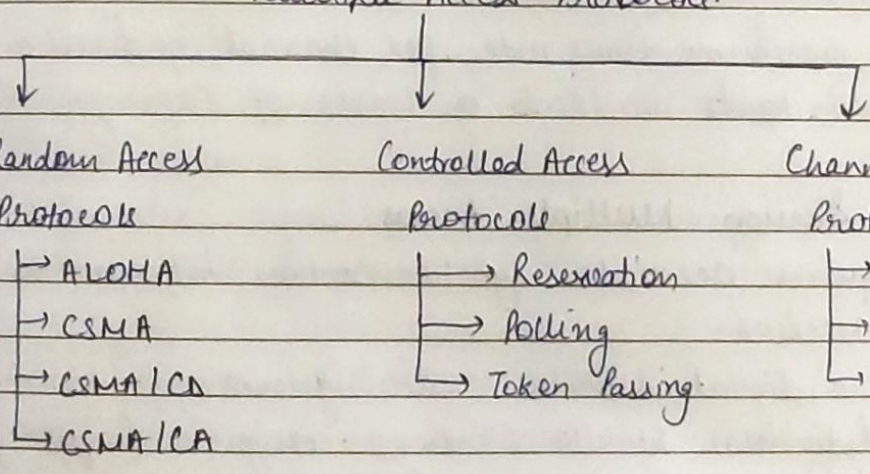


(*) Cell Sectoring:
→ Cells are divided into a number of wedge-shaped sectors, each with its own set of channels.
→ By wedge-shaped we mean that the cells are divided at an angle of 60° or 120°.
→ These sectored cells are called microcells.
→ Like cell splitting, cell sectoring also helps in increasing the channel capacity and reducing interference.
→ 3 or 6 sectors are created from a given cell.
→ Unlike cell splitting, here the cell radius does not change after sectoring.
→ It increases system performance.
→ It uses directional antenna.



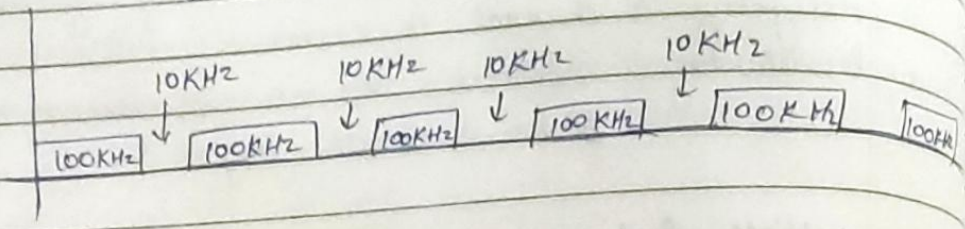
→ Sectoring increases signal to interference ratio.
→ The cluster size gets reduced.
→ Reduces interference without altering system performance.
→ Assigning a channel is easier.
→ Disadvantages: ⓐ. Increases the no. of antennas per base station
ⓑ. Decreases efficiency.

(*). Multiple Radio Access protocols:
→ Suppose there is no dedicated path to communicate or transfer data between two devices, in this case, multiple stations access the channel & simultaneously transmits the data over the channel.
→ It may create collision and crosstalk. Multiple Access Protocols are used to reduce collision and crosstalk.



(*). Frequency division Multiple Access:
→ Guard bands are used between the adjacent signal spectrum to minimize crosstalk between the channels.
→ Often used in first generation of analog mobile phone.
→ A specific frequency band is given to one person and it

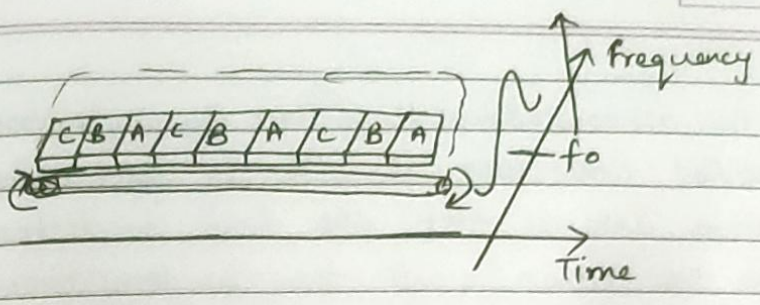
will be received by identifying each of the frequ... on the receiving end.



→ Advantages:
(a). Reduces bit rate information.
(b). Use of efficient numerical codes increases capacity.
(c). Reduces cost and lowers Interference.
(d). Can be easily Implemented.
(e). It can be easily configured.
(f). Transmission is continuous, less number of bits are required for synchronization and framing.

→ Disadvantages:
(a). The maximum flow rate per channel is fixed and small.
(b). Guard bands leads to a waste of capacity.

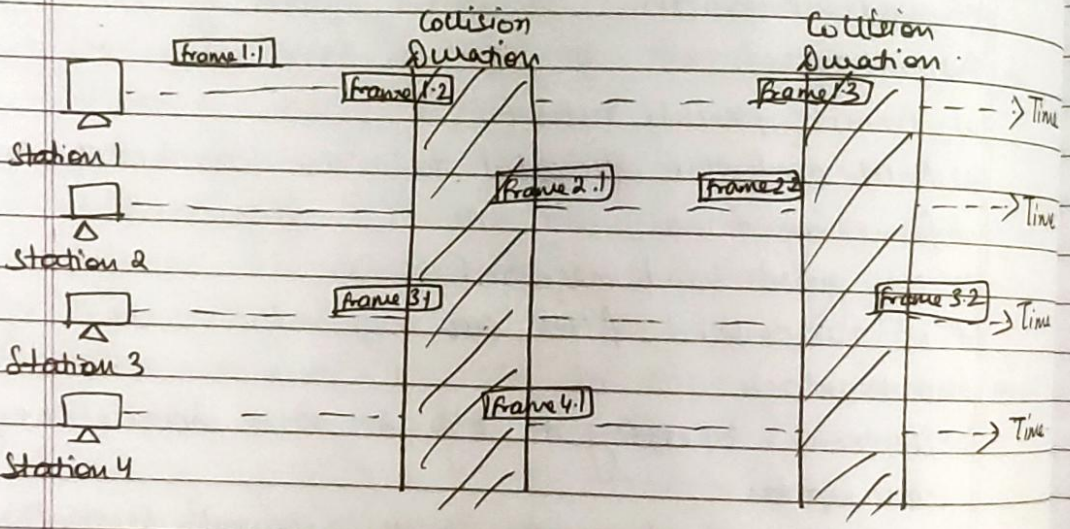
(*). Time Division Multiple Access:
→ It requires accurate synchronization between the transmitter and receiver.
→ Used in digital Mobile radio Systems.
→ The Individual Mobile Stations assign a frequency for the exclusive use of a time interval.
→ The frequency of system is divided into sub-bands and TDMA is used for multiple access in each sub band.
→ Sub bands are called carrier frequencies.
→ The mobile system that uses this technique is refered as multi-carrier Systems.
→ The entire bandwidth is available to the user but only for a finite period of time



→ In the given example, the frequency band has been shared by 3 users.
→ Each user is assigned different time slots to send and receive data.
→ In this example, user 'B' sends after user 'A' and user 'C' sends thereafter.
→ Advantages:
(a). Permits flexible rates.
(b) Number of slots allocated to a user can be changed frame by frame.
(c). No guard band required.
(d) NO narrowband filter required.
→ Disadvantages:
(a). Electronics operating at high bit rates increase energy consumption.
(b). Complex signal processing is required to synchronize within short slots.

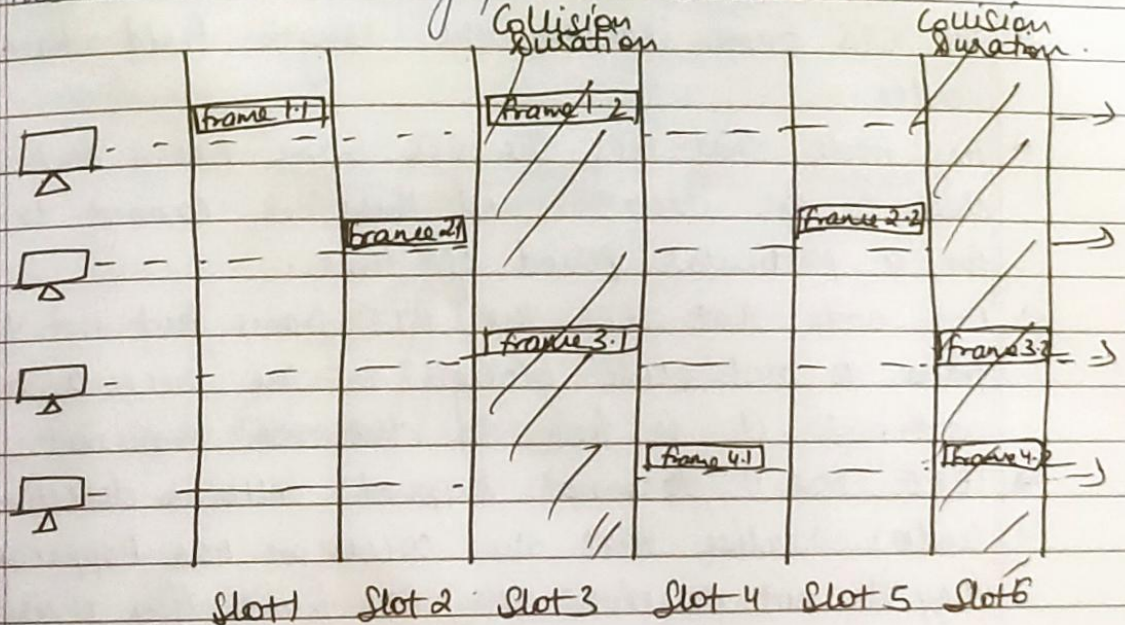
(*) FIXED ALOHA: (PURE ALOHA):
→ Used when data is available for sending over a channel at stations.
→ Each station transmits data to a channel without checking whether the channel is idle or not.
→ The chances of collision may occur and the data frame can be lost.
→ Station expects the acknowledgement from the receiver,

if the acknowledgement of the frame is received at a specified time, then it will be OK, otherwise the station assumes that the frame is destroyed.
→ Then the station waits for random amount of time and then after that it retransmits the frame.
→ Time is not synchronized, it is continuous.
→ It does not decrease the no. of collisions to half.
→ The maximum throughput is about 18%.



(ii) Slotted ALOHA:
→ There is a high possibility of frame hitting in Pure ALOHA, so Slotted ALOHA is designed to overcome it.
→ Slotted Aloha does not allow transmission of data whenever the station wants to send it.
→ The shared channel is divided into fixed time interval called slots.
→ If a station wants to send a frame to a shared channel the frame can only be sent at the beginning of the slot.

→ Only one frame is allowed to be sent to each slot.
→ If a station fails to send the data, it has to wait until the next slot.
→ There is still a possibility of collision if two stations try to send a frame at the beginning of the time slot.
→ Time is globally synchronized. Time is discrete in it.
→ Enhances efficiency of fixed aloha. It decreases the number of collisions to half.
→ The maximum throughput is about 37%.



(*). Multiple Access with collision Avoidance:
→ Multiple Access with collision Avoidance (MACA) is a Medium Access Control (MAC) layer protocol used in wireless ad hoc network.
→ It is an alternate to Carrier Sense multiple Access (CSMA).
→ MACA is used to solve the hidden terminal and exposed terminal problem.
→ IEEE 802.11

Working:

→ The sender and the receiver sends/exchange control frames with each other before the sender actually transmits data.

→ This exchange informs all nearby nodes that a transmission is about to begin.

→ Sender transmits a Request to Send (RTS) frame to the receiver.

→ The RTS frame includes a field that indicates how long the sender wants to hold the medium.

→ Receiver replies with a Clear to Send (CTS) frame.

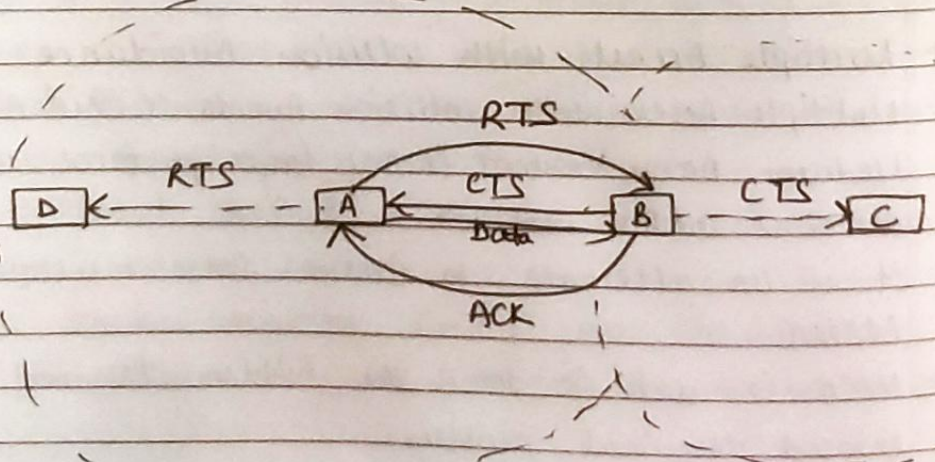
→ The CTS frame echoes the length field back to the sender.

→ Any node that sees the CTS frame knows that it is close to the receiver and therefore cannot transmit for a particular period of time.

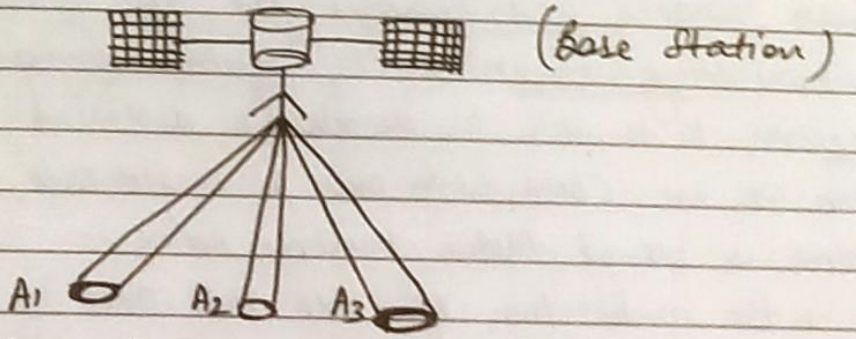
→ Any node that sees the RTS frame but not the CTS frame is not close enough to the receiver to interfere with, so it is free to transmit.

→ IEEE 802.11 does not support collision detection.

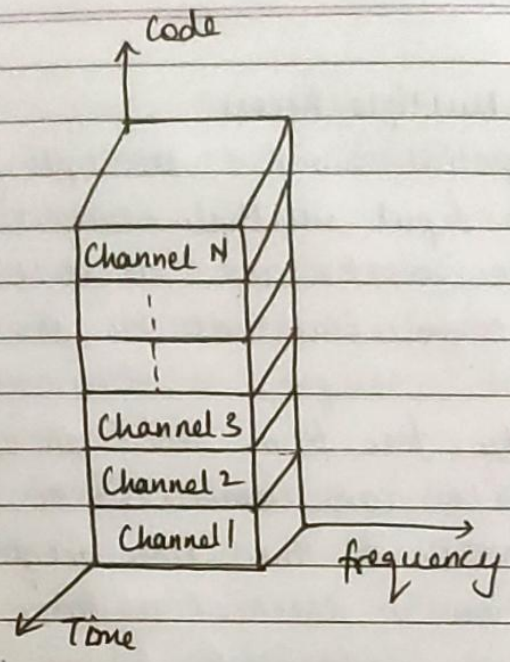
→ Senders realise that the collision has happened when they do not receive the CTS frame after a period of time



(*) Space Division Multiple Access:
→ Also called Spatial Division Multiple Access.
→ MIMO (Multiple-Input multiple-Output) architecture
→ Used mostly in wireless and satellite communication.
→ All users can communicate at the same time using the same channel.
→ It is completely free from interference
→ A single satellite can communicate with more satellite receivers of the same frequency.
→ The base station in SSMA can track a moving user
→ Main advantage is frequency reuse and free from interference.



(*) Code Division Multiple Access:
→ Several transmitters use a single channel to send information simultaneously.
→ Every user uses the full available spectrum instead of getting alloted by seperate frequencies.
→ Much recommended for voice and data communications.
→ While multiple codes occupy the same channel, the users having same codes can communicate with each other
→ It uses spread spectrum.



(*) Spread ALOHA Multiple Access:

→ CDMA senders and receivers are not really simple
→ Communicating with n devices requires programming of the receiver to be able to decode n different codes.
→ When we use CDMA with only a single code, the resultant scheme is spread Aloha Multiple Access.
→ It is the combination of CDMA and TDMA.
→ Each sender uses the same spreading code.
→ It allows multiple users to access a shared communication medium efficiently.
→ This single code is known as chipping sequence.

(*) OFDM:

→ Orthogonal Frequency Division Multiplexing.
→ A method of digital data modulation.
→ A stream of data is divided into several seperate sub-streams for transmission via multiple channels.
→ It uses the principle of frequency Division Multiplexing
→ The available bandwidth is divided into a set of sub-

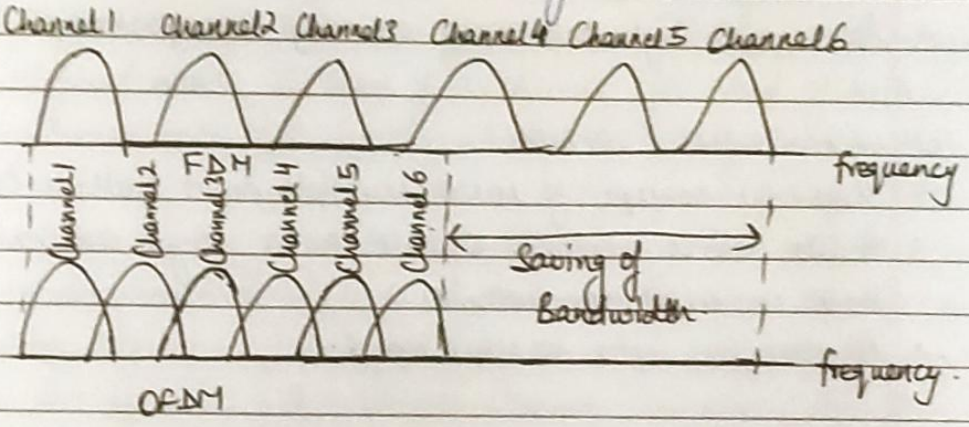
having seperate frequency bands.

→ The sub streams in which the main signal is divided are orthogonal to each other, i.e, perpendicular to each other.

→ These orthogonal signals do not interfere with each other.

→ No interference occurs between the signals even if their sidebands overlap. (Guard bands can therefore be removed, thus saving bandwidth).

→ FDM vs OFDM to depict the saving in bandwidth:



(*). Variants of OFDM:

(A). Coded OFDM:

→ A term used for a system in which the error control coding and the OFDM modulation process work closely together.

→ A form of OFDM where error correction coding is incorporated into the signal.

→ It is capable of handling very strong echoes.

→ It is more immune to impulse Noise.

(B) Orthogonal Frequency Division Multiple Access (OFDMA)

→ Used to provide Multiple Access capability when using OFDM technologies.

→ It is a multiuser version of OFDM digital modulation scheme.
→ It is a combination of OFDM and CDMA.

(C) Flash OFDM: (FOFDM):
→ Fast hopped form of OFDM.
→ It uses multiple tones and fast hopping to spread signal over a given spectrum band.
→ It supports high data rates at very low packet and delay.

(D) Vector OFDM (VOFDM):
→ Uses the concept of MIMO (Multiple Input Multiple Output).
→ It can deliver multiple signals on a single antenna or all them on multiple antennas.
→ It provides upto 20 Mbps speed.

(E) Wideband OFDM (WOFDM):
→ The spacing between the channels is large enough so that any frequency errors between the transmitter and the receiver have no effect on the performance of the system.
→ Particularly applicable to Wi-fi systems.
→ 2.4 GHz Bandwidth.
→ 30-45 Mbps speed.
→ Low power Multipoint Radio Networks.

(*) Comparision of Multiple Access Techniques:

FDMA	TDMA	CDMA
① Frequency Division Multiple Access	① Time Division Multiple Access.	① Code Division Multiple Access.
② Sharing of bandwidth among different stations	② Only sharing of time of satellite transponder.	② Sharing of both, bandwidth and time.
③ No need of code word.	③ No need of code word.	③ Code word is needed.
④ Need of guard bands	④ Need of guard time	④ Need of both.
⑤ Synchronization not required.	⑤ Synchronization Required.	⑤ Synchronization not required.
⑥ Rate of data is low.	⑥ Rate of data is medium	⑥ Rate of data is high.
⑦ Mode of data transfer is continuous signals.	⑦ Mode of data transfer is signal is bursts.	⑦ Mode of data transfer is digital signal.
⑧ Little flexible	⑧ Moderate flexible	⑧ Highly flexible.