BUDDHA SERIES

(Unit Wise Solved Question & Answers)

Course – B. Tech (ECE)

College – Buddha Institute of Technology

(AKTU CODE-525)

Department: Electronics and Communication Engineering

Subject: Wireless & Mobile Communications (KEC076)

Faculty Name: AKC

Unit – 1

Q. 1 Explain the term 'Evolution of mobile radio communication fundamentals'.

Ans: In the last few decades, Mobile Wireless Communication networks have experienced a lot of changes. The cellular wireless Generation(G) generally refers to a change in the nature of the system, speed, technology and frequency. Each generation have some standards, capacities, techniques and new features which differentiate it from the previous one.

First Generation (1G) Wireless Mobile Communication System:

- Launched in Tokyo in 1979
- Technology: Analog Switching
- Frequency: 800 MHz and 900 MHz
- Bandwidth : 10 MHz (666 Duplex Channels with a bandwidth of 30 KHz
- Data Rate:2.4 Kbps
- Modulation : Frequency Modulation (FM)
- Mode of Service: Voice only
- Access Technique: Frequency Division Multiple Access (FDMA)
- Poor Voice Quality
- Large Size Mobile Phones
- Roaming was not possible
- Limited number of users and cell coverage
- Less Security

Second Generation (2G) Wireless Mobile Communication System:

- Launched in Finland in 1991
- Technology: Digital Switching
- Bandwidth: 25 MHz
- Modulation : Gaussian Minimum Shift Keying (GMSK)
- Standard: Global System for Mobile Communication (GSM) and Code Division Multiple Access (CDMA)
- SMS service possible
- Roaming is possible
- Enhanced Security
- Encrypted Voice transmission
- First internet at lower speed
- Data Rate14.4 to 64 Kbps

2.5 G Wireless Mobile Communication System

- To support higher data rate, General Packet Radio Service (GPRS) was introduced which supports data rates upto 171 Kbps.

- Enhanced Data GSM Evolution (EDGE) was developed to support data rates upto 473.6 Kbps for GSM.
- CDMA2000 standard was introduced to support higher data rates upto 384 Kbps for CDMA networks.

Third Generation (3G) Wireless Mobile Communication System:

3G mobile communication started with the introduction of UMTS (Universal Mobile Telecommunication System).

- Launched in 2001 in Japan.
- Bandwidth:25 MHz
- Higher Data Rate: 144 Kbps to 2 Mbps
- Modulation: WCDMA and OFDM
- Supports video calling on mobile devices
- Enhanced security, more users and coverage
- Supports mobile Apps
- Supports multimedia messages
- Location tracking and maps
- Better web browsing
- TV streaming
- High quality 3D games
- Higher bandwidth requirements to support a higher data rates
- Costly mobile devices

Fourth Generation (4G) Wireless Mobile Communication System:

- **Launched in 2009 in Stockholm**
- 4G systems are enhanced version of 3G networks developed by IEEE
- Bandwidth:100 MHz
- Supports much higher data rate 100 Mbps to 1 Gbps
- Modulation: QAM & QPSK
- Enhanced security and mobility
- Supports High- definition video streaming and gaming
- Expensive hardware and infrastructure
- Voice over LTE network (VoLTE)
- Uses IP Packets for voice
- High-end mobile devices compatible with 4 G technology are required which is costly.

Fifth Generation (5G) Wireless Mobile Communication System:

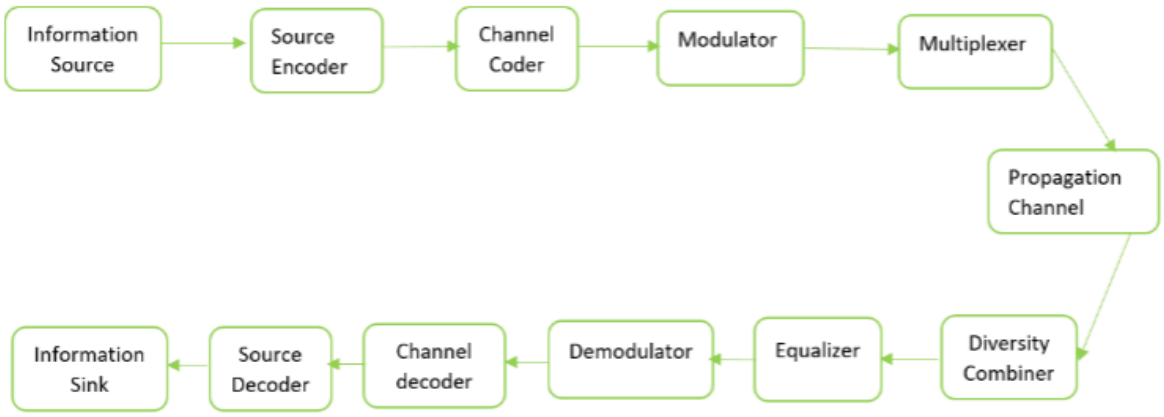
- Launched in 2019 in South Korea
- Supports Ultra fast mobile internet upto 10 Gbps.
- Bandwidth:100 MHz
- Freq 30 GHz t0 300 GHz
- Modulation: OFDM
- Low Latency in milliseconds
- Total cost reduction for data

- Higher security and reliable networks
- Uses technologies like small cells cells and beamforming to improve efficiency.
- Cloud based infrastructure offers power efficiency, easy maintenance and upgrade o hardware

Q2. Explain the general model of wireless communication link in brief.

General Model of Wireless Communication Link:

The Structure of a wireless communication link involves several key components that work together and maintains the connection between the transmitter and the receiver.



Transmitter Side

- **Information Source:** It is a device that contains the information, or we can say it produces information and that information must be processed before transmitting through the propagation channel.
- **Source Encoder:** It is a device that compresses the data provided by the information source in order to reduce the amount of data to be transmitted by removing the redundancies in the data.
- **Channel Coder:** It is a device that is used to increase the reliability of the system by adding the redundant bit (parity bit) to the codded message to protect against errors that may occur during the transmission.
- **Modulator:** It is a device that converts the codded message into a signal so that it can be transmitted through the communication channel. It converts digital data into analog signals.
- **Multiplexer:** It is a device that allows multiple signals to share a single transmission line by combining them to a single composite signal.

Propagation Channel

It is a physical medium that carries the modulated signal. it is the medium through which the signal travels. It can be air, water, or any other medium that allows the signal to propagate.

Receiver Side

- **Diversity Combiner**: It is a device that combines multiple versions of the same signal that have been transmitted through different paths or channels. It Combines all the best-arising signals and by combining them produces the high power signal.
- **Equalizer:** It is a device that compensates for the distortion introduced by the propagation channel by adjusting the amplitude and phase of the received signal.
- **Demodulator:** A device that extracts the original codded message from the modulated signal received from the propagation channel. it is a device that converts the analog signal to digital data.

- **Channel Decoder:** It is a device that corrects the errors in the codded message transmitted by the information source. It uses various techniques in order to correct the errors that occur due to noise and various other causes.
- **Source Decoder:** It is a device that performs the opposite of the work performed by the source encoder, It decompresses the coded message back to its original format in order to recover the original data.
- **Information Sink:** A device that receives and processes the information transmitted by the information source.

Q3: Discuss the cellular system infrastructure and components in brief.

ANS: Cellular System Infrastructure:

Early wireless systems had a high-power transmitter, covering the entire service area. This required a very huge amount of power and was not suitable for many practical reasons. The cellular system replaced a large zone with a number of smaller hexagonal cells with a single BS (base station) covering a fraction of the area. Evolution of such a cellular system is shown in the given figures, with all wireless receivers located in a cell being served by a BS.

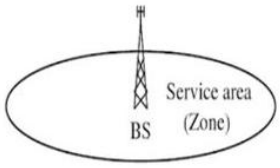


Fig: Early wireless system: large zone

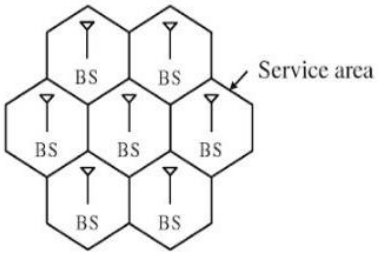


Fig: Cellular system: small zone

In a cellular structure, a MS (mobile station) needs to communicate with the BS of the cell where the MS is currently located and the BS acts as a gateway to the rest of the world. Therefore, to provide a link, the MS needs to be in the area of one of the cells (and hence a BS) so that mobility of the MS can be supported. Several base stations are connected through hard-wires and are controlled by a BS controller (BSC), which in turn is connected to a mobile switching center (MSC).

Several mobile switching centers are interconnected to a PSTN (public switched telephone network) and the ATM (asynchronous transfer mode) backbone. To provide a better perspective of wireless communication technology, simplified system infrastructure for cellular system is shown in the figure:

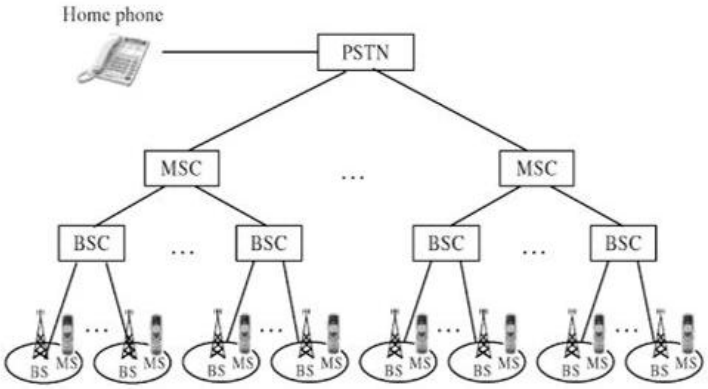
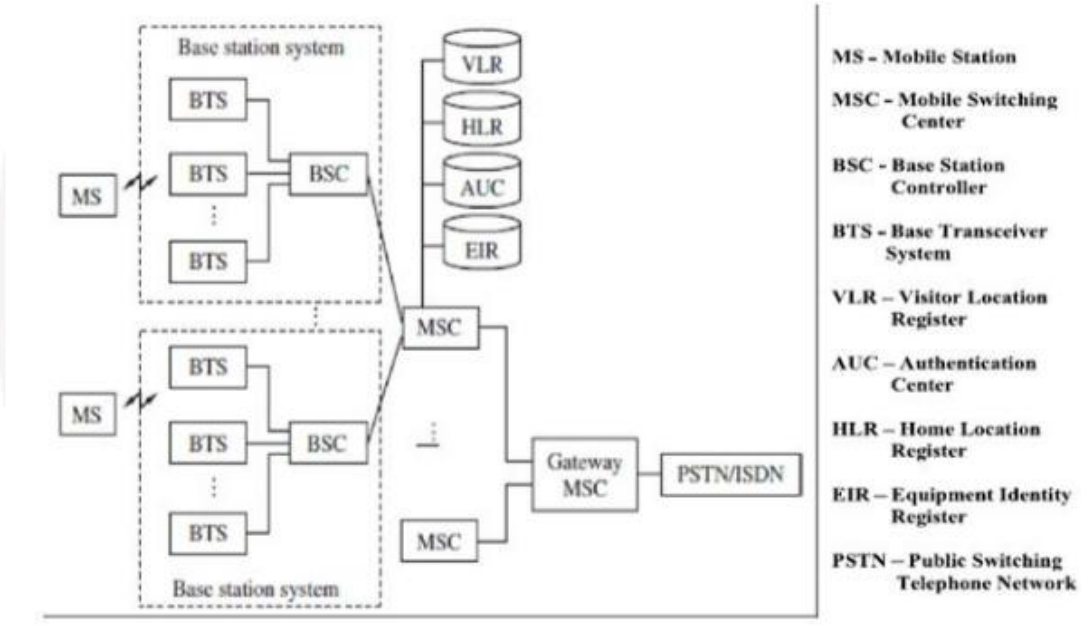


Fig: cellular system infrastructure

A cellular system requires a fairly complex infrastructure. A generic block diagram in shown in the figure:



A BS consists of a base transceiver system (BTS) and a BSC. Both tower and antenna are a part of the BTS, while all associated electronics are contained in the BSC.

The HLR (home location register) and VLR (visitor location register) are two sets of pointers that support mobility and enable the use of the same telephone numbers worldwide.

The AUC (authentication center) unit provides authentication and encryption parameters that verify the user's identity and ensure the confidentiality of each cell.

The EIR (equipment identity register) is a database that information about identity of mobile equipment. Both AUC and EIR can be implemented as individual stand-alone units or as a combined AUC/EIR unit.

The HLR is located at the MSC where MS is initially registered and is the initial home location for billing and access information.

In simple words, any incoming call, based on the calling number, is directed to the HLR of the home MS where the MS is registered. The HLR then points to the VLR of the MSC where the MS is currently located The VLR contains information about all MS visiting that particular MSC and hence points to the HLR of the visiting MSs for exchanging related information about the MS.

Such a pointer allows calls to be routed or rerouted to the MS, wherever it is located. In cellular systems, a reverse direction pointer is needed that allows traversal of many control signals back and forth between the HLR and VLR such bidirectional HLR-VLR pointers help in carrying out various functionalities.

Q4. Explain the basic terms used in wireless mobile communication.

ANS:

Base Station :A fixed station in a mobile radio system used for radio communication with mobile stations. Base stations are located at the center or on the edge of a coverage region and consist of radio channels and transmitter and receiver antennas mounted on a tower.

Control Channel: Radio channels used for transmission of call setup, call request, call initiation, and other beacon or control purposes.

Forward Channel Radio channel used for transmission of information from the base station to the mobile.

Full Duplex System: Communication systems which allow simultaneous two-way communication. Transmission and reception is typically on two different channels (FDD) although new cordless PCS systems are using TDD.

Half Duplex System: Communication systems which allow two-way communication by using the same radio channel for both transmission and reception. At any given time, the user can only either transmit or receive information.

Handoff: The process of transferring a mobile station from one channel or base station to another.

Mobile Station: A station in the cellular radio service intended for use while in motion at unspecified locations. Mobile stations may be hand-held personal units (portables) or installed in vehicles (mobiles).

Mobile Switching Center: Switching center which coordinates the routing of calls in a large service area. In a cellular radio system, the MSC connects the cellular base stations and the mobiles to the PSTN. An MSC is also called a mobile telephone switching office (MTSO).

Page :A brief message which is broadcast over the entire service area, usually in a simulcast fashion by many base stations at the same time.

Reverse Channel: Radio channel used for transmission of information from the mobile to base station.

Roamer: A mobile station which operates in a service area (market) other than that from which service has been subscribed.

Simplex Systems: Communication systems which provide only one-way communication.

Subscriber: A user who pays subscription charges for using a mobile communication system.

Transceiver A device capable of simultaneously transmitting and receiving radio signals.

Q5: Explain how a cellular mobile phone call is made?

ANS: When a cellular phone is turned on, but is not yet engaged in a call, it first scans the group of forward control channels to determine the one with the strongest signal, and then monitors that control channel until the signal drops below a usable level. At this point it again scans the control channels in search of the strongest base station signal. For each cellular system typically about 5% of the total number of channels are assigned as control channels.

Since the control channels are standardized and are identical throughout different markets within the country or continent, every phone, scans the same channels while idle. When a telephone call is placed

to a mobile user, the MSC dispatches the request to all base stations in the cellular system. The mobile identification number (MIN), which is the subscriber's telephone number, is then broadcast as a paging message over all of the forward control channels throughout the cellular system. The mobile receives the paging message sent by the base station which it monitors, and responds by identifying itself over the reverse control channel. The base station relays the acknowledgment sent by the mobile and informs the MSC of the handshake. Then, the MSC instructs the base station to move the call to an unused voice channel within the cell (typically, between ten to sixty voice channels and just one control channel are used in each cell's base station). At this point the base station signals the mobile to change frequencies to an unused forward and reverse voice channel pair, at which point another data message (called an alert) is transmitted over the forward voice channel to instruct the mobile telephone to ring, thereby instructing the mobile user to answer the phone. All of these events occur within a few seconds and are not noticeable by the user.

Once a call is in progress, the MSC adjusts the transmitted power of the mobile and changes the channel of the mobile unit and base stations in order to maintain call quality as the subscriber moves in and out of range of each base station. This is called a handoff Special control signaling is applied to the voice channels so that the mobile unit may be controlled by the base station and the MSC while a call is in progress. When a mobile originates a call, a call initiation request is sent on the reverse control channel. With this request the mobile unit transmits its telephone number (MIN), electronic serial number (ESN), and the telephone number of the called party. The mobile also transmits a station class mark (SCM) which indicates what the maximum transmitter power level is for the particular user. The cell base station receives this data and sends it to the MSC. The MSC validates the request, makes connection to the called party through the PSTN, and instructs the base station and mobile user to move to an unused forward and reverse voice channel pair to allow the conversation to begin.

Q6: Explain frequency reuse concept with the help of proper cellular diagram. Also draw a cellular system with 19-cell reuse and locate the co-channel cells for this system. [AKTU 2021-22]

Frequency Reuse:

Cellular radio systems are based on reuse of channels throughout a coverage region. Each cellular base station is allocated a group of radio channels to be used within a small geographic area called a cell. Base stations in adjacent cells are assigned channel groups which contain completely different channels than neighboring cells. The base station antennas are designed to achieve the desired coverage within the particular cell. By limiting the coverage area to within the boundaries of a cell, the same group of channels may be used to cover different cells that are separated from one another by distances large enough to keep interference levels within tolerable limits. The design process of selecting and allocating channel groups for all of the cellular base stations within a system is called frequency reuse or frequency planning.

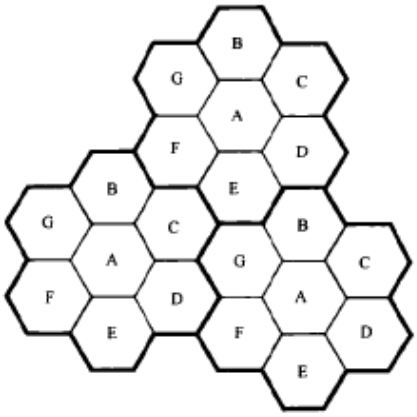


Fig: Illustration of the cellular frequency reuse concept. Cells with the same letter use the same set of frequencies. A cell cluster is outlined in bold and replicated over the coverage area. In this example, the cluster size, N, is equal to seven, and the frequency reuse factor is 1/7 since each cell contains one-seventh of the total number of available channels.

If each cell is allocated a group of k channels and if the S channels are divided among N cells into unique and disjoint channel groups which each have the same number of channels, the total number of available radio channels can be expressed as

$$S = kN$$

The N cells which collectively use the complete set of available frequencies is called a cluster. If a cluster is replicated M times within the system, the total number of duplex channels, C, can be used as a measure of capacity and is given

$$C = MkN = MS$$

The capacity of a cellular system is directly proportional to the number of times a cluster is replicated in a fixed service area. The factor N is called the cluster size and is typically equal to 4, 7, or 12. If the cluster size N is reduced while the cell size is kept constant, more clusters are required to cover a given area and hence more capacity (a larger value of C) is achieved. A large cluster size indicates that the ratio between the cell radius and the distance between co-channel cells is large. Conversely, a small cluster size indicates that co-channel cells are located much closer together. The value for N is a function of how much interference a mobile or base station can tolerate while maintaining a sufficient quality of communications.

From a design point of view, the smallest possible value of N is desirable in order to maximize capacity over a given coverage area (i.e.. to maximize C in equation). The frequency reuse factor of a cellular system is given by I /N, since each cell within a cluster is only assigned I /N of the total available channels in the system.

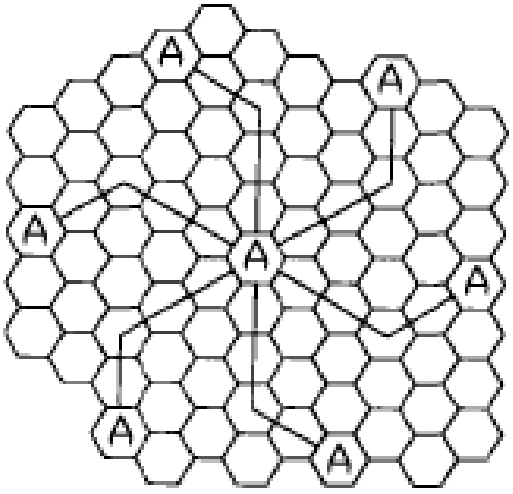
The number of cells per cluster $N = i^2+ij+j^2$

where i and j are non-negative integers. '

To find the nearest co-channel neighbors of a particular cell, one must do the following:

(1) move i cells along any chain of hexagons and then

(2) turn 60 degrees counter-clockwise and move j cells. This is illustrated in following fog for i = 3 and j = 2 (example, N = 19).



Method of locating co-channel cells in a cellular system. In this example, N = 19 (i.e., i = 3, j = 2).

Q7: Discuss different channel assignment strategies used in mobile communication.

Ans: Channel Assignment Strategies: For efficient utilization of the radio spectrum, a frequency reuse scheme with the objectives of increasing capacity and minimizing interference is required. A variety of channel assignment strategies have been developed to achieve these objectives.

Channel assignment strategies can be classified as either fixed or dynamic.

Fixed channel assignment strategy:

In a fixed channel assignment strategy; each cell is allocated a predetermined set of voice channels. Any call attempt within the cell can only be served by the unused channels in that particular cell. If all the channels in that cell are occupied, the call is blocked and the subscriber does not receive service. Several variations of the fixed assignment strategy exist. In one approach, called the borrowing strategy, a cell is allowed to borrow channels from a neighboring cell if all of its own channels are already occupied. The mobile switching center (MSC) supervises such borrowing procedures and ensures that the borrowing of a channel does not disrupt or interfere with any of the calls in progress in the donor cell.

Dynamic channel assignment strategy

In a dynamic channel assignment strategy, voice channels are not allocated to different cells permanently. Instead, each time a call request is made, the serving base station requests a channel from the MSC. The switch then allocates a channel to the requested cell following an algorithm that takes into account the likelihood of fixture blocking within the cell, the frequency of use of the candidate channel, the reuse distance of the channel, and other cost functions. Accordingly, the MSC only allocates a given frequency if that frequency is not presently in use in the cell or any other cell which falls within the minimum restricted distance of frequency reuse to avoid co-channel interference. Dynamic channel assignment reduce the likelihood of blocking, which increases the trunking capacity of the system, since all the available channels in a market are accessible

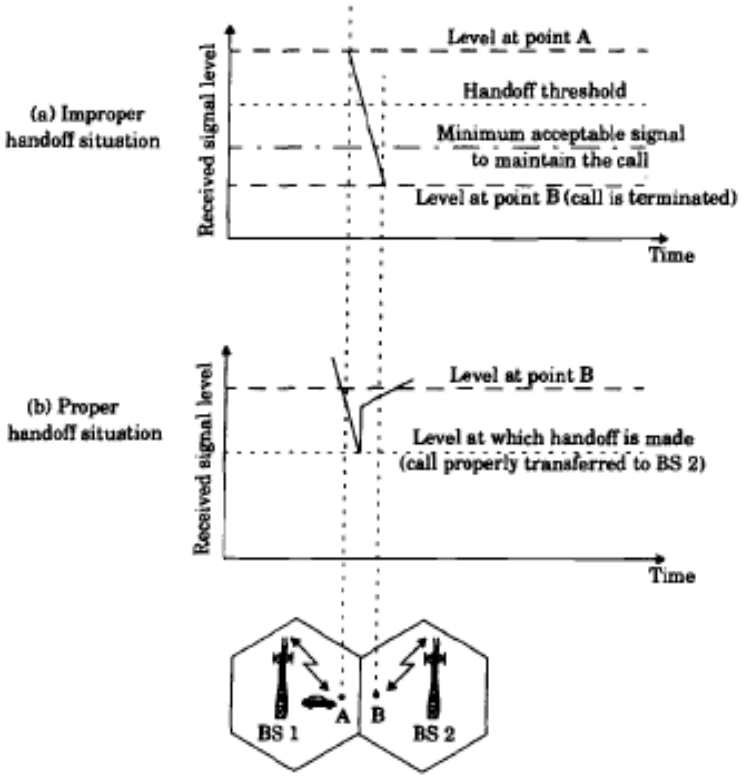
to all of the cells. Dynamic channel assignment strategies require the MSC to collect real-time data on channel occupancy, traffic distribution, arid radio signal strength indications (RSS!) of all channels on a continuous basis. This increases the storage and computational load on the system but provides the advantage of increased channel utilization and decreased probability of a blocked call.

Q8. What do you mean by Hand-Off used in wireless cellular communication? Explain a hand off situation at Cell boundary by showing proper and improper handoff.

Ans: Handoff :

When a mobile moves into a different cell while a conversation is in progress, the MSC automatically transfers the call to a new channel belonging to the new base station. Transfer of call to a new channel belong to new base station is called Hand-off.

This handoff operation not only involves a new base station, but also requires that the voice and control signals be allocated to channels associated with the new base station. Handoffs must be performed successfully and as infrequently as possible. In order to meet these requirements, system designers must specify an optimum signal level at which to initiate a handoff. Once a particular signal level is specified as the minimum usable signal for acceptable voice quality at the base station receiver (normally taken as between —90 dBm and —100 dBm), a slightly stronger signal level is used as a threshold at which a handoff is made. This margin, given by $\Delta = P_{r\ handoff} - P_{r\ minimum\ usable}$ cannot be too large or too small. If Δ is too large, unnecessary handoffs which burden the MSC may occur, and if Δ is too small, there may be insufficient time to complete a handoff before a call is lost due to weak signal conditions. Therefore, Δ is chosen carefully to meet these conflicting requirements.



Q9: Explain handoff Strategies used in wireless mobile communication.
Or
Illustrate the MAHO technique and Queuing concept in hand off. Also explain the different types of handoff in mobile communication.

Ans: **Handoff Strategies:** When a mobile moves into a different cell while a conversation is in progress, the MSC automatically transfers the call to a new channel belonging to the new base station. This procedure is called handoff. The handoffs are of following types:

1. Hard Handoff
2. Soft Handoff
3. Queued Handoff
4. Mobile Assisted Handoff (MAHO)

Hard Handoff:

- The definition of a hard handover or handoff is one where an existing connection must be broken before the new one is established.
- Hard handoff allocates different frequency of user.
- In hard hand off a handset always communicates with one BS at any given time
- Hard handoff is typically used in TDMA and FDMA systems.
- Hard handoff is not very complicated.
- Since the radio link between the BS and the handset is broken before it is connected in hard handoff, the link transfer may fail due to long network response time even if radio channels are available in the new BS.

Soft handoff:

- Soft handoff is defined as a handover where a new connection is established before the old one is released.
- Soft hand off allocate same frequency.
- In soft handoff a handset may connect up to three or four radio links at the same time.
- Soft handoff used in CDMA and some TDMA systems.

- Soft handoff is more complicated than hard handoff.
- On the other hand, soft handoff degrades channel availability because a handset may consume multiple radio channels.

Queued hand off:

The MTSO will queue the requests of handoff calls instead of rejecting them if the new cell sites are busy.. With Queuing of originating calls only, the probability of blocking is reduced. It is effective when implementing a simple queue for hand off calls which reduces call drops.

Mobile Assisted Handoff (MAHO)

Mobile Assisted Handoff (MAHO) is a process used in GSM cellular networks where a mobile phone assists/helps the cellular base station to transfer a call to another base station. It is a technique used in mobile telecom to transfer a mobile phone to a new radio channel with stronger signal strength and improved channel quality.

MAHO is based on a mobile phone's capabilities in detecting and identifying better radio channels to be used within a call. MAHO works when a mobile phone can scan, review and monitor nearby radio channels. The mobile collects the measurements, usually in the form of RF signal quality, received signal strength indication (RSSI), bit error rate and similar results from other available channels. These measurements are then sent to the base station, which evaluates them and transfers the call to the best available channel.

- In Mobile Assisted Handoff (MAHO) every mobile station measures the received power from surrounding base stations and continually reports the results of these measurements to the serving base station.
- A handoff is initiated, when the power received from the base station of a neighboring cell begins to exceed the power received from the current base station by a certain level or for a certain period of time.
- In MAHO method call handed over between base stations is much faster than first generation analog systems .As handoff measurements are made by each mobile . MSC no longer constantly monitors signal strengths. MAHO is particularly suited for microcellular environments where handoffs are more frequent. During the course of a call, if a mobile moves from one cellular system to a different cellular system controlled by a different MSC, an intersystem handoff becomes necessary.

Intersystem Handoff

An MSC engages in an intersystem handoff when a mobile signal becomes weak in a given cell and the MSC cannot find another cell within its system to which it can transfer the call in progress. If during ongoing call mobile unit moves from one cellular system to a different cellular system which is controlled by different MTSO, a handoff procedure which is used to avoid dropping of call is referred as Inter System Handoff. An MTSO engages in this handoff system.

Q10.How prioritizing handoffs technique is used to decrease the probability of force termination of a call due to lack of available channels? [AKTU 2015-16]

Ans: Prioritizing Handoffs: Prioritizing handoff techniques are-

(i) Using guard channel concept:

One method for giving priority to handoffs is called the guard channel concept, whereby a fraction of the total available channels in a cell is reserved exclusively for handoff equests from

ongoing calls which may be handed off into the cell. This method has the disadvantage of reducing the total carried traffic, as fewer channels are allocated to originating calls. Guard channels, however, offer efficient spectrum utilization when dynamic channel assignment strategies, which minimize the number of required guard channels by efficient demand based allocation, are used.

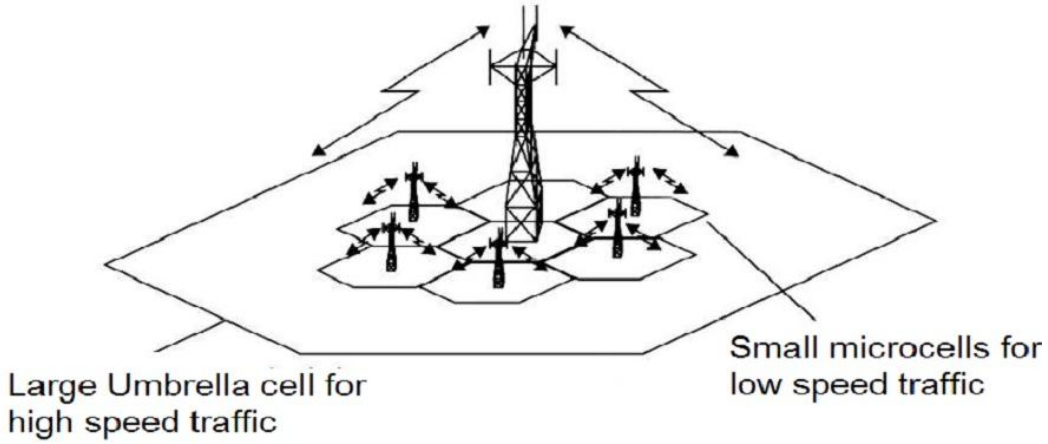
(ii)Queuing of handoff requests:

Queuing of handoff requests is another method to decrease the probability of forced termination of a call due to lack of available channels. There is a tradeoff between the decrease in probability of forced termination and total carried traffic. Queuing of handoffs is possible due to the fact that there is a finite time interval between the time the received signal level drops below the handoff threshold and the time the call is terminated due to insufficient signal level. The delay time and size of the queue is determined from the traffic pattern of the particular service area. It should be noted that queuing does not guarantee a zero probability of forced termination, since large delays will cause the received signal level to drop below the minimum required level to maintain communication and hence lead to forced termination.

Q11. Discuss Umbrella Cell Approach with diagram to enhance the connectivity in mobile communication. [AKTU: 2015-16]

Ans: Umbrella Cell Approach:

- Capacity of cellular system can be increased using additional cell sites but it is practically difficult to get new physical site in urban areas. Thus instead of new cell sites additional channels and base stations can be installed to increase the capacity.
- Different antenna heights and different power levels can be used to provide small and large cells located at single site. This technique is called as umbrella cell approach.



Umbrella Cell Approach

- This approach is used to provide large area coverage to high speed users while small area coverage to low speed users. It also ensures additional microcell channels for pedestrian users.

- The speed of each user is estimated by base station or MSC by evaluating how rapidly the short term average signal strength on RVC changes over time or with sophisticated algorithms.
- If high speed user in the large umbrella cell is approaching the base station, and its velocity is rapidly decreasing, the base station may decide to hand the user into the co-located microcell without MSC permission.
- This approach is basically used to reduce number of hand off for high speed users.

Q12: What are the main sources of interferences in cellular mobile communication?

Ans: Interferences in cellular wireless mobile system:

Interference is the major limiting factor in the performance of cellular radio systems. Sources of interference are-

- Another mobile in the same cell
- a call in progress in a neighboring cell
- Other base stations operating in the same frequency band
- Any non-cellular system which leaks energy into the cellular frequency band.

Interference on voice channels causes cross talk, where the subscriber hears interference in the background due to an undesired transmission. On control channels, interference leads to missed and blocked calls due to errors in the digital signaling. Interference is more severe in urban areas, due to the greater HF noise floor and the large number of base stations and mobile phones.

The main two sources of interference are

(i) Co-channel interference

(ii) Adjacent- channel interference

Co-channel interference:

Co-channel cells are those cells that use the same frequency in a given coverage area. Interference from these cells is called co-channel interference. In cellular wireless system, the cells are clustered as close together as possible to reduce the co-channel interface and provide sufficient isolation. Co-channel interference can be reduced by-

- Proper planning and implementation.
- The frequency reuse technique increases overall system capacity and reduces co-channel interference.
- The co-channel interference can be reduced by using directional antennas. This means that, each cell is divided into three or six sectors and use three or six directional antennas at a base station.

Adjacent Channel Interference

The interference that results from the signal that is adjacent in frequency to the required signal called adjacent channel interference.

The reasons behind adjacent channel interference are as follows:

- Due to multiple channels close to each other communicating using similar frequencies.
- Irrelevant power emission from an adjacent channel.

Adjacent Channel Interference can be reduced by-

- Proper filtering
- Careful Channel Assignments
- By managing the space between two adjacent cells which should remain constant.
-

Q13. Describe the effect of co-channel interference in cellular systems. How it affects system capacity?

Ans: Effect of Co-channel interference on system capacity:

Co-channel cells are those cells that use the same frequency in a given coverage area. Interference from these cells is called co-channel interference. Co-channel interference cannot be compensated by simply increasing the carrier power of a transmitter This is because an increase in carrier transmit power increases the interference to neighboring co-channel cells. To reduce co-channel interference, co-channel cells must be physically separated by a minimum distance to provide sufficient isolation.

When the size of each cell is approximately the same, and the base stations transmit the same power, then co-channel reuse ratio Q for a hexagonal geometry is given by-

$$Q = \frac{D}{R} = \sqrt{3N}$$

Where D= Distance between centers of the nearest co-channel
R= Radius of Cell
N= Cluster Size

By increasing the ratio of D/R, the separation between co-channel cells relative to the coverage distance of a cell is increased. Thus interference is reduced. A small value of Q provides larger capacity since the cluster size N is small, whereas a large value of Q improves the transmission quality, due to a smaller level of co-channel interference. A trade-off must be made between these two objectives in actual cellular design.

Let i_0 be the number of co-channel interfering cells. Then, the signal-to interference ratio (S/I or SIR) for a mobile receiver which monitors a forward channel can be expressed as

$$\frac{S}{I} = \frac{S}{\sum_{i=1}^{i_0} I_i}$$

where S is the desired signal power from the desired base station and I is the interference power caused by the i th interfering co-channel cell base station

The average received power P_r at a distance d from the transmitting antenna is approximated by

$$P_r = P_0\left(\frac{d}{d_0}\right)^{-n}$$

$$P_r(\text{dBm}) = P_0(\text{dBm}) - 10n\log\left(\frac{d}{d_0}\right)$$

where P_0 = Power received at a close-in reference point in the far field region of the antenna at a small distance d_0 from the transmitting antenna

n = Path loss exponent

Considering only the first layer of interfering cells .When the transmit power of each base station is equal and the path loss exponent is the same throughout the coverage area, S/I for a mobile can be given as -

$$\frac{S}{I} = \frac{(D/R)^n}{i_0} = \frac{(\sqrt{3N})^n}{i_0}$$

The above equation relates S/I to the cluster size N which determines the overall capacity of the system.

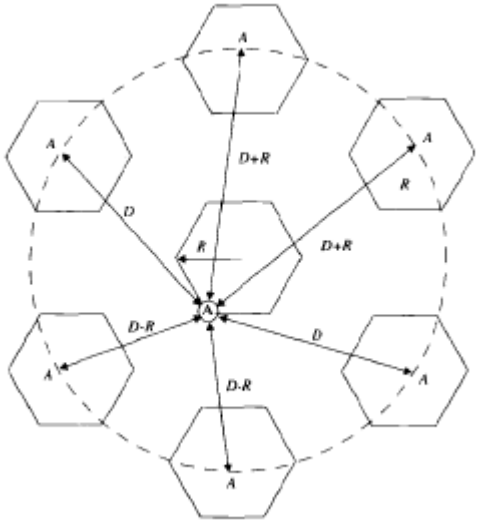


Illustration of the first tier of co-channel cells for a cluster size of N=7. When the mobile is at the cell boundary (point A), it experiences worst case co-channel interference on the forward channel. In this case for n=4, the S/I ratio can be given as-

$$\frac{S}{I} = \frac{R^{-4}}{2(D-R)^{-4} + 2(D+R)^{-4} + 2D^{-4}}$$

$$\frac{S}{I} = \frac{1}{2(Q-1)^{-4} + 2(Q+1)^{-4} + 2Q^{-4}}$$

Q-14 If a signal to interference ratio of 15 dB is required for satisfactory forward channel performance of a cellular system, what is the frequency reuse factor and cluster size that should be used for maximum capacity if the path loss exponent is (a) it = 4 , (b) it = 3? Assume that there are 6 co-channels cells in the first tier, and all of them are at the same distance from the mobile. Use suitable approximations. [AKTU: 2021-22]

ANS:

(a) When Path Loss Exponent n = 4

First, let us consider a 7-cell reuse pattern.

N=7

Number of co-channel interfering cells

$I_0=6$

Co-channel reuse ratio

Q= D/R = $\sqrt{3N}$ = $\sqrt{3 * 7}$ = 4.583.
Signal-to-noise interference ratio is given by

$$\frac{S}{I} = \frac{(D/R)^n}{i_0} = \frac{(\sqrt{3N})^n}{i_0}$$

S/I= (I/6)x$(4.583)^4$ = 75.3 = 18.G6 dB.
Since this is greater than the minimum required S/I, N = 7 can be used.

b) When Path Loss Exponent n = 3
First, let us consider a 7-cell reuse pattern.
Signal-to-interference ratio is Number of co-channel interfering cells
I_0=6
given by
S/I = (I/6)x$(4.583)^3$ = 16.04 = 12.05 dB.
Since this is less than the minimum required S/I, we need to use a larger
N. Let N = 12, (I = j = 2).
The corresponding co-channel ratio is given by
Q= D/R =$\sqrt{3N} = \sqrt{3 * 12 =}$ 6.0.

Signal-to-interference ratio is given by
S/I = (1/6) X $(6)^3$ = 36 = 15.56 dB.
Since this is greater than the minimum required S/I, hence N = 12 can be used.

Q15. If a total of 33 MHz of bandwidth is allocated to a particular FDD cellular telephone system which uses two 25 kHz simplex channels to provide full duplex voice and control channels, compute the number of channels available per cell if a system uses (a) 4-cell reuse, (b) 7-cell reuse (c) 12-cell reuse. If 1 MHz of the allocated spectrum is dedicated to control channels, determine an equitable distribution of control channels and voice channels in each cell for each of the three systems. [AKTU 2014-15, 2015-16]]

Ans: Given: Total bandwidth =33 MHz
Channel bandwidth = 25 kHz x 2 simplex channels = 50 kHz/duplex channel
Total available channels = 33,000/50 = 660 channels

(a) For N= 4,
total number of channels available per cell = 660/4= 165 channels.

(b)For N=7,

5 Cell with 94 voice channels
2 cell with 95 voice channels

(c) For N = 12,
total number of channels available per cell = 660/12 = 55 channels.

A 1 MHz spectrum for control channels implies that there are 1000/50 = 20 control channels out of the 660 channels available. 'To evenly distribute the control and voice channels, simply allocate the same number of channels in each cell wherever possible. Here, the 660 channels

must be evenly distributed to each cell within the cluster. In practice, only the 640 voice channels would be allocated, since the control channels are allocated separately as 1 per cell.

(a) For N = 4, we can have 5 control channels and 160 voice channels per cell.

In practice, however, each cell only needs a single control channel (the control channels have a greater reuse distance than the voice channels). Thus, one control channel and 160 voice channels would be assigned to each cell.

(b) For N = 7, 4 cells with 3 control channels and 92 voice channels, 2 cells with 3 control channels and 90 voice channels, and 1 cell with 2 control channels and 92 voice channels could be allocated. In practice, however, each cell would have one control channel, four cells-would have 91 voice channels, and three cells would have 92 voice channels.

(c) For N = 12, we can have 8 cells with 2 control channels and 53 voice channels, and 4 cells with 1 control channel and 54 voice channels each. In an actual system, each cell would have 1 control channel, 8 cells would have 53voice channels, and 4 cells would have 54 voice channels.

Q15: Discuss the techniques to improve the coverage and capacity of a cellular system.

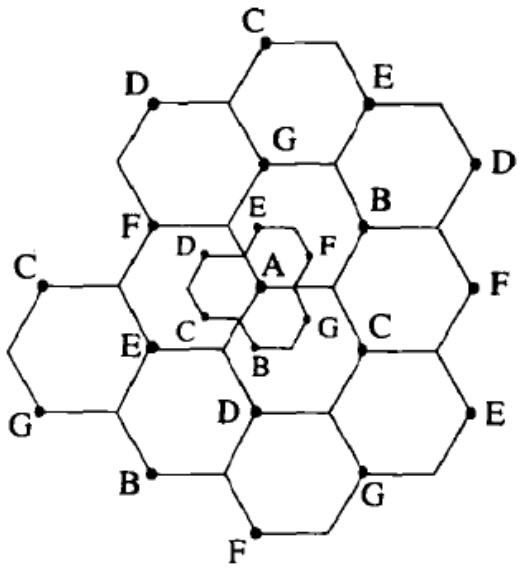
[AKTU 2017-18, 2015-16]

ANS: Improving Capacity In Cellular Systems: To improve the coverage and capacity of a cellular system, the three main techniques are-

- **(i)** Cell Splitting
- **(ii)** Sectoring
- **(iii)** Microcell Zone Concept

(i)Cell Splitting:

Cell Splitting is the 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 and has reduced antenna height and transmitter power. The creation of new smaller cells increases the capacity of the system as a whole. Cell Splitting increases the frequency reuse factor. A higher frequency reuse factor increases the capacity of the cellular system in Cell Splitting.



Advantages

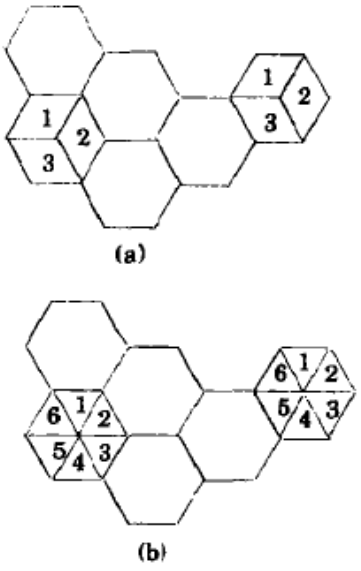
- Increases the capacity of the channel considerably.
- Enhances dependability of cellular networks.
- Increases the frequency reuse factor.
- Increases signal-to-noise (SNR) ratio.
- Reduces interference.

Disadvantages

- For each individual cell, an individual base station is required so a huge number of base stations are needed in this process.
- Handoff occurs frequently.
- 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 120° or 60°. These sectored cells are called microcells. Like Cell Splitting, it also helps in increasing channel capacity and decreases channel interference. 3 or 6 sectors are created from a given cell. But unlike Cell Splitting, here the cell radius does not change after sectoring the cells although the co-channel reuse ratio has decreased. It increases system performance by using a directional antenna.



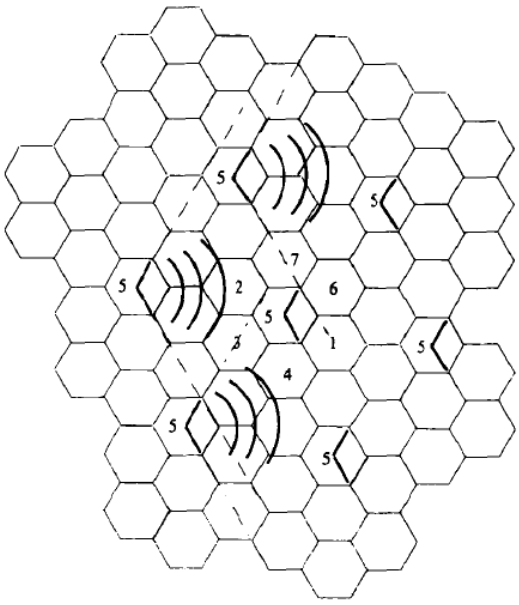


Illustration of how 120° sectoring reduces interference from co-channel cells. Out of the 6 co-channel cells in the first tier, only 2 of them interfere with the center cell. If omni-directional antennas were used at each base station, all 6 co-channel cells would interfere with the center cell.

Advantages

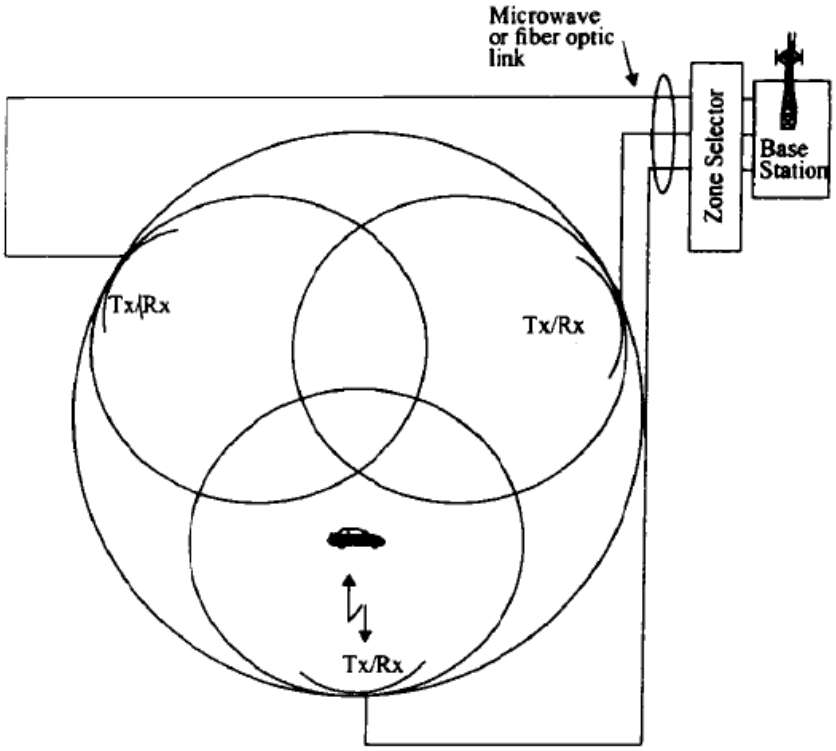
- Sectoring increases the signal-to-interference ratio which means the cluster size gets reduced.
- Reduces interference without altering the system performance.
- Increases channel capacity without necessarily changing the cell radius.
- Increases frequency reuse by reducing the number of cells in the cluster.
- Assigning a channel is easier.

Disadvantages

- Increases the number of antennas per base station.
- It decreases efficiency as sectoring reduces the channel groups.
- Excessive interference leads to traffic loss.
- The number of handoffs increases as the working area of the cell decreases in Cell Sectoring.

Microcell Zone Concept

The increased number of handoffs required when sectoring is employed results in an increased load on the switching and control link elements of the mobile system. A solution to this problem was proposed by Lee . This proposal is based on a microcell concept for 7 cell reuse, as shown in fig. In this scheme, each of the three (or possibly more) zone sites are connected to a single base station and share the same radio equipment. The zones are connected by coaxial cable, fiber optic cable, or microwave link to the base station. Multiple zones and a single base station make up a cell.



Microcell Zone Concept

As a mobile travels within the cell, it is served by the zone with the strongest signal. This approach is superior to sectoring since antennas are placed at the outer edges of the cell, and any base station channel may be assigned to any zone by the base station.

As a mobile travels from one zone to another within the cell, it retains the same channel. Thus, unlike in sectoring, a handoff is not required at the MSC when the mobile travels between zones within the cell. The base station simply switches the channel to a different zone site. In this way, a given channel is active only in the particular zone in which the mobile is traveling, and hence the base station radiation is localized and interference is reduced. The co-channel interference in the cellular system is reduced since a large central base station is replaced by several lower powered transmitters (zone transmitters) on the edges of the cell. Decreased co-channel interference improves the signal quality and also leads to an increase in capacity.

Q16.Discuss various types of small scale fading based on multipath time delay spread. Distinguish between flat fading and frequency selective fading. [AKTU 2017-18]

Ans: Fading:

Fading in wireless communication is defined as the fluctuation in the strength of the signal received at the receiver. These are basically unwanted variations introduced at the time when the signal propagates from an end to another by taking multiple paths.

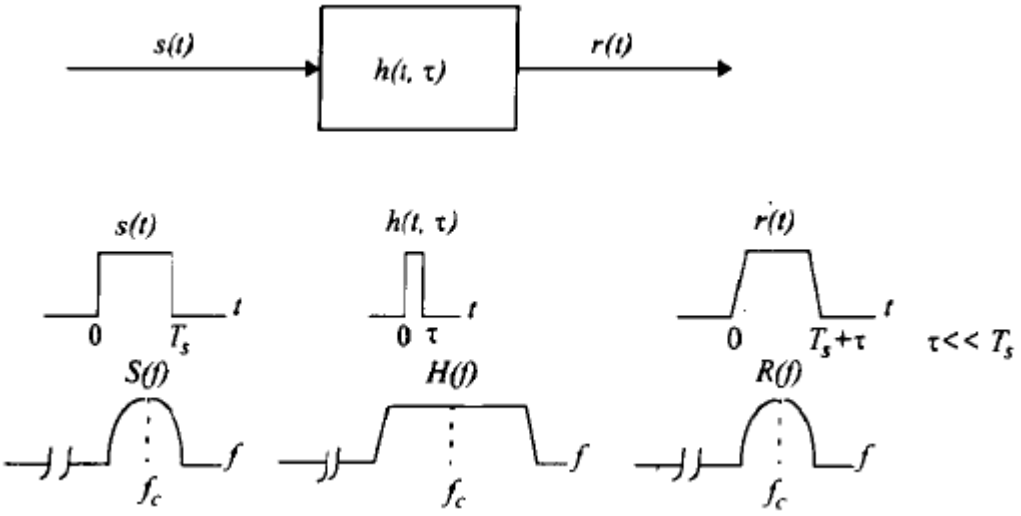
Small scale fading is concerned with rapid fluctuations of received signal strength over very short distance and short time period.

Based on multipath delay spread there are two types of small scale fading viz. flat fading and frequency selective fading.

Flat fading:

If the mobile radio channel has a constant gain and linear phase response over a bandwidth which is greater than the bandwidth of the transmitted signal, then the received signal will undergo flat fading. In this type of fading all the frequency components of the received signal fluctuate in same proportions simultaneously. It is also known as non-selective fading.

The effect of flat fading is seen as decrease in SNR. These flat fading channels are known as amplitude varying channels or narrowband channels.



Flat Fading

- Channel response in flat fading impaired signal has flat gain/linear phase over bandwidth (BW) which is greater than signal BW.
- Spectral characteristics of flat fading impaired signal are preserved over time.
- The above figure shows time domain and frequency domain flat fading channel characteristics.
- As gain of the signal varies over time, flat fading channels are known as amplitude varying channels. They are also called as narrowband channels as signal BW is narrow compare to channel BW.
- Signal undergoes flat fading if following conditions are met-

  BW of signal < BW of channel

  Delay spread <Symbol period

Frequency Selective Fading:

If the channel possesses a constant-gain and linear phase response over a bandwidth that is smaller than the bandwidth of transmitted signal, then the channel creates frequency selective fading on the received signal.

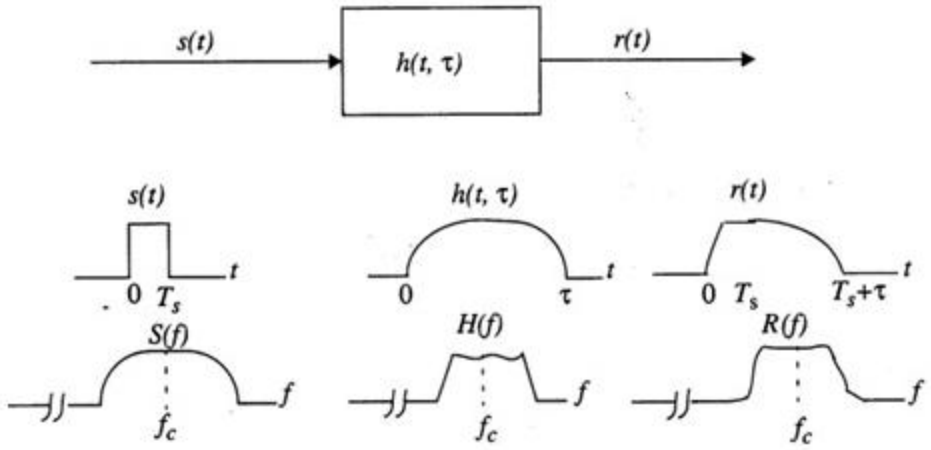
It affects different spectral components of a radio signal with different amplitudes. Hence the name frequency selective fading.

- In this faded signal, channel response of signal has constant gain/linear phase over bandwidth (BW) which is less than that of signal BW.
- It is caused by ISI (Inter Symbol Interference) where in received signal consists of multiple delayed and attenuated versions of the transmitted signal.
- The above figure shows time domain and frequency domain frequency selective fading channel characteristics.

- Signal undergoes frequency selective fading if following conditions are met-

  BW of signal > BW of channel

  Delay spread > Symbol period



Frequency selective fading

Difference between flat fading and frequency selective fading:

Following points summarize difference between flat fading and frequency-

In flat fading, BW of signal is less than the BW of channel where as in frequency selective fading, BW of signal is greater than BW of channel.

➨In flat fading, delay spread is less than symbol period where as in frequency selective fading, delay spread is greater than symbol period.

➨In flat fading, range of frequencies in a frequency spectrum are equally faded unlike in frequency selective fading where in one part of frequency spectrum is faded more than the other part of frequency spectrum.

BUDDHA SERIES

(Unit Wise Solved Question & Answers)

Course – B. Tech (ECE)

College – Buddha Institute of Technology

(AKTU CODE-525)

Department: Electronics and Communication Engineering

Subject: Wireless & Mobile Communications (KEC076)

Faculty Name: AKC

Unit – 2

Q1. Classify and explain different types of vocoders.

[AKTU 2021-22, 19-20, 16-17, 14-15]

ANS:

Vocoders- Vocoders are a class of speech coding systems that analyze the voice signal at the transmitter, transmit parameters derived from the analysis, and then synthesize the voice using those parameters.

The speech signal is two types – voiced and unvoiced. voiced sound (m, n, v pronunciations) are produced by vibrations of vocal chord. Unvoiced sounds (f, s, sh pronunciations) are produced by air flow through through a constriction The parameters associated to this model are the voice pitch, Pole frequencies of modulating filter and the corresponding amplitude parameters. The pole frequencies correspond to the resonant frequencies of vocal tract are called formants of the speech signal. By adjusting the parameters of speech generation model, good quality speech can be synthesized.

Types of Vocoders-

* Channel Vocoders
* Formant Vocoders
* Cepstrum Vocoders
* Voice-Excited Vocoders.

(i) Channel Vocoders- Channel vocoders are frequency domain vocoders that determine the envelope of speech signal for a number of frequency bands and then sample, encode and multiplex these samples with the encoded outputs of the other fielers.

* Sampling is done at every 10 ms to 30 ms.
* Along with the energy information of each band, the voiced / unvoiced decision, and the pitch frequency for voiced speech are also transmitted.

(ii) Formant Vocoders-

* Formants are frequency peaks in the spectrum which have a high degree of energy. They are especially prominent in vowels.
* Theoretically, the formant vocoder can operate at lower bit rate than channel vocoder because it uses fewer control signals.
* Instead of sending samples of the power spectrum envelope, the formant vocoder transmits the positions of the peak (formants) of spectral envelope.
* Typically, a formant vocoder must be able to identify at least three formants for representing the speech sounds and it must also control the intensities of the formants.
* Formant vocoders can reproduce speech at bit rate lower than 1200 bits/s.
* Due to difficulties in accurately computing the location of formants and formant transitions from human speech, formant vocoders are not very sucessful.

(3) Cepstrum Vocoders-

* The Cepstrum vocoder seperates the excitation and vocal tract spectrum by inverse Fourier transforming of the log magnitude spectrum to produce the cepstrum of the signal.
* The Low frequency coefficients in the cepstrum corresponds to the vocal tract spectral envelope, with the high frequency excitation coefficients forming a periodic pulse train at multiples of the sampling period.

* Linear filtering is performed to seperate the vocal tract cepstral coeficients from the excitation coefficients
* In the receiver, the vocal tract cepstral coefficients are Fourier transformed to produce the vocal tract impulse response. By convolving this impulse response with a synthetic excitation signal (random noise or periodic pulse train), the original speech is reconstructed.

Voice - Excited Vocoders -

* Voice excited vocoders eliminate the need of pitch extraction and voicing detections. This system uses a hybrid combination of PCM transmission for Low frequency band of speech, combined with Channel vocoding of higher frequency bands.
* A pitch signal is generated at the synthesizer by rectifying, bandpass filtering, and clipping the baseband signal.
* Voice excited vocoders operate at 7200 b/s to 9600 bits/s and their quality is superior to traditional pitch excited vocoders

Q2. Write the properties of speech signal. [AKTU: 2021-22]

ANS:

Properties of Speech Signal -

(*) In telephony the usable frequency range is 300 Hz to 3400 Hz.
* Speech signal has nonuniform probability density function (pdf).
* The speech signal has very high probability of near-zero amplitudes, a significant probability of very high amplitudes, and a monotonically decreasing function of amplitudes between these extrems.

* Speech signal has high correlation between adjacent samples of a segment. It means in every sample of speech, there is a large component that is easily predicted from the value of the previous samples.

* The Power spectral Density Function (PSD) of speech signal has nonflat characteristic. Due to nonflat characteristic of PSD, significant speech compression is possible by speech coding.

Q3. Explain Linear Predictive Coder (LPC) with block diagram.

ANS:

Linear Predictive Coders (LPC Vocoders) -

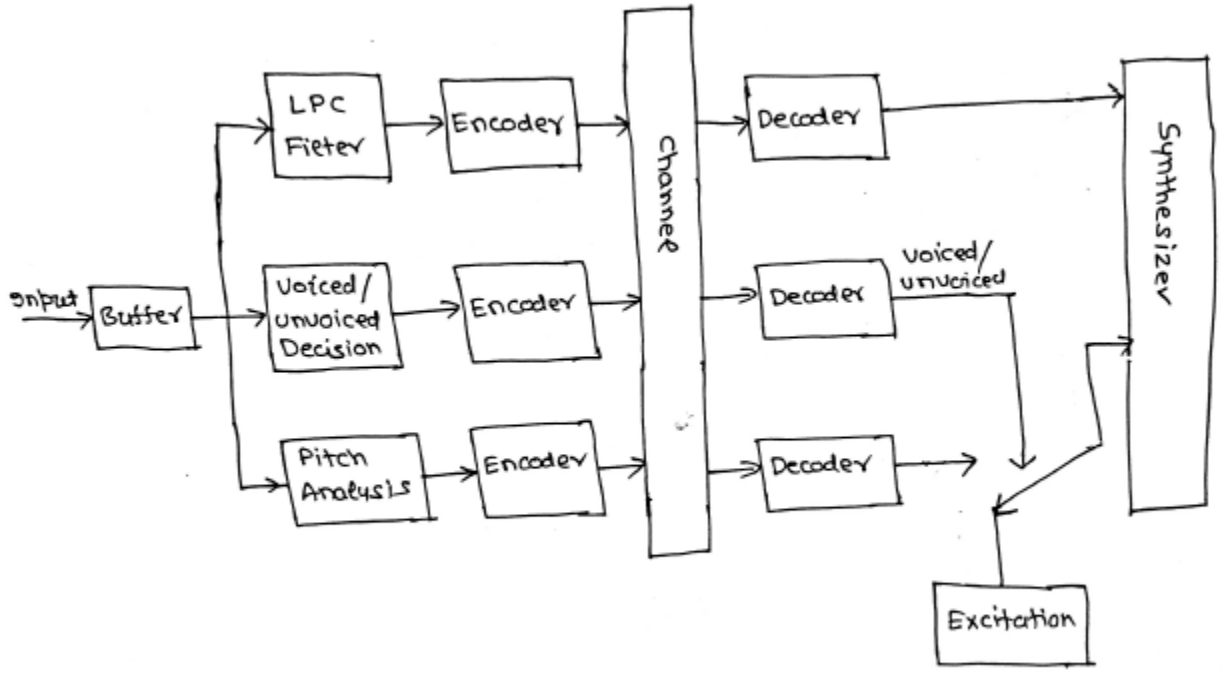
* LPC Vocoders belong to the time domain class of Vocoders. LPC Vocoder extracts the significant features of speech from the time waveform.

* The LPC system models the vocal tract as an all pole linear filter. The excitation to this filter is either a pulse at the pitch frequency or random white noise depending on whether the speech segment is voiced or unvoiced. The coefficients of the all pole filter are obtained in time domain using linear prediction techniques. The error signal is the difference between predicted and actual waveform.

* LPC system transmits only selected characteristics of the error signal. The transmitted parameters are gain factor, pitch information and voiced / unvoiced decision information.

* At the receiver, the received information about the error signal is used to determine the appropriate excitation for the synthesis filter.

* Using LPC, it is possible to transmit good quality voice at 4.8 Kbps and poor quality voice at even lower rates.



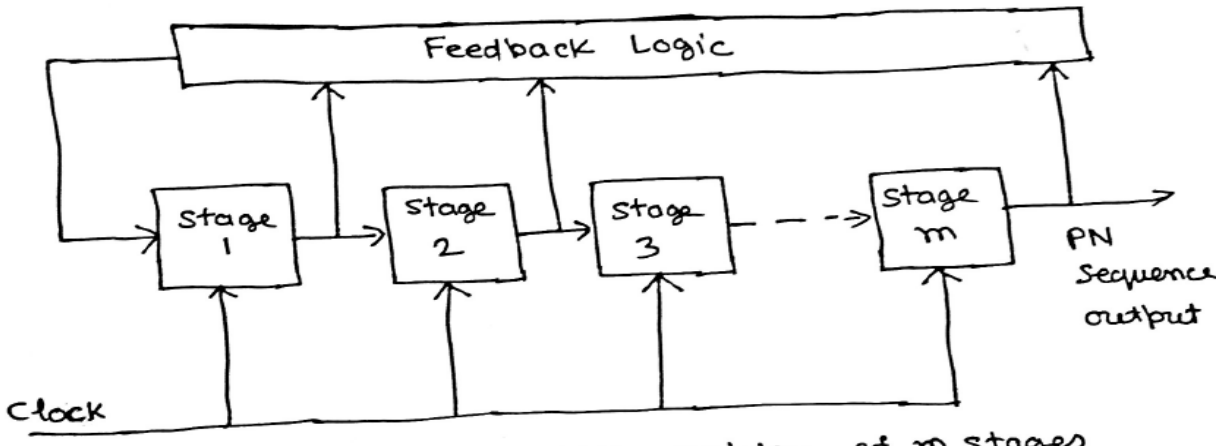
Block Diagram of a LPC coding system

Q4. What is PN sequence? Explain the generation of PN sequence with the help of 3- bit linear feedback shift register. [AKTU: 2021-22, 2017-18]

ANS:

Pseudo-Noise (PN) sequence- A binary sequence with specific autocorrelation properties is known as a pseudo-noise (PN) sequence.

* Although PN sequence is deterministic sequence but it has many characteristics that are similar to random binary sequence.
* A PN sequence has a nearly equal number of 0s and 1s, very low correlation between shifted versions of the sequence, very low cross correlation between any two sequences.



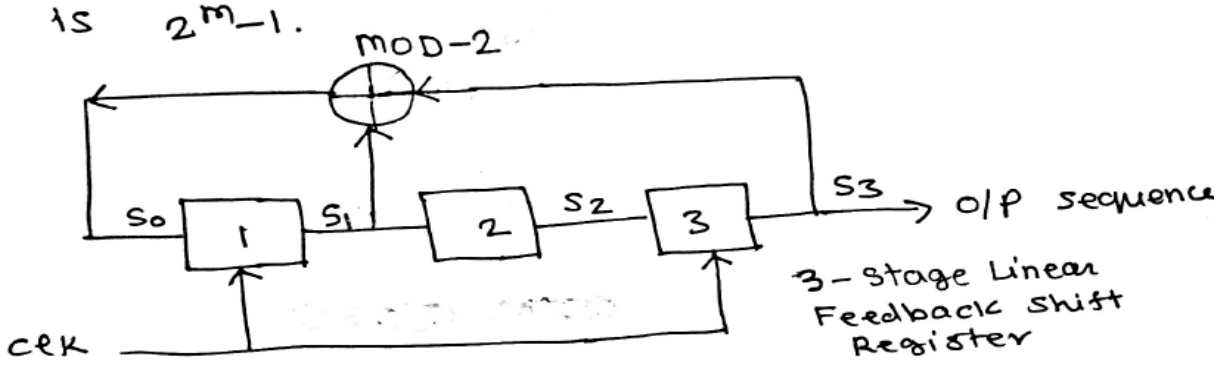
Linear Feedback shift register of m stages

* PN sequences are generated by linear feedback shift registers. A Linear feedback shift register (LFSR) is a shift register which input bit is the output of a linear function of two or more of its previous stages.
* A linear Feedback shift Register (LFSR) of length m consists of m stages, each stage capable of storing one bit and a clock input.

* A linear Feedback shift Register (LFSR) of length m consists of m stages, each stage capable of storing one bit and a clock input.

* Outputs of all the flip-flops of the shift register are fed to a feedback logic circuit. The output of logic circuit is again fed to the input of primary (Left most) flip-flop.

* The maximum length of the period of PN sequence generated by a m stage LFSR is $2^m - 1$.



Clock Pulse no.	Intermediate states			output
	S_1	S_2	S_3	
1	1	1	1	1
2	0	1	1	1
3	1	0	1	1
4	0	1	0	0
5	0	0	1	1
6	1	0	0	0
7	1	1	0	0
8	1	1	1	1

As shown in fig, the output of entire 3-stage LFSR is S_3. After application of a clock pulse outputs of the flip-flops becoms –

$$S_2 = S_1$$
$$S_3 = S_2$$
$$S_1 = S_0 = S_1 \oplus S_3$$

* The above state table is made by taking initial contents of shif register as 111. In this exclample generated PN sequence is 1110100

Q5. With the help of block diagram and suitable expressions explain the generation and reception of direct sequence spread spectrum (DS-SS) signal using BPSK modulation.
[AKTU: 2017-18]
ANS:

Spread Spectrum Modulation Technique –

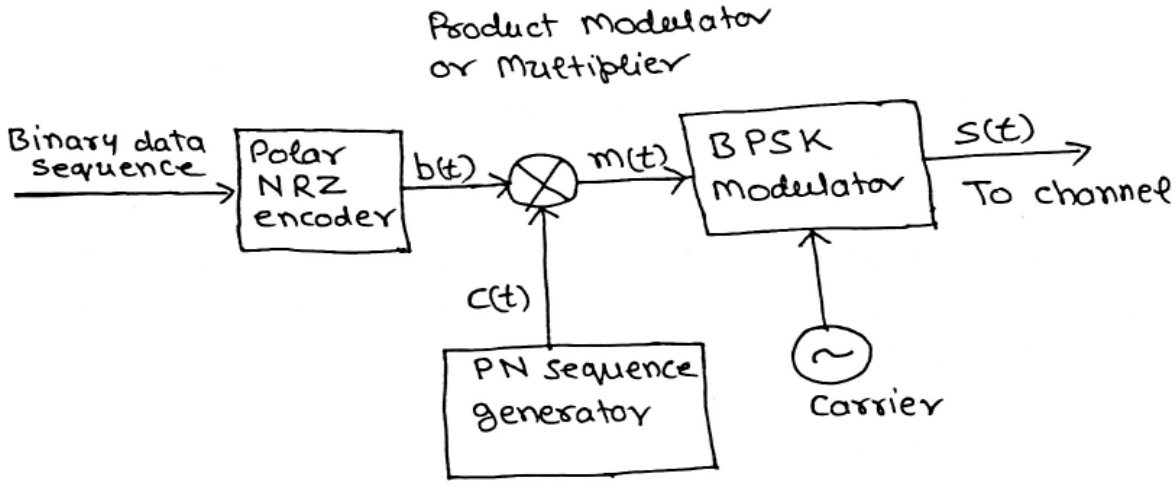
* The spread spectrum is a type of modulation where modulated signal bandwidth is much larger than the baseband signal bandwidth. A special code (pseudo noise code) is used to spread the spectrum at the transmitter and same code is used to despread the signal at the receiver.

* The spread spectrum signals are pseudorandom and have noise like properties when compared with the digital data. The spreading waveform is controlled by a pseudo-noise (PN) sequence or pseudo-noise code which is a binary sequence that appears random but can be reproduced at the receiver.

* Spread spectrum signals are demodulated at the receiver through cross-correlation with a locally-genereted version of pseudorandom sequence. Cross-correlation with the correct PN sequence despreads the spread spectrum signal and original data is recovered at the receiver.

Direct Sequence Spread spectrum (DS-SS) -

* A Direct Sequence spread spectrum system spreads the baseband data by directey multiplying the baseband data pulses with a pseudonoise sequence. The pseudonoise sequence is produced by a pseudonoise (PN) sequence generator. A single pulse or symbol of the PN waveform is called a chip.

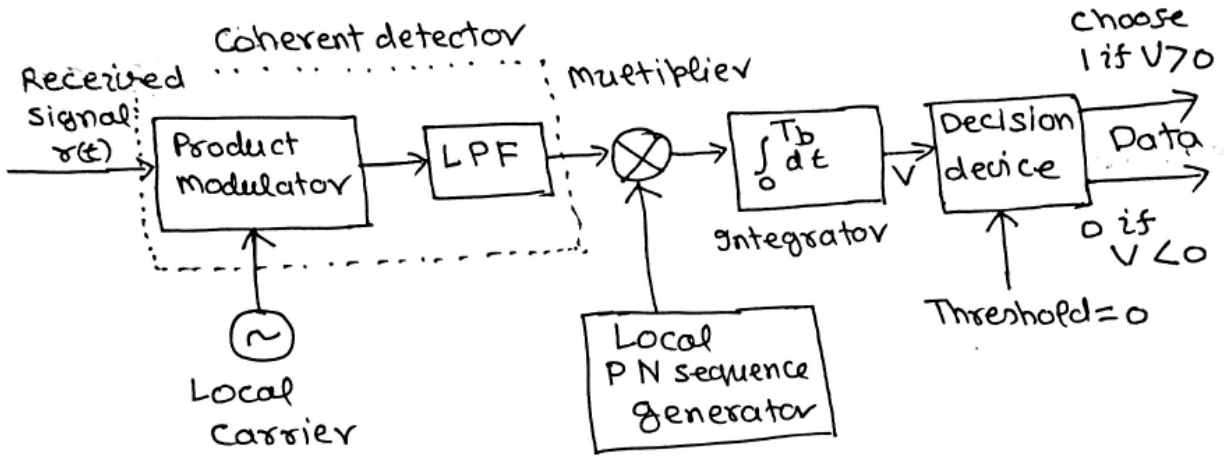


DS-SS BPSK Transmitter

In DS-SS BPSK transmitter two stages of modulation are used. The NRZ encoder converts the encoming data sequence into an NRZ sequence b(t). at the first step. PN sequence generator is used to generate PN sequence c(t).

The NRZ data sequence b(t) and PN sequence c(t) are applied to the product modulator. Output of product modulator is $m(t) = b(t) \cdot c(t)$

In second stage, the output of product modulator is used to modulate the Local carrier for BPSK modulation. The output of second state s(t) is a binary phase-shift keyed Direct-sequence spread signal.



DS-SS BPSK Receiver

* At receiver, demodulation takes place in two stages. In first stage the received signal is applied to coherent detector. The coherent detector uses a locally generated carrier signal.
* The output of coherent detector is then de-spread in second stage. It is multiplied by a locally generated PN sequence. After despreading the observed random signal V is integrated over a bit duration. The output of integrator is given to the decision device which generates the original data sequence.

Q6. What is frequency hopped spread spectrum technique? Explain frequency hopped spread spectrum transmitter and receiver with block diagram.

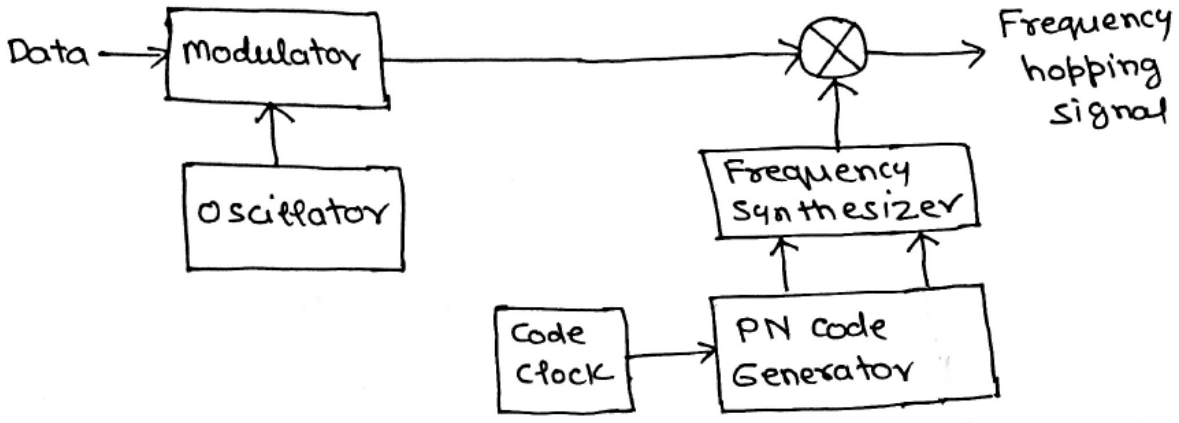
Ans:

Frequency Hopped spread spectrum (FH-SS) -

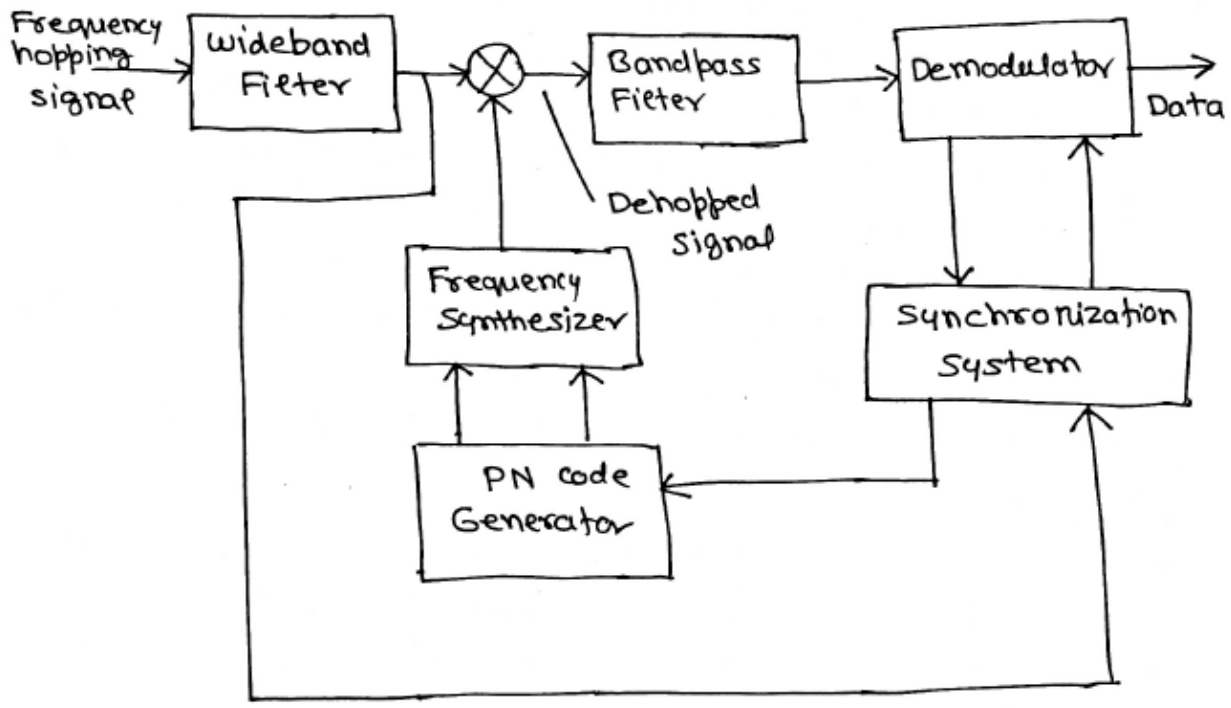
* FH-SS is a method of transmitting radio signal by rapidly switching a carrier among many frequency channel using pseudonoise sequence. (PN sequence).
* This system helps to avoid the problem of failing communication at a particular frequency, because of a fade or interference.
* The set of possible carrier frequencies is called the hopset. The bandwidth of a channel used in the hopset is called the instantaneous bandwidth. The bandwidth of the spectrum over which the hopping occurs is called the total hopping bandwidth.

* Data is sent by hopping the transmitter carrier to random channels which are known only to the desired receiver. On each channel, small bursts of data are sent using narrowband modulation before the transmitter hops again.
* The time duration between hops is called the hop duration.
* Frequency hoping may be classified as fast or slow. Fast frequency hopping occurs if there is more than one frequency hop during each transmitted symbol.

* Slow frequency hopping occurs if one or more symbols are transmitted in the time interval between frequency hops.
* In fast frequency hopping spread spectrum, multiple hops are required to transmit one symbol.
In slow frequency hopping spread spectrum, multiple symbols are transmitted in one frequency hop.



FH-SS Transmitter



FH-SS Receiver

Q7. **Explain Diversity technique.** **[AKTU: 2017-18]**

Diversity Techniques-

* Diversity is a powerful communication receiver technique that improves signal to noise ratio (SNR) at the receiver at relatively low cost.
* Diversity uses random nature of radio propagation by finding independent signal paths for communication. If one path undergoes a deep fade, another independent path may have a strong signal. Then receiver will select strong signal.
* For example, if two antennas are seperated by a fraction of a meter, one may receive a null while the other receives a strong signal. By selecting the best signal at all time, a receiver can minimize the small scale fading effects. (This is called antenna diversity or space diversity).

Q8: Derive an expression for selection diversity improvement in terms of probability of receiving signal using single branch or using M branch. **[AKTU: 2015-16, 2017-18]**

ANS:

Derivation of Selection Diversity Improvement -

Consider m independent Rayleigh fading channels (branches) available at a receiver. Assume each branch has some average SNR given by -

$$SNR = \Gamma = \frac{E_b \overline{\alpha^2}}{N_0}$$

where E_b = Average Carrier Energy
N_0 = Noise power spectral Density
α = A Random Variable used to represent amplitude value of fading channel with respect to E_b/N_0

Assume $\overline{\alpha^2} = 1$

If each branch has an instantaneous SNR $= \gamma_i$, then Pdf of γ_i is given by -

$$p(\gamma_i) = \frac{1}{\Gamma} e^{-\frac{\gamma_i}{\Gamma}} \quad , \quad \gamma_i \geq 0$$

The probability that a single branch has an instantaneous SNR less than some threshold γ is

$$P_\gamma [\gamma_i \leq \gamma] = \int_0^\gamma p(\gamma_i)\, d\gamma_i$$

$$= \int_0^\gamma \frac{1}{\Gamma} e^{-\gamma_i/\Gamma} d\gamma_i$$

$$= \frac{1}{\Gamma} \left[\frac{e^{-\gamma_i/\Gamma}}{\left(-\frac{1}{\Gamma}\right)} \right]_0^\gamma$$

$$= -\left[e^{-\gamma/\Gamma} - e^0 \right] = 1 - e^{\frac{\gamma}{\Gamma}}$$

$$P_\gamma [\gamma_i \leq \gamma] = 1 - e^{-\frac{\gamma}{\Gamma}} \quad \text{——— (2)}$$

Now, the probability that all M independent diversity branches receives signals which are simultaneously Less than some specific SNR threshold γ

$$P_r[\gamma_1, \cdots \gamma_M \leq \gamma] = (1 - e^{\gamma/\Gamma})^M$$
$$= P_M(\gamma)$$

The probability that SNR $> \gamma$ for one or more branches is given by

$$P_r[\gamma_i > \gamma] = 1 - P_M(\gamma) = 1 - (1 - e^{\gamma/\Gamma})^M$$

Q9: Derive an expression for maximal ratio combining improvement in terms of probability of receiving signal using single branch or using M branch.

Derivation of maximal Ratio Combining Improvement-

In maximal ratio combining, the voltage signals r_i from each of the M diversity branches are co-phased to provide voltage addition. If each branch has gain G_i, then resulting signal applied to the detector is

$$r_m = \sum_{i=1}^{M} G_i r_i$$

Assuming that each branch has the same average noise power N, Then total noise power N_T applied to the detector is given by

$$N_T = N \sum_{i=1}^{M} G_i^2$$

The SNR applied to the detector is given by

$$\gamma_m = \frac{r_m^2}{2N_T}$$

Using chebycheV's inequality, γ_m is maximized when $G_i = \frac{r_i}{N}$

So,

$$\gamma_m = \frac{\sum_{i=1}^{m} G_i^2 \gamma_i^2}{2N \sum_{i=1}^{m} G_i^2}$$

$$= \frac{\sum_{i=1}^{m} \frac{\gamma_i^2}{N^2} \cdot \gamma_i^2}{2N \sum_{i=1}^{m} \frac{\gamma_i^2}{N^2}} = \frac{1}{2} \sum_{i=1}^{m} \frac{\gamma_i^2}{N}$$

$$\gamma_m = \sum_{i=1}^{m} \gamma_i$$

Thus the SNR out of diversity combiner is simply the sum of the SNR in each branch.

Q10: What is space diversity? Explain different methods used to implement space diversity.

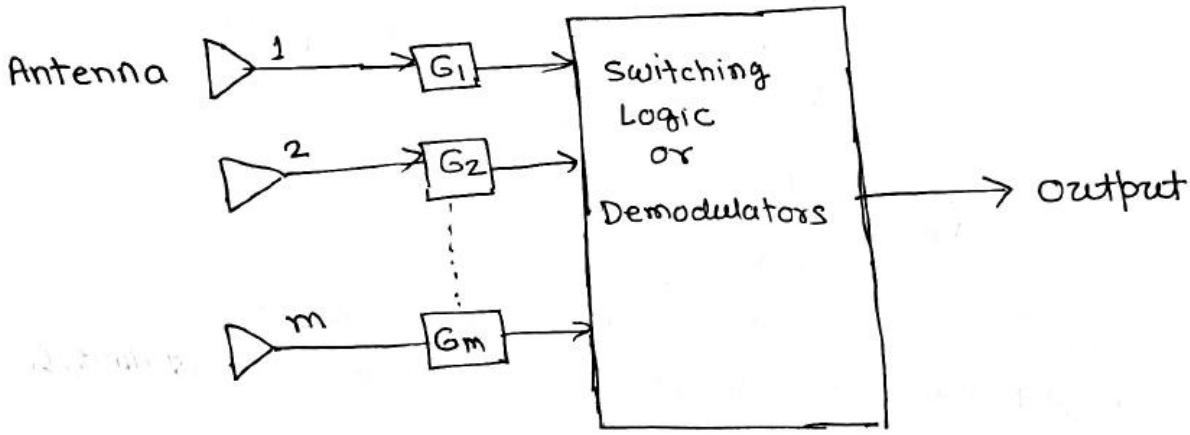
ANS:

Antenna Diversity or
Space Diversity - Space diversity uses multiple antennas, usually withe same characteristics, that are physically seperated from one another. Replica of same signal is transmitted through different antenna. space should be between adjacent antenna so that channel gain will be independent of signal path. space diversity may give a path that avoid shadowing and also decrease the large scale fading.

* space diversity is also known as antenna diversity.

Space diversity reception methods can be classified as—

(i) Selection diversity
(ii) Feedback diversity
(iii) Maximal ratio combining
(iv) Equal Gain diversity.

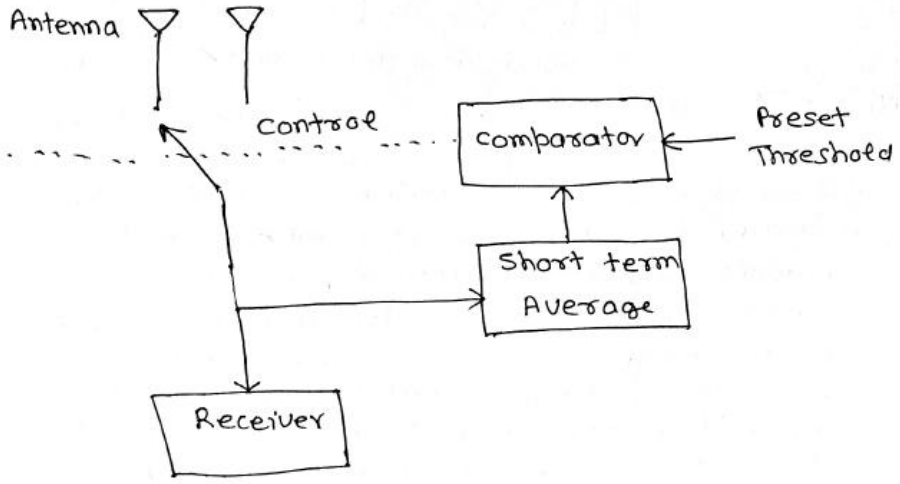


Generalized block diagram for space diversity

(i) Selection Diversity — Block diagram of selection diversity is same as generalized block diagram of space diversity, where m demodulators are used to provide m diversity branches. The receiver branch having highest SNR is connected to the demodulator. The antenna signals themselves could be sampled and the best one sent to a single demodulator. In practice, the branch with largest (S+N)/N is used, since it is difficult to measure SNR alone.

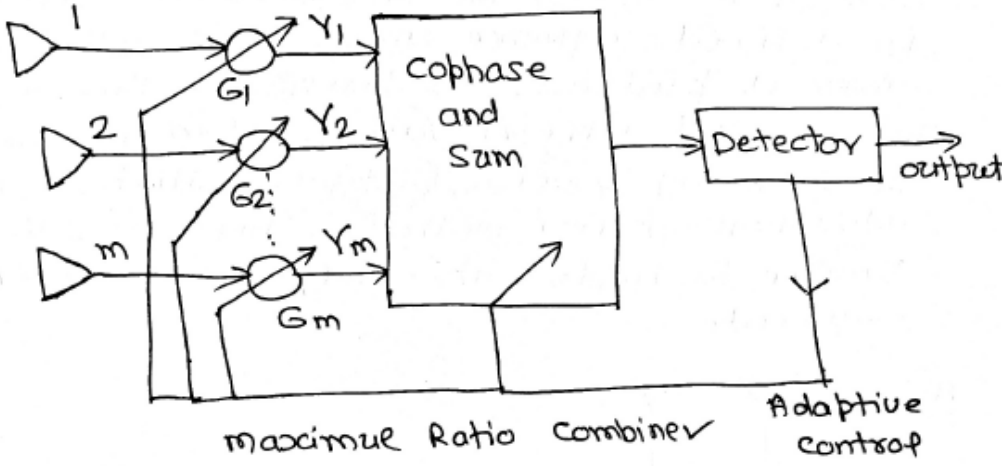
(ii) Feedback or Scanning Diversity-

Scanning diversity is very similar to selection diversity except that instead of always using the best of M signals, the M signals are scanned in a fixed sequence until one is found to be above a predetermind threshold. This signal is then received until it falls bellow threshold and the scanning process is again initiated. The advantage of this method is that it is very simple to implement — only one receiver is required.



Block diagram of basic form of scanning diversity

(iii) Maximal Ratio combining - In this method, the SNR of all the m branches are added. Here, the individual signals must be co-phased before being added, which requires an individual receiver and phasing circuit for each antenna element. Maximal ratio combining produces an output SNR equal to sum of the individual SNR. Thus it has the advantage of producing an output with an acceptable SNR even when none of the individual signals are themselves acceptable.



(iv) Equal Gain Combining - In equal gain combining, each signal branch weighted with the same factor, irrespective of signal amplitude. However, co-phasing of all signal is needed to avoid signal cancellation. The equal gain combining is simpler to implement than maximal ratio combining. The average SNR improvement of equal gain combining is typically about 1 dB which is less than maximal Ratio combining but still much better than without diversity.

Q11. Explain different types of diversity techniques used in wireless communication.

[AKTU: 2018-19]

ANS: Diversity techniques can be classified as-

(1) Time diversity
(2) Frequency diversity
(3) Space or antenna diversity
(4) Polarization diversity

(i) Time Diversity = Time diversity repeatedly transmits information at time spacings that exceed the coherence time of the channel. Due to this multiple repetitions of the signal will be received with independent fading conditions. In time diversity multiple versions of the same signal are transmitted at different time instant.

(ii) Frequency Diversity - Frequency diversity is implemented by transmitting information on more than one carrier frequency. The frequencies seperated by more than the coherence bandwidth of the channel will be uncorrelated and will not experience the same fades. Theoritically, if the channels are uncorrelated then probability of simultaneous fading will be the product of the individual fading probabilities. so, simultaneous fading probability will be less than individual fading probability. Frequency diversity is generally used in microwave line-of-sight links which carry several channels in frequency division multiplex mode (FDM).

(iii) Space diversity or Antenna Diversity -

space diversity or antenna diversity uses multiple antennas that are physically seperated from one another. Depending upon the expected incidence of incoming signal, sometimes a space on the order of a wavelength is sufficient. other times much larger distances are needed.

If two antennas are seperated by a fraction of a meter, one may receive a null while other receives a strong signal. By selecting the best signal at all time, a receiver can minimize the small scale fading effects.

Space diversity reception methods can be classified as -

(1) selection diversity
(2) Feedback diversity
(3) maximal ratio combining
(4) Equal gain diversity

(iv) Polarization Diversity - Polarization diversity requires two transmitter and two receiving antennas with different polarization, the transmission of wave with two different polarization constitutes two different paths. This provides only two different diversity branches. Polarization diversity uses half power by dividing the power between two different polarized antennas.

* In polarization diversity, multiple versions of a signal are transmitted and received via antennas with different polarization.

* Polarization diversity can reduce the effects of fading and interference, and increases the diversity gain and the channel capacity of the system.

Q12 Explain multiplexing in MIMO system. **[AKTU: 2018-19]**

ANS: Multiplexing in MIMO system:

* Spatial multiplexing is a technique used in MIMO that boosts data rates by sending the data payload in seperate streams through spatially seperated antennas.

* In spatial multiplexing, the overall data payload to be sent to the end-user device is transmitted in multiple parallel data streams. Each data stream can carry portions of the overall data, allowing the network to communicate with the device more efficiently. As a result, the mobile network utilizes the available frequency spectrum more efficiently, which improves the overall network capacity.

* Spatial multiplexing improves data rates by allowing the overall data payload to be communicated to a user device in the form of multiple data streams that carry small portions of the overall information. The data streams can be targeted at a single user device or multiple user device.
* In spatial multiplexing or space division multiplexing (SDM) a transmitter or receiver can use several antennas seperated in space by their angular direction. These antennas can send and receive multiple data streams using the same frequency and time resources and act as individual channels to communicate the information between the transmitter and receiver.
* Spatial multiplexing is based on multi-input and multiple-output (MIMO) technology where multiple antennas at both the transmitter and receiver are used to carry multiple data streams simultaneously within the same frequency band.

BUDDHA SERIES

(Unit Wise Solved Question & Answers)

Course – B. Tech (ECE)

College – Buddha Institute of Technology

(AKTU CODE-525)

Department: Electronics and Communication Engineering

Subject: Wireless & Mobile Communications (KEC076)

Faculty Name: AKC

Unit – 3

Q1. What do you mean by multiple access techniques? Explain FDMA in detail with suitable diagram. [AKTU:2018-19. 2021-22]

ANS:

Multiple Access Techniques-

The techniques used to share the available bandwidth by multiple users is known as multiple access Techniques. The three major access techniques are-

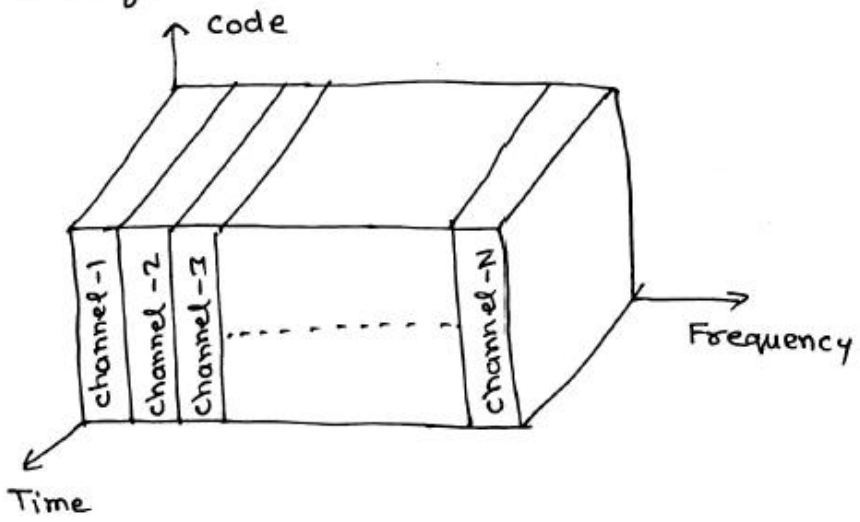
(1) Frequency division multiple accen (FDMA)
(2) Time division multiple access (TDMA)
(3) Code division multiple Access (CDMA)

Frequency Division Multiple Access (FDMA)-

FDMA allows multiple users to send data through a single communication channel by dividing the Bandwidth of the channel into seperate non-overlapping frequency sub-channels and allocating each sub-channel to a seperate user.

* FDMA channel carries only one phone circuit at a time.
* If an FDMA channel is not in use, then it sits idle and can not be used by other users.

* After the assignment of a voice channel, the base station and mobile transmit simultaneously and continuously.



* The FDMA is usually used in narrow-band systems.
* Intersymbol interference is low, hence little or no equalization is required in FDMA narrow band systems.
* The complexity of FDMA mobile systems is lower when compared to TDMA systems.
* Since FDMA is a continuous transmission scheme, hence less bits are required for overhead purpose as compared to TDMA.
* FDMA mobile unit uses duplexers since both the transmitter and receiver operate at the same time. This increases the cost of FDMA subscriber unit and base stations.
* FDMA requires tight RF filtering to minimize adjacent channel interference.
* FDMA systems have higher cell site system costs as compared to TDMA systems.
* The number of channels supported in FDMA system is given by

$$N = \frac{B_t - 2B_{guard}}{B_c}$$

where B_t = Total spectrum allocation
B_{guard} = guard band
B_c = channel bandwidth.

Q2. Explain TDMA in detail with suitable diagram. [AKTU:2018-19, 2021-22]

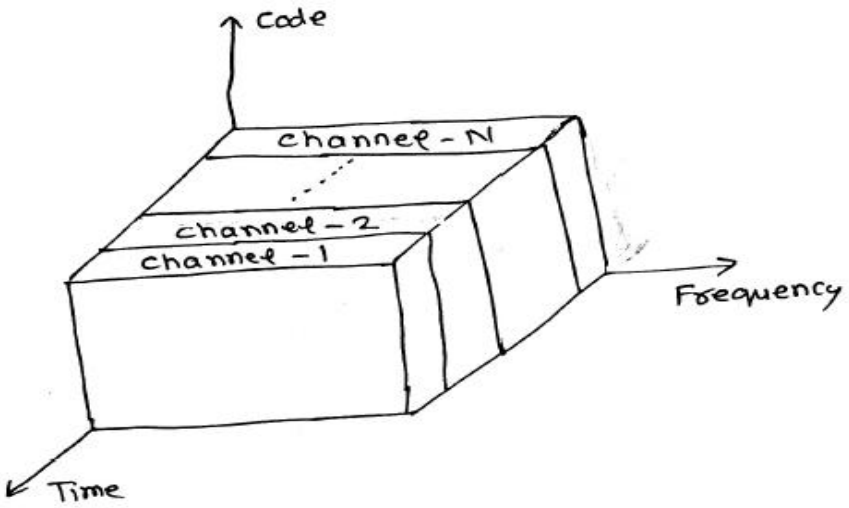
ANS:

Time Division Multiple Access (TDMA)–

Time division multiple access systems devide the radio spectrum into time slots, and in each slot only one user is allowed to send or receive.

* TDMA systems transmit data in a buffer-and-burst method hence transmission for any user is noncontinuous.

* TDMA is a digital system which supports digital data and digital modulation.

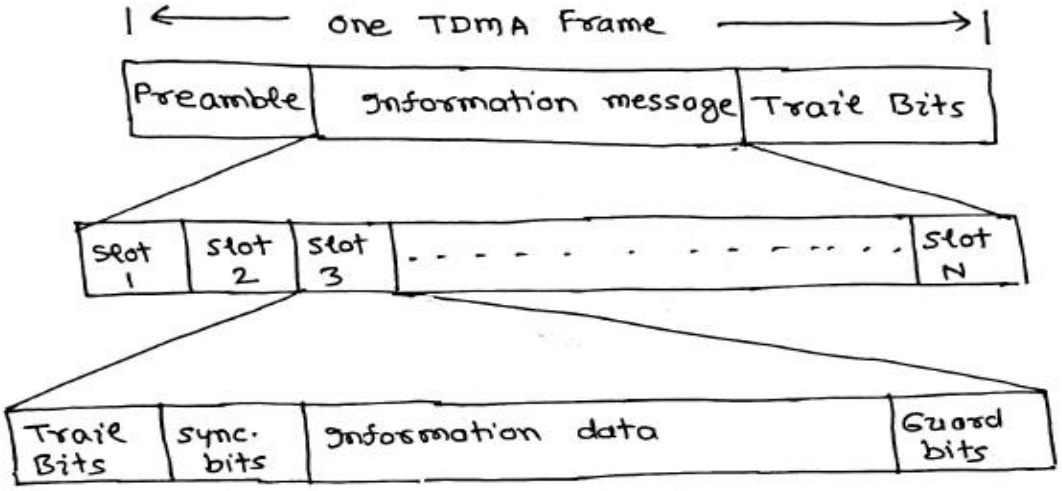


* TDMA shares a single carrier frequency with many users where each user uses its allocated time slot only. The number of time slot per frame depends on several factors such as modulation technique, available bandwidth etc.

* Data transmission for users of a TDMA system is not continuous but occurs in burst. This results in low battery consumption, since subscriber transmitter can be turned off when not in use.
* Because of discontinuous transmission in TDMA, the handoff process is much simpler for a subscriber unit, since it is able to listen for other base stations during the idle time slots.

* TDMA uses different time slots for transmission and reception; thus duplexers are not required.
* Adaptive equalization is usually necessary in TDMA systems, since transmission rates are very high as compared to FDMA channels.

* High synchronization overhead is required in TDMA systems because of burst transmission.



TDMA frame structure.

* Number of channels in TDMA system is given by

$$N = \frac{m\,(B_{tot} - 2B_{guard})}{B_c}$$

where m = maximum number of TDMA users supported on each radio channel

B_{tot} = Total frequency allocation

B_{guard} = Guard band

B_c = channel bandwidth

Q3. Explain spread spectrum multiple access in detail.

ANS:

Spread Spectrum Multiple Access - (SSMA)

* Spread spectrum multiple Access (SSMA) uses signals which have transmission bandwidth that is much greater than the minimum required RF Bandwidth. A PN sequence (pseudo-noise) converts a narrow band signal to wideband noise-like signal before transmission.
* SSMA provides immunity to multipath interference.
* SSMA is not bandwidth efficient when used by a single user. However, since many users can share the same spread spectrum bandwidth without interfering with one another, spread spectrum systems become bandwidth efficient in a multiple user environment.

* There are two types of spread spectrum multiple access techniques -
  (i) Frequency Hopped multiple Access (FHMA)
  (ii) Direct Sequence Multiple (DSMA)

(1) Frequency Hopped multiple Access (FHMA)

* Frequency hopped multiple access (FHMA) is a digital multiple access system in which the carrier frequencies of the individual users are varied in a pseudorandom fashion within a wideband channel.
* FHMA allows multiple users to simultaneously occupy the same spectrum at the same time.
* The digital data of each user is broken into uniform sized bursts which are transmitted on different channels within the allocated spectrum band.

* The instantaneous bandwidth of any one transmission burst is much smaller than the total bandwidth.
* In the FH receiver, a locally generated PN code is used to synchronize the receiver's instantaneous frequency with that of transmitter.
* At any given point in time, a frequency hopped signal only occupies a single, relatively narrow channel since narrowband FM or FSK is used.

(2) Code Division Multiple Access (CDMA)
OR
Direct Sequence Multiple Access (DSMA)

* In code division multiple access (CDMA), the narrow band message signal is multiplied by a very large bandwidth signal called the spreading signal. The spreading signal is a pseudo-noise code sequence that has a chip rate which is greater than the data rate of the message.

* Many users of a CDMA system share same carrier frequency and may transmit simultaneously. Either TDD or FDD may be used.
* Each user has its own pseudorandom codeword which is approximately orthogonal to all other codewords.
* Unlike TDMA or FDMA, CDMA has a soft capacity limit. Increasing the number of users in a CDMA system increase the noise floor in a linear manner. Thus there is no absolute limit on the number of users in CDMA. The system performance gradually degrades for all users as the number of users is increased, and improves as the number of users is decreased.

Q4. Write a short note on CDMA technique. [AKTU:2018-19]

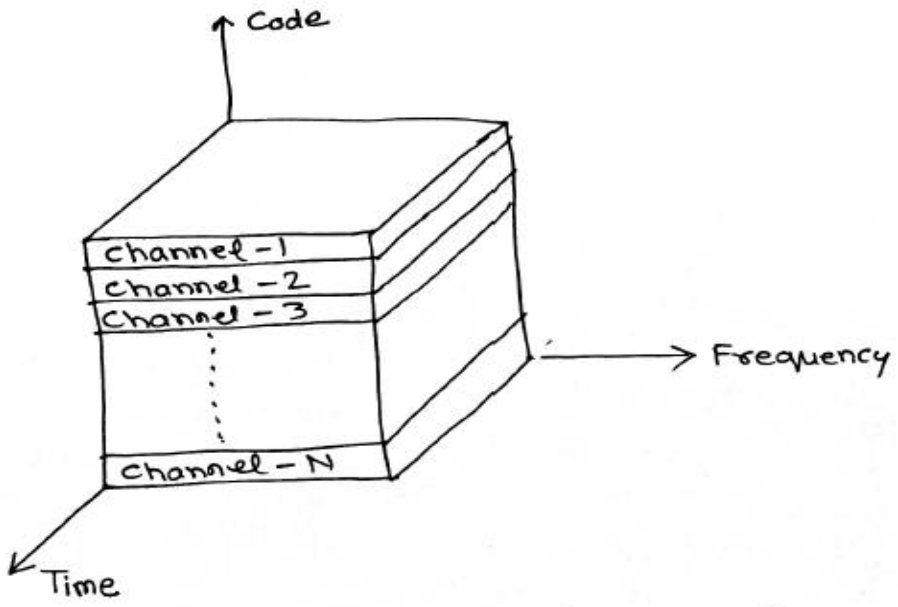
Or

Explain direct sequence multiple access (DSMA) technique in detail.

ANS:

Code Division Multiple Access (CDMA)
or
Direct Sequence Multiple Access. (DSMA)

* In code division multiple access (CDMA), the narrow band message signal is multiplied by a very large bandwidth signal called the spreading signal. The spreading signal is a pseudo-noise code sequence that has a chip rate which is greater than the data rate of the message.



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* Each user has its own pseudorandom codeword which is approximately orthogonal to all other codewords.

* Unlike TDMA or FDMA, CDMA has a soft capacity limit. Increasing the number of users in a CDMA system increase the noise floor in a linear manner. Thus there is no absolute limit on the number of users in CDMA. The system performance gradually degrades for all users as the number of users is increased, and improves as the number of users is decreased.
* Multipath fading may be reduced because the signal is spread over a large spectrum.
* Channel data rates are very high in CDMA.
* A RAKE receiver can be used to improve reception by collecting time delayed versions of the required signal.

* Since CDMA uses co-channel cells, it can use macroscopic spatial diversity to provide soft handoff. Soft handoff is performed by the MSC, which can simultaneously monitor a particular user from two or more base stations. The MSC may chose the best version of the signal at any time without switching frequency.
* Self-Jamming is a problem in CDMA.
* The near-far problem occurs in CDMA receiver if an undesired user has a high detected power as compared to the desired user.

Q5. Write a short note on Frequency hopped multiple access (FHMA) technique.

Frequency Hopped Multiple Access (FHMA)

* Frequency hopped multiple access (FHMA) is a digital multiple access system in which the carrier frequencies of the individual users are varied in a pseudorandom fashion within a wideband channel.

* FHMA allows multiple users to simultaneously occupy the same spectrum at the same time.
* The digital data of each user is broken into uniform sized bursts which are transmitted on different channels within the allocated spectrum band.

* The instantaneous bandwidth of any one transmission burst is much smaller than the total bandwidth.
* In the FH receiver, a locally generated PN code is used to synchronize the receivers instantaneous frequency with that of transmitter.

* At any given point in time, a frequency hopped signal only occupies a single, relatively narrow channel since narrowband FM or FSK is used.
* The difference between FHMA and FDMA system is that the frequency hopped signal changes channels at rapid intervals.
* If the rate of change of the carrier frequency is greater than the symbol rate, then the system is known as a fast frequency hoped system.

* If the rate of change of the carrier frequency is less than symbol rate, then the system is known as slow frequency hopped system.
* FHMA system provide a very good level of security because unauthorized user cannot detect the FHMA signal without knowing the correct PN sequence.

Q6. Write a short note on hybride spread spectrum multiple access technique.

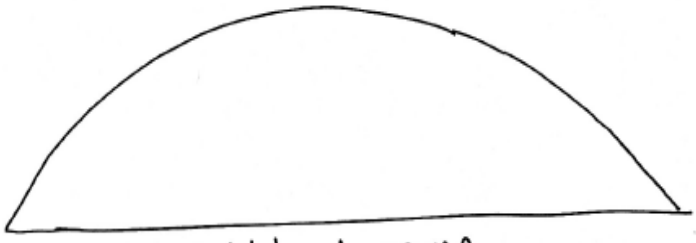
ANS:

Hybrid Spread Spectrum Techniques-

The hybrid combinations of spread spectrum techniques are-

(i) Hybrid FDMA/CDMA (FCDMA)
(ii) Hybrid DS/FHMA
(iii) Time division CDMA (TCDMA)
(iv) Time division frequency hopping (TDFH)

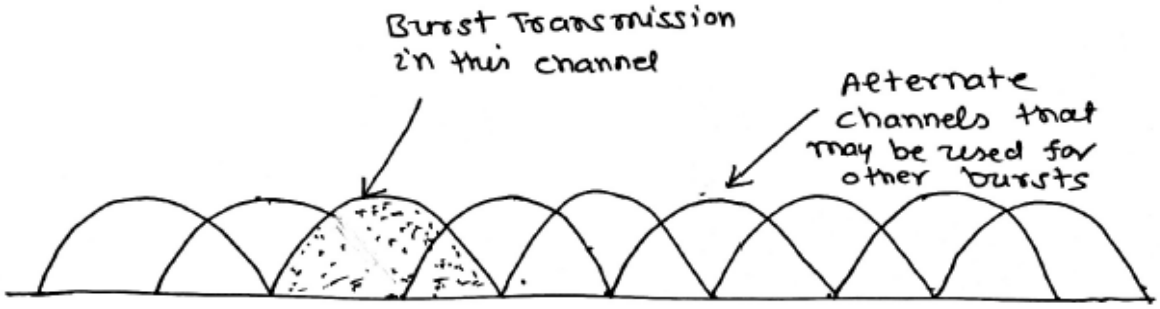
(i) **Hybrid FDMA/CDMA (FCDMA)** – In this technique, the available wideband spectrum is divided into a number of subspectras with smaller bandwidths. Each of these smaller subchannels becomes a narrowband CDMA system having processing gain lower than the original CDMA system. In this system the required bandwidth need not be contiguous and different users can be allotted different subspectrum bandwidths depending on their requirements. The capacity of this FDMA/CDMA technique is calculated as the sum of the capacities of a system operating in the subspectra.



Wideband CDMA

Spectrum of narrowband CDMA

(ii) Hybrid Direct Sequence / Frequency hopped Multiple Accen (DS/FHMA) –



Frequency spectrum of a hybrid FH/DS system

* This technique consists of a direct sequence modulated signal whose center frequency is made to hop periodically in a pseudorandom fashion.
DS/FHMA systems have an advantage in that they avoid the near-far effect. However, frequency hopped CDMA systems are not adaptable to the soft handoff process since it is difficult to synchronize the frequency hopped base station receiver to the multiple hopped signals.

(iii) Time Division CDMA (TCDMA)– In TCDMA (also called TDMA/CDMA) system, different spreading codes are assigned to different cells. Within each cell, only one user per cell is allotted a particular time slot. Thus at any time, only one CDMA user is transmitting in each cell. When a handoff takes place, the spreading code of the user is changed to that of a new cell. This system avoids the near-far effect since only one user transmits at a time within a cell.

(iv) Time Division Frequency hopping (TDFH) – This multiple access technique has an advantage in severe multipath or when severe co-channel interference occurs. The subscriber can hop to a new frequency at the start of a new TDMA frame. This technique avoids a severe fade on a particular channel. This technique has been adopted for the GSM standard, where the hopping sequence is predefined and the subscriber is allowed to hop only on certain frequencies which are assigned to a cell. This technique also avoids co-channel interference problems between neighboring cells. The use of TDFH can increase the capacity of GSM by several fold.

Q.7. Write short note on OFDMA. [AKTU: 2017-18]

ANS:

Orthogonal Frequency-Division Multiple Access – (OFDMA) –

* OFDMA is a multiuser version of OFDM and has the capability to serve multiple users simultaneously with different amounts of data consumption. This process is done by splitting channels into smaller frequencies known as resource units (RU's). These resource units may be 20, 40, 80 and 160 MHz channel sizes. Number and size of resource units depends on the amount of data a given device requires.

* The OFDM concept is based on spreading the high speed data to be transmitted over a large number of low rate carriers. The carriers are orthogonal to eachother and frequency spacing between them are created by using the Fast Fourier transform.

* The main benefit of OFDMA is that it allows an access point to allocate the whole channel to a single user at a time or it may partition a channel to serve multiple users simultaneously.

Advantages of OFDMA-

(i) High throughput : OFDMA allows radio waves to carry more data in shorter time frames.

(ii) Low Latency : OFDMA reduces response time and enhances performance of video, artifical intelligence, and virtual and augmented reality applications

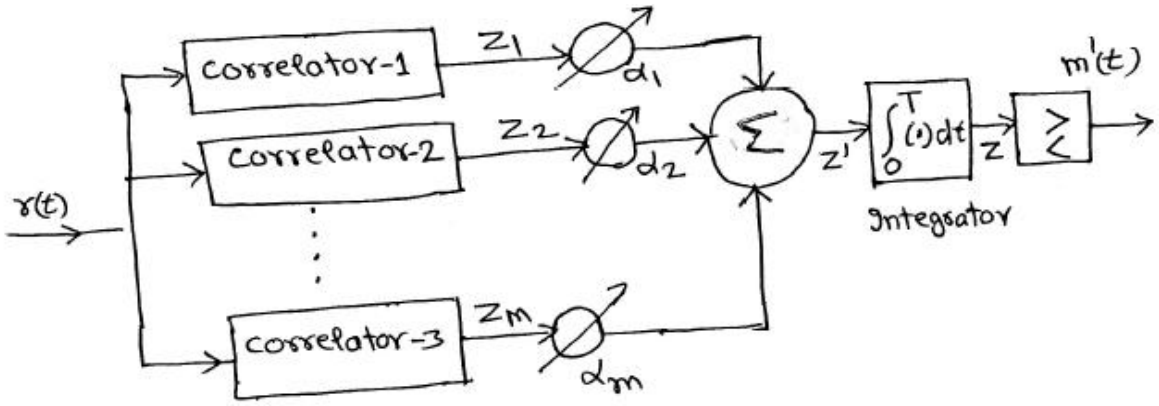
(iii) IoT optimization : OFDMA prevents Internet of Things (IoT) devices from using disproportionate network resources.

(iv) More-efficient power consumption — OFDMA allows per-channel or per subchannel power and lower maximal transmission power for low data rate users, eliminating pulsed carriers and conserving battery life in devices.

Q8. Draw and explain RAKE receiver using block diagram. [AKTU:2017-18, 2018-19]

ANS:

RAKE Receiver – A RAKE receiver is a radio receiver which is designed for the purpose to counter the effects of multipath fading. Due to reflections from multible obstacles in the environment, the radio channel can consists of multiple copies of the transmitted signal having different amplitude, phases or delays. A rake receiver can resolve this issue and combine them. For this purpose, several sub-receivers are used which are known as " fingers".



M - Branch (M - finger) RAKE Receiver

A RAKE Receiver collects the time-shifted versions of the original signal by using a seperate correlation receiver for each of the multipath signals.

RAKE receiver utilizes multipath correlators to separately detect the M strongest multipath components. The outputs of each correlater are then weighted to provide a better estimate of the transmitted signal than is provided by a single component. Demodulation and bit decisions are then based on the weighted outputs of the M correlators.

* If only a single correlator is used in the receiver, once the output of the single correlator is corrupted by fading, the receiver cannot correct the value. Bit decisions based on only a single correlator may produce a large bit error rate.
* In a RAKE receiver, if output from one correlat is corrupted by fading, the other may not be, and the corrupted signal may be discounted through the weighting process. Decisions based on the combination of the M seperate decision statistics offered by the RAKE receiver provide a form of diversity which can overcome fading and improve CDMA reception.

* The overall signal Z' is given by

$$Z' = \sum_{m=1}^{M} d_m Z_m$$

Z_m = output of correlators
d_m = weighting coefficients.

Q9. Explain adaptive equalization and decision feedback equalizer. [AKTU: 2018-19]

ANS: Adaptive equalization:

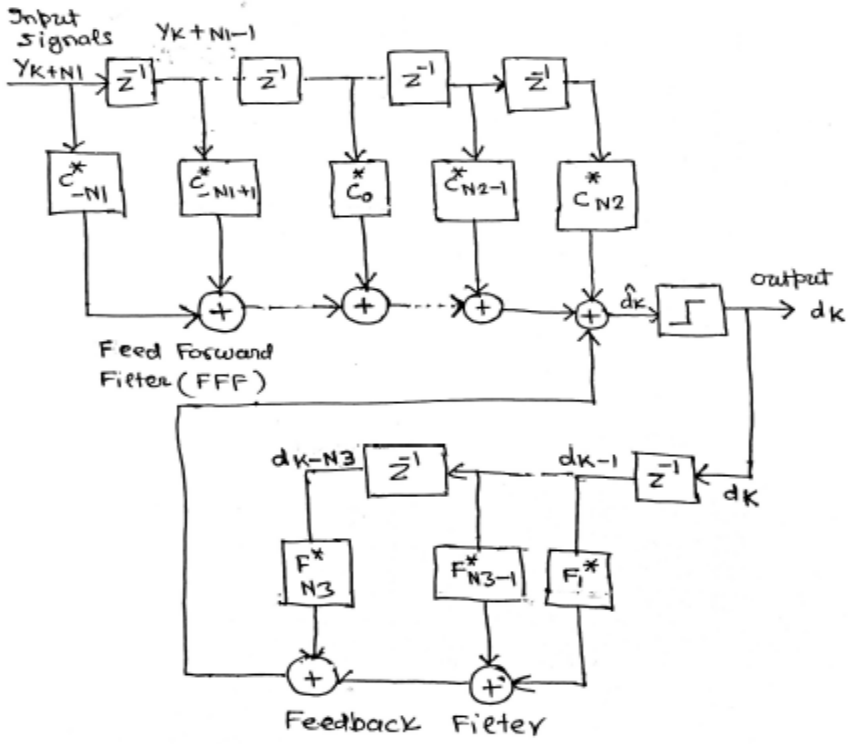
An adaptive equalizer is an equalizer that automatically adapts to the time varying properties of the communication channel. Adaptive equalization uses algorithms to estimate the channel response and then adaptively adjusts the filter coefficients to minimize the error between the received signal and the transmitted signal.

The adaptive equalizer has two operating modes (i) training (ii) tracking

* In training mode, the equalizer is trained to learn the characteristics of the channel by using a known training sequence. The training sequence is a predetermined sequence of symbols that is transmitted by the transmitter and known by the receiver. The receiver uses this known sequence to estimate the channel characteristics and adapts the equalizer coefficients accordingly.
* In tracking mode, the equalizer uses the received signal to estimate the channel characteristics and adjust the filter coefficients to compensate any change in the channel.

Decision Feedback Equalizer – (DFE) –

The basic idea behind decision feedback equalization is that once an information symbol is detected, the ISI that it induces on future symbols can be estimated and subtracted out before detection of subsequent symbols.



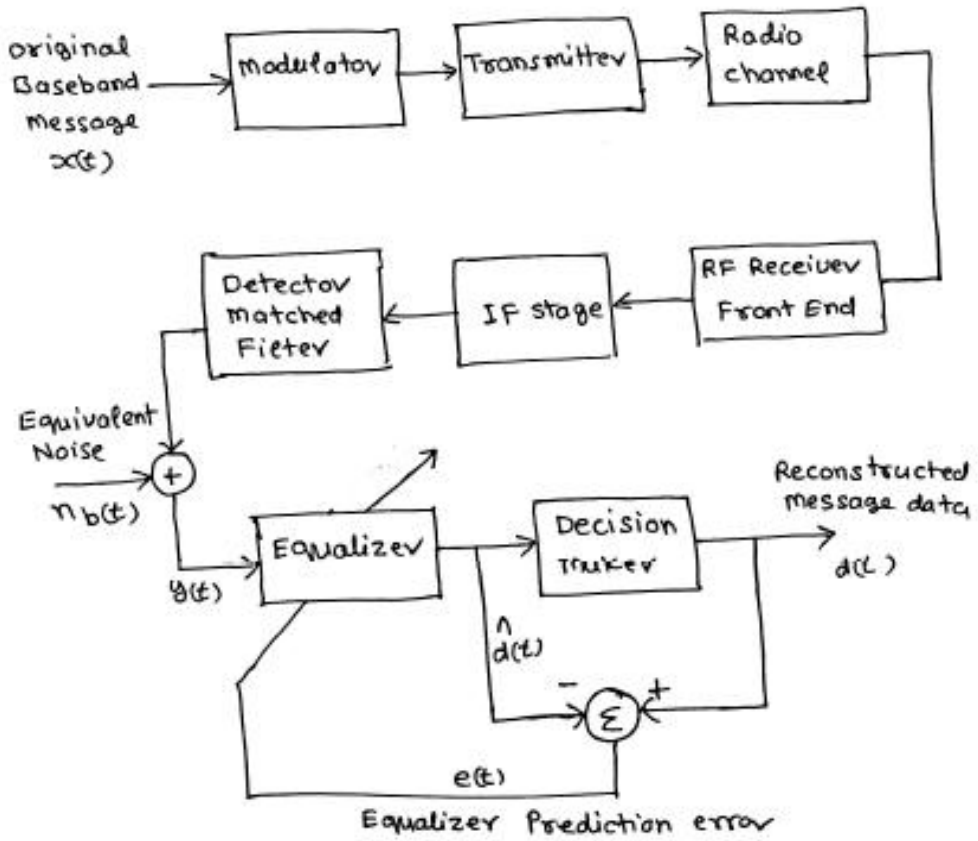
* The Decision Feedback Equalizer consists of a feed forward filter (FFF) and a feedback filter (FBF). The feedback filter is driven by decisions on the output of detector and its coefficients can be adjusted to cancel the ISI on the current symbol from past detected symbols.
* The equalizer has $N_1 + N_2 + 1$ taps in feed forward filter and N_3 taps in feedback filter.
* The output of filter is given by

$$\hat{d}_k = \sum_{n=-N_1}^{N_2} c_n^* y_{k-n} + \sum_{i=1}^{N_3} F_i^* d_{k-i}$$

$c_n^* \longrightarrow$ Tap gains for forward filter
$y_n \longrightarrow$ Inputs for forward filter
$F_i^* \longrightarrow$ Tap gains for feedback filter
$d_i \ (i < k) \longrightarrow$ previous decision made on detected signal

Q10: Show that an equalizer is an inverse filter of the channel. [AKTU: 2015-16]

ANS: Adaptive Equalizer:



Block diagram of a simplified communication system using an adaptive equalizer at the receiver

If $f(t)$ = combined impulse response of the transmitter, channel and RF/IF sections of the receiver

$x(t)$ original message signal

Signal received by the equalizer,

$$y(t) = x(t) \otimes f^*(t) + n_b(t)$$

$n_b(t)$ = baseband noise at the input of equalizer

If, $h_{eq}(t)$ = Impulse response of equalizer, then

output of the equalizer

$$\hat{d}(t) = x(t) \otimes f^*(t) \otimes h_{eq}(t) + n_b(t) \otimes h_{eq}(t)$$
$$= x(t) \otimes g(t) + n_b(t) \otimes h_{eq}(t) \quad \text{— (1)}$$

where $g(t)$ = combined impulse response of transmitter, channel, RF/IF section of receiver and equalizer

$$h_{eq}(t) = \sum_n C_n \delta(t - nT)$$

where, C_n = complex filter coefficient of equalizer

The desired output of equalizer is $x(t)$, the original data source. Assume $n_b(t) = 0$, then in order to force $\hat{d}(t) = x(t)$ in equation (1), $g(t)$ must be equal to

$$g(t) = f^*(t) \otimes h_{eq}(t) = \delta(t) \quad \text{— (2)}$$

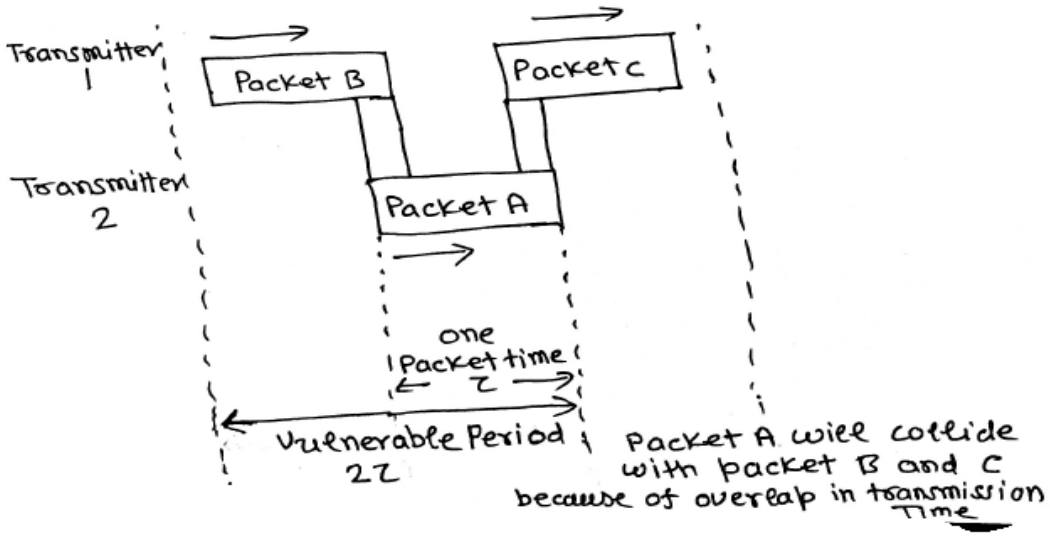
In frequency domain equation (2) can be expressed as $H_{eq}(f)\, F^*(-f) = 1$ ——— (3)

where $H_{eq}(f)$ and $F^*(-f)$ are Fourier transform of $h_{eq}(t)$ and $f(t)$ respectively.

Equation (3) indicates that an equalizer is actually an inverse filter of the channel.

Q11. Explain pure ALOHA & Slotted ALOHA protocol. [AKTU: 2017-18, 2021-22]

Pure ALOHA- The pure ALOHA protocol is a random access protocol used for data transfer. A user access a channel as soon as a message is ready to be transmitted. After a transmission, the user waits for an acknowledgment on either a same channel or seperate feedback channel. In case of collisions (i.e. when a NACK is received), the terminal waits for a random period of time and retransmits the message. As the number of users increases, a grater delay occurs because the probability of collision increases. For the ALOHA protocol, the vulnerable period is double the packet duration.



* The Probability of no collision during interval 2τ is given by

$$P_r(n) = \frac{(2R)^n e^{-2R}}{n!}$$

at $n = 0$,

The probability of no collision is

$$P_r(0) = e^{-2R}$$

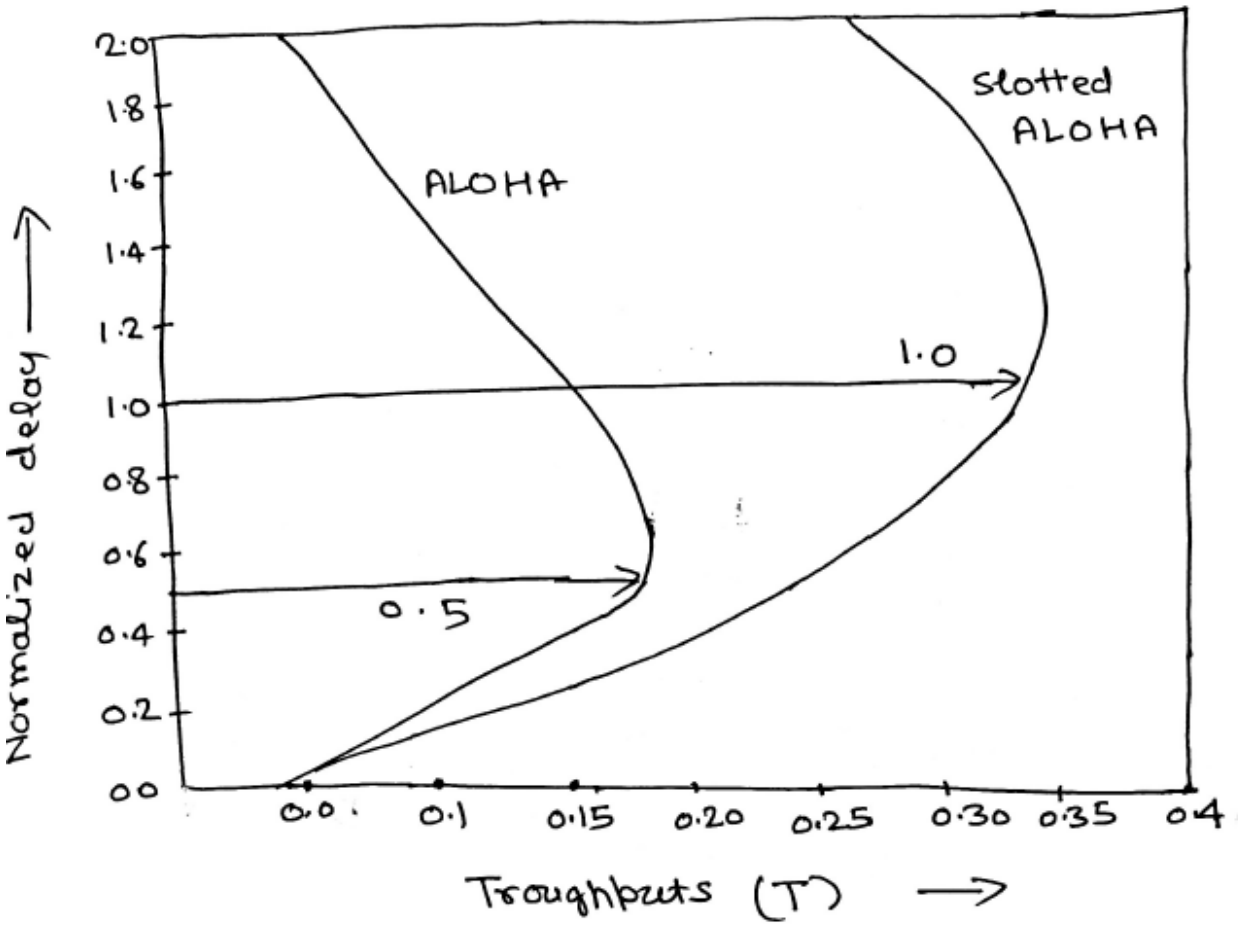
The throughput of ALOHA protocal is given by

$$T = R \cdot e^{-2R}$$

(ii) Slotted ALOHA - In slotted ALOHA, time is divided into equal time slots of length greater than the packet duration. Each subscribers have synchronized clocks and transmit a message only at the begining of a new time slot, thus resulting in a discrete distribution of packets. This prevents partial collisions, where one packet collides with a portion of other. As the number of users increases, a greater delay will occur due to complete collisions and the resulting repeated transmission of those packets originally lost. The number of slots which a transmitter

waits prior to retransmitting also determines the delay characteristics of the traffic.

* The vulnerable period for slotted ALOHA is only one packet duration, since partial collisions are prevented through synchronization.
* The probability that no other packets will be generated during the vulnerable period is e^{-R}.
* The throughput of slotted ALOHA is $T = Re^{-R}$.



Q12: Write a short note on CSMA/CD protocol.

Carrier Sense Multiple Access (CSMA) Protocol -

* CSMA protocols are based on the fact that each terminal on the network is able to monitor the status of the channel before transmitting information. If the channel is idle (i.e. no carrier is detected), then the user is allowed to transmit a packet based on a particular algorithm which is common to all the transmitters of the network. In CSMA protocols, detection delay and propagation delay are two important parameters.
* Detection delay is the time required for a terminal to sense whether are not the channel is idle. Propagation delay is a measure of how fast a packet travel from a base station to a mobile terminal.

* Propagation delay $$t_d = \frac{t_p R_b}{m}$$

where t_p = Propagation time
R_b = channel bit rate
m = Expected number of bits in a data packet.

* 1-Persistent CSMA — The terminal listens to the channel and waits for transmission until it finds the channel idle. As soon as the channel is idle, the terminal transmits its message with probability one.
* Non-persistent CSMA - In this type of CSMA strategy, after receiving a negative acknowledgement the terminal waits a random time before retransmission of the packet.
* p-persistent CSMA — p-persistent CSMA is applied to slotted channels. When a channel is found to be idle, the packet is transmitted in the first available slot with probability p or in the next slot with probability 1 — p.

* CSMA/CD – In CSMA with collision detection (CD), a user monitors its transmission for collisions. If two or more terminals start a transmission at the same time, collision is detected, and the transmission is immediately aborted in midstream.

BUDDHA SERIES

(Unit Wise Solved Question & Answers)

Course – B. Tech (ECE)

College – Buddha Institute of Technology

(AKTU CODE-525)

Department: Electronics and Communication Engineering

Subject: Wireless & Mobile Communications (KEC076)

Faculty Name: AKC

Unit – 4

Q.1 What is GSM? Write its services & features in brief.
Ans:

Global System for Mobile (GSM)–

* GSM is a second generation cellular system standard that was developed to solve the fragmentation problems of first generation cellular system in Europe.
* GSM was the world's first cellular system to specify digital modulation and network level architectures and services, and is the world's most popular 2G technology.
* Before GSM, European countries used different cellular standards throughout the continent, and it was not possible for a customer to use a single subscriber unit throughout Europe.

GSM Services and Features–

GSM services can be classified as –

(i) Teleservices
(ii) Data services

* Teleservices include standard mobile telephony and mobile-originated or base-originated traffic.
* Data services include computer-to-computer communication and packet-switched traffic.

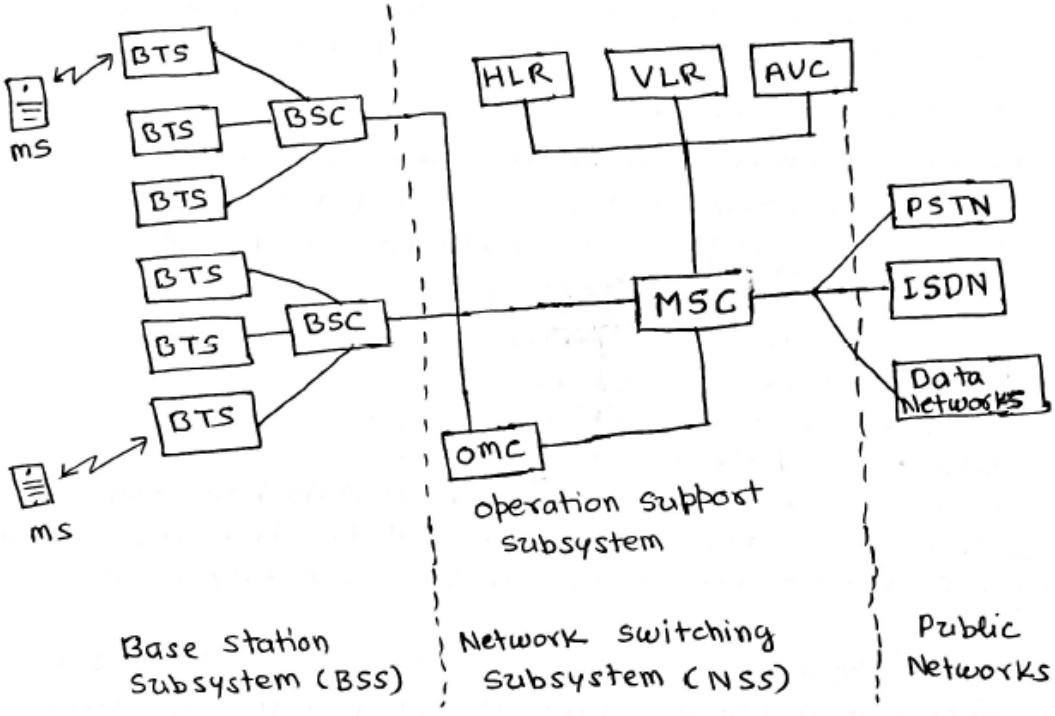
User services may be divided into three major categories.

* Telephone services
* Bearer services or data services
* Supplementary ISDN services – call diversion, closed user groups, caller identification, short messaging services (SMS).

* The first remarkable feature of GSM is the Subscriber Identity Module (SIM) which is a memory device that stores information such as the subscriber's identification number, the networks and countries where the subscriber is entitled to service, privacy keys and other user specific information.
* The second remarkable feature of GSM is on-the-air privacy which is provided by the system. The privacy is made possible by encrypting the digital bit stream sent by GSM transmitter, according to a specific secret cryptographic key that is known only to the cellular carrier. This key changes with time for each user.

Q2. Explain GSM network architecture. Also give brief view of various Interface standard in GSM. **[AKTU: 2016-17, 2021-22]**

ANS: GSM Network Architecture:



* GSM system architecture consists of three major interconnected subsystems.
  (i) Base station sub system
  (ii) operation support subsystem
  (iii) Network switching subsystem.

Base station Subsystem - (BSS) -

The mobile stations (MSs) communicate with the base station subsystems (BSS) over the radio air interface. BSS provides and manages radio transmission paths between the mobile stations and mobile switching center (MSC). BSS also manages the radio interface between the mobile stations and all othe subsystems of GSM. The BSS consists of many BSCs which connect to a single MSC and each BSC typically controlls upto several hundred Base transciver stations (BTSs).

* The mobile handoffs between two BTSs under the control of the same BSC are handled by the BSC and not by MSC. This greatly reduces the switching burden of the MSC.

Network and Switching Subsystem (NSS) -

The NSS manages the switching functions of the system, and allows the MSCs to communicate with other networks such as the PSTN and ISDN.

The NSS handles the switching of GSM calls between external networks and the BSCs in the radio subsystem and is also responsible for managing and providing external access to several customer data base.

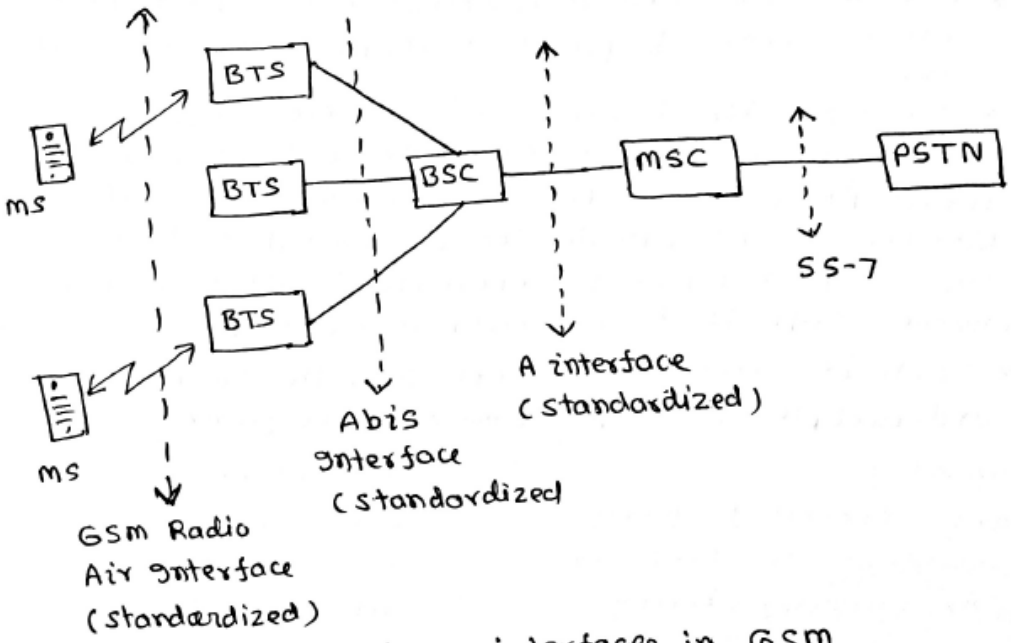
In NSS there are three different data base -

(i) HLR (Home Location Register)
(ii) VLR (Visitor Location Register)
(iii) AUC (Authentication Center)

* Home Location Register (HLR) is a data base which contains subscriber information and location information for each user who resides in the same city as the MSC.
* Each subscriber in a particular GSM market is assigned a unique International Mobile Subscriber Identity (IMSI) and this number is used to identify each home user.
* Visitor Location Register (VLR) is a data base which temprarily stores the IMSI and customer information for each roaming subscriber who is visiting the coverage area of a particular MSC.
* Authentication center (AUC) is a strongly protected data base which handles the authentication and encryption keys for every single subscriber in the HLR and VLR.

* The Authentication center contains a register called Equipment Identity Register (EIR) which indentifies stolen or fraudently altered phones that transmit identity data that does not match with information contained in either the HLR or VLR.
* The OSS supports one or several operation maintenance centers (OMC) which are used to monitor and maintain the performance of each MS, BTS, BSC and MSC within a GSM system.

GSM Interfaces -



Various interfaces in GSM

* The interface which connects a BTS to a BSC is called the Abis interface. The Abis interface carries traffic and maintenance data.
* The BSCs are physically connected via dedicated/ leased lines or microwave links to the MSC. The interface between a BSC and MSC is called A interface.
* The A interface allows a service provider to use base stations and switching equipment made by different manufactures.

Q3. Describe GSM Radio subsystem.

GSM Radio Subsystem -

* GSM originally used two 25 MHz cellular bands, by all member countries but now it is used globally in many bands. The 890 – 915 MHz band was for subscriber-to-base transmissions (reverse link) and 935–960 MHz band was for base-to-Subscriber transmissions (forward link).

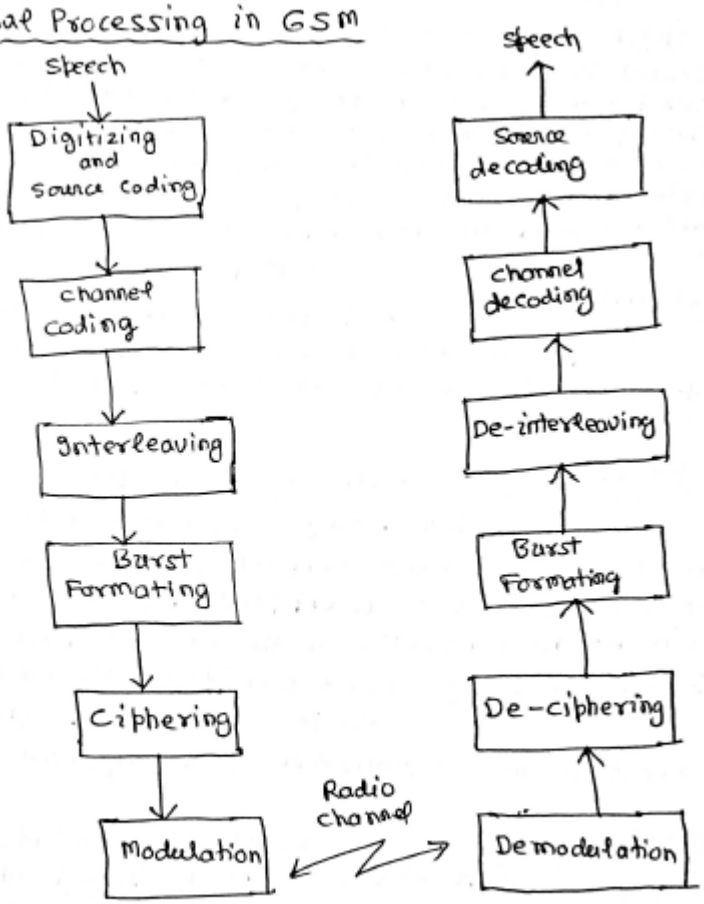
* GSM uses FDD and a combination of TDMA and FHMA schemes to provide multiple access to mobile users.
* The available forward and reverse frequency bands are divided into 200 KHz wide channels called ARFCNs (Absolute Radio Frequency channel Number). The ARFCN denotes a forward and reverse channel pair which is seperated by 45 MHz. Each channel supports 8 subscribey using TDMA.
* Each of eight subscribers uses the same ARFCN and occupies a unique time slot per frame.

Parameters	Specifications
Reverse channel frequency	890 – 915 MHz
Forward channel Frequency	935 – 960 MHz
Tx/Rx Frequency spacing	45 MHz
Modulation Data Rate	270.8333 Kbps
Frame period	4.615 ms
User per frame	8
Time slot period	576.9 µs.
Bit period	3.692 µs
Modulation	0.3 GMSK
ARFCN channel spacing	200 KHz

Q4. Explain signal processing and GSM operation from speech input to speech output with diagram. **[AKTU: 2015-16, 2017-18]**

ANS:

Signal Processing in GSM



GSM operations from speech input to speech output.

Speech Coding → GSM speech coder is Residually excited linear predictive coder. In a normal conversation, each person speaks on average for less than 40 %, of time. By using a voice activity detector in speech coder, GSM systems operate in a discontinuous transmission mode which provides a longer subscriber battery and reduces radio interference since GSM transmitter is not active during silent period.

channel coding – The purpose of channel coding is to provide the GSM receiver with the ability to detect transmission errors and correct some of these.

Interleaving – Interleaving is the process of distributing consecutive bits of a block into different subblocks. If a sequence in one subblock is corrupted then these bits will not be consecutive in the original block.

Burst Formating – Burst formating adds binary data in order to help synchronization and equalization of the received signal

Ciphering – ciphering modifies the contents of eight interleaved blocks through the use of encryption techniques known only to the particular mobile station and BTS.

Modulation – GSM user 0.3 GMSK (0.3 Gaussian minimum shift keying) where 0.3 describes 3 dB bandwidth of Gaussian pulse shaping filter.

Q5.Explain GSM frame structure.

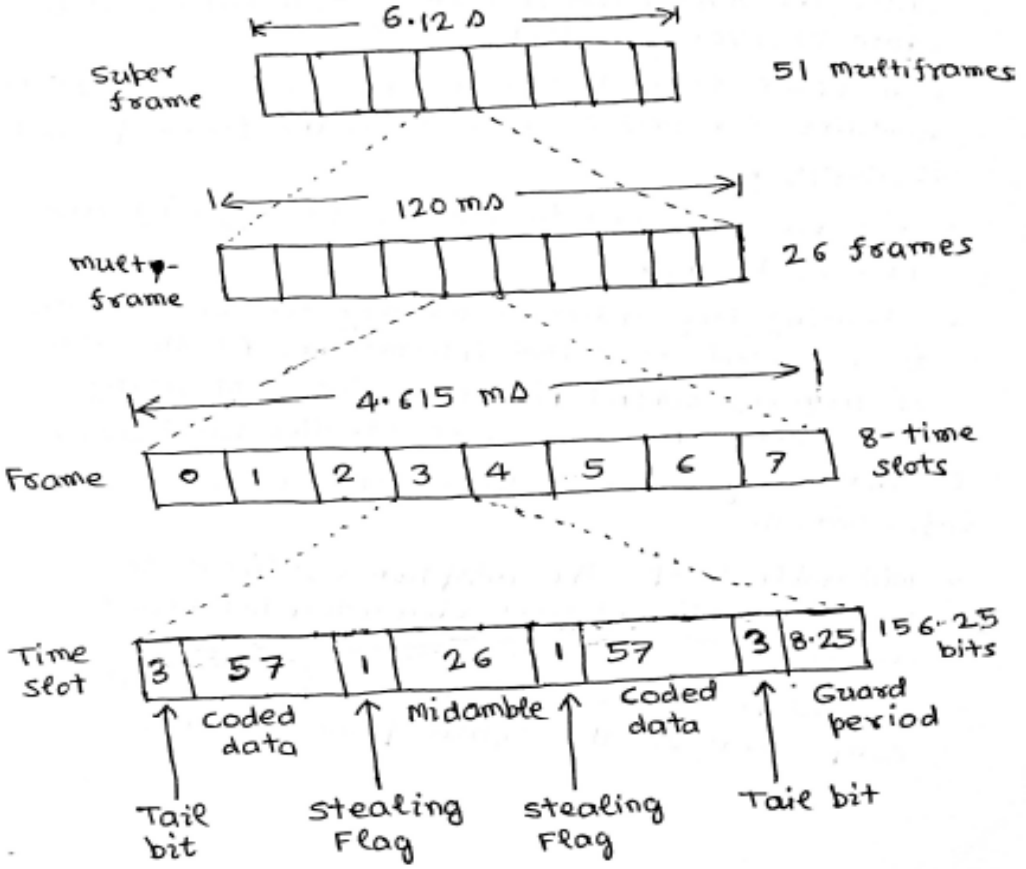
ANS: GSM Frame Structure:

* Each user transmits a burst of data during the time slot assigned to it.

* The data structure of a normal burst consists of 148 bits and an unused guard time of 8.25 bits. The data burst in GSM is transmitted at a rate of 270.8333 Kbps.

* A TDMA frame has eight time slots. So a frame contains $8 \times 156.25 = 1250$ bits. The frame period is 4.615 ms.

Frame structure of GSM-



GSM Frame Structure

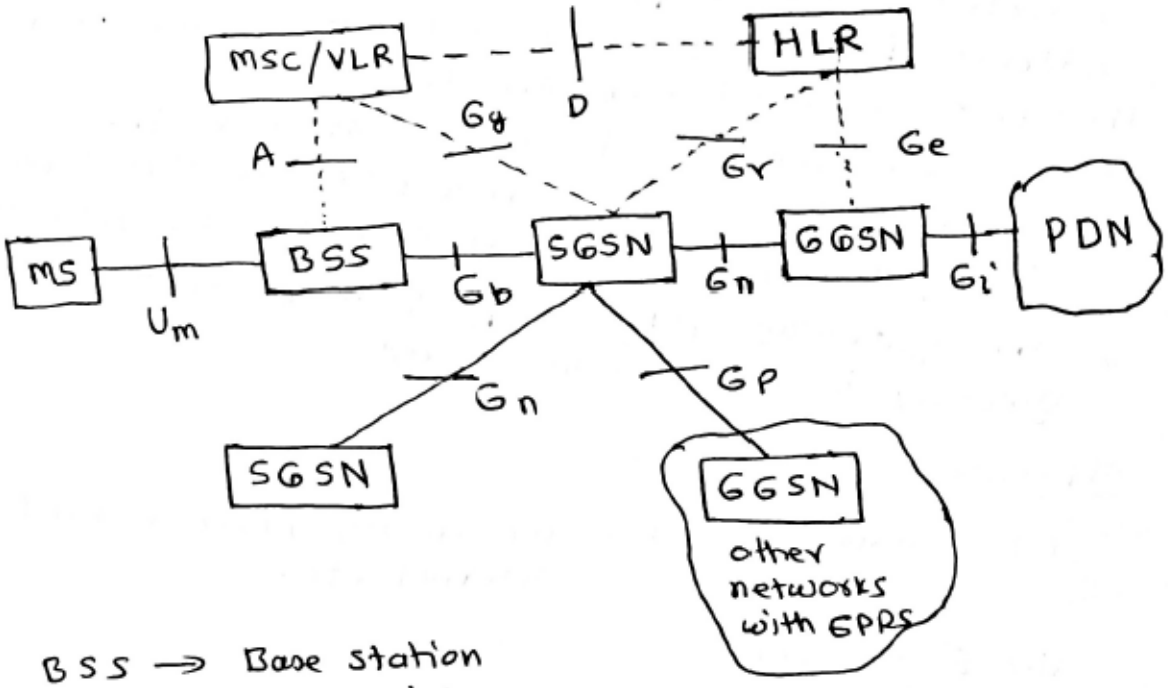
* Tail bits are used to indicate the begining and end of the burst.
* Stealing Flag indicates whether the coded data is a control or actual information. At the time of urgency control bits are also sent using voice channel. At that time stealing bit becomes 0, indicating coded data carries control information.
* Midamble helps the adaptive equalizer to analyze radio channel characteristics before coding.
* Gaurd period is used to ramp up and ramp-down of the signal power level.

Q6. Write a short note on 'General Packet Radio Service' (GPRS)

ANS:

General Packet Radio Service (GPRS)

* The GSM technology was developed for voice services, but it did not have the capability to provide data services. To enhance the services of GSM network, GPRS was developed on the GSM plateform.



BSS → Base station subsystem

PDN → Packet data network

GGSN → Gateway GPRS support node

SGSN → serving support node

HLR → Home Location Register

VLR → Visitor Location Register

MS → Mobile station

A, Gg, Gr, Ge, D are the interface for signalling

Um, Gb, Gn, Gp and Gi are interfaces for signalling and transmission.

* GPRS is a wireless communication service that allows data to be transmitted over a cellular network.
* GPRS uses packet- switching technology to transmit data, which means that data is divided into small packets. and sent over the network in a more efficient way.
* GPRS offers always on connectivity, which means that a user can stay connected to the network at all time, without having to establish a connection every time they want to send or receive data.
* GPRS Provides faster data transfer rates compared to earlier generation of cellular network such as GSM.

* GPRS enables new applications and services such as mobile internet browsing and e-mail.
* The data from BSC is routed through the serving GPRS suport node (SGSN). Thei forms the gateway to the services within the network
* The gateway GPRS support node forms the gateway to the outside world.

Advantages of GPRS —

* A high-speed data transfer is possible to mobile devices through GPRS.
* Web browsing, e-mail sending and receiving, and online shopping are just a few of the online services that GPRS user can access while they are on move.

* GPRS offers a cost effective approach to transmitting statistics because it only charges for volume of data transfered not for the amount of time spent online.
* Because GPRS is always operational, customers can access the internet quickly and without any problems without utilizing dial-up.

Q7. Write short note on IMT-200 standard. [AKTU: 2014-15]
ANS:

IMT-2000 (International mobile Telecommunications -2000)- IMT-2000 is the global standard for third generation (3G) wireless communication and it is defined by International Telecommunication Union. In 1999 ITU approved five radio interfaces for IMT-2000. These five standards are-

(1) IMT-2000 CDMA Direct spread
- also known as W-CDMA
- used in UMTS
- the successor to GSM

(2) IMT-2000 CDMA Multi-Carrier
- Also known as CDMA 2000
- the successor to 2G CDMA (IS-95)

(3) IMT-2000 CDMA TDD
- Also known as TD-SCDMA

(4) IMT-2000 TDMA Single Carrier
- Also known as EDGE
- an intermediate 2.5 G technology.

(5) IMT-2000 FDMA/TDMA
- Also known as DECT

* To meet the IMT-2000 standards, a system must provide peak data rates of 384 Kbps for mobile stations and 2 mbps for fixed stations.

The main characteristics of IMT-2000 are-
- worldwide usage, integration of satellite and terrestrial systems to provide global coverage.
- Used for all radio environments (LAN, cordless, cellular, satellite.
- wide range of telecommunications services (voice, data, multimedia, internet)
- supports both packet-switched (PS) and circuit-switched (CS) data transmission.
- offer high data rates up to 2 mbps.
  (i) 144 Kbps for high mobility
  (ii) 384 Kbps with restricted mobility
  (iii) 2 mbps in indoor office environment
- offer high spectrum efficiency.

Q8: Describe IS-95 wireless standard in detail. **[AKTU:2018-19]**
ANS:

CDMA Digital Cellular Standard (IS-95)

* Interim Standard 95 (IS-95) is a second generation (2G) mobile telecommunications standard based on code division multiple access (CDMA) technology. IS-95 operates in the 800 MHz and 1900 MHz frequency band.
* IS-95 is also known as CDMA one standard. IS-95 was first digital cellular technology that used code division multiple access.
* It was developed by Qualcomm and leter adapted as a standard by Telecommunication Industry Associan in TIA/EIA/IS-95 released and published. in 1995.

* IS-95 allows each user within a cell to use the same radio channel, and users in adjacent cells also use the same radio channel, since this is direct sequence spread spectrum CDMA system. CDMA completely eleminates the need for frequency planning within a market.
* Each IS-95 channel occupies 1.25 MHz of the spectrum on each one way link, or 10% of the available cellular spectrum for a US cellular provider.
* US cellular system is allocated 25 MHz and each service provider receives half the spectrum or 12.5 MHz. In practice, AMPS carriers must provide a 270 KHz guard band on each side of the spectrum dedicated for IS-95.

* Unlike other cellular standards, the user data rate changes in real time, depending upon the voice activity and requirements in the network
* IS-95 uses a different modulation and spreading technique for forward and reverse links. On the forward link, the base station simultaneously transmits the user data for all mobile in the cell by using a different spreading sequence for each mobile.
* The speech coder used in IS-95 system is the Qualcomm 9600 bps Code Excited Linear Predictive (QCELP) coder. The original implementation of this vocoder detects voice activity and reduces the data rate to 1200 bps during silent period.

* IS-95 is specified for reverse link operation in the 824 – 849 MHz band and 869 – 894 MHz for the forward link. A Forward and reverse channel pair is seperated by 45 MHz for cellular band operation. The maximum user data rate is 9.6 Kb/s.
* IS-95 provides enhanced call quality and coverage due to its digital nature and ability to reduce interference and noise.

Q9: Explain the network architecture of UMTS. [AKTU:2021-22]

ANS:

UMTS (Universal Mobile Telecommunication System)

* UMTS is a third generation mobile cellular system for networks based on GSM standard. UMTS is a component of International Telecommunication Union IMT-2000 standard set.
* UMTS uses wideband code division multiple Access (W-CDMA) technology to offer greater spectral efficiency and bandwidth to mobile network operators
* UMTS specifies a complete network system which includes the radio access network, the core network and authentication of users via SIM cards.
* Unlike EDGE and CDMA2000, UMTS requires new base stations and new frequency allocations.

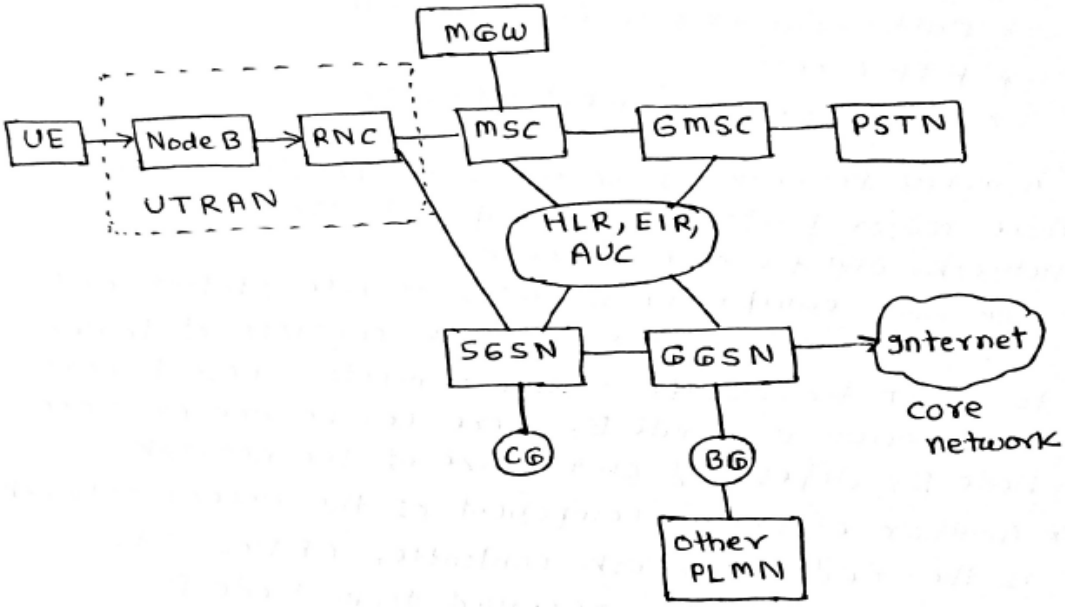
* UMTS supports maximum theoritical data transfer rates of 42 mbps, when Evolved HSPA (HSPA+) is implemented in the network. Users in developed networks can expect a data transfer rate up to 384 Kbps for R99 handsets and 7.2 mbps for High Speed Downlink Packet Access (HSDPA) handsets in the downlink connection. These speeds are faster than 9.6 kbps of a single GSM circuit switched data channel. The high data speed of UMTS
* UMTS uses the same core network standard as GSM/EDGE. This allows a simple migration for existing GSM operators. However, the migration path to UMTS is still costly. Much of the core infrastructure is shared with GSM, the cost of obtaining new spectrum licenses and overlaying UMTS at existing towers is high.

* The original frequency band defined by UMTS standard are -

1885 — 2025 MHz for Uplink transmission
(mobile-to-base)

2110 — 2200 MHz for downlink transmission
(base-to-mobile)

UMTS Network Architecture -



UE → User Equipment
RNC → Radio Network Controller
SGSN → Serving GPRS Support Node
GGSN → Gateway GPRS Support Node
CG → charging gateway
BG → Border Gateway
MSC → Mobile switching center
GMSC → Gateway MSC
PSTN → Public Switched Telephone Network
HLR → Home Location Register
EIR → Equipment Identity Register
AUC → Authentication Center

* A mobile network of the UMTS can be divided into three major parts – user equipment, the access network, and the core network.
* The user equipment includes mobile station and SIM card. The access network consists of towers to which the mobile station connects. These towers are known as Node B. There can be one or more Node Bs depending on the size of the network.
* Another essential component of the access network is the radio network controller (RNC). It processes the data received from Node B connected to it. Node B and RNC composite structure is known as UMTS terrestrial radio access network (UTRAN).

* The core network consists of a circuit-switched (CS) domain and Packet-switched (PS) domain. The circuit-switched domain is responsible for voice calls, while the packet-switched domain is responsible for carrying the packet data. The packet switched domain takes care of the internet services.

UMTS Applications

* Streaming / Download (Video, Audio)
* Video-conferencing
* Fast Internet / Intranet
* Mobile E-Commerce (M-Commerce)
* Remote Login
* Background class applications
* Multimedia - messaging, E-mail
* FTP Access
* Mobile Entertainment (Games)

Q10. Write a short note on WLL (Wireless Local Loop).

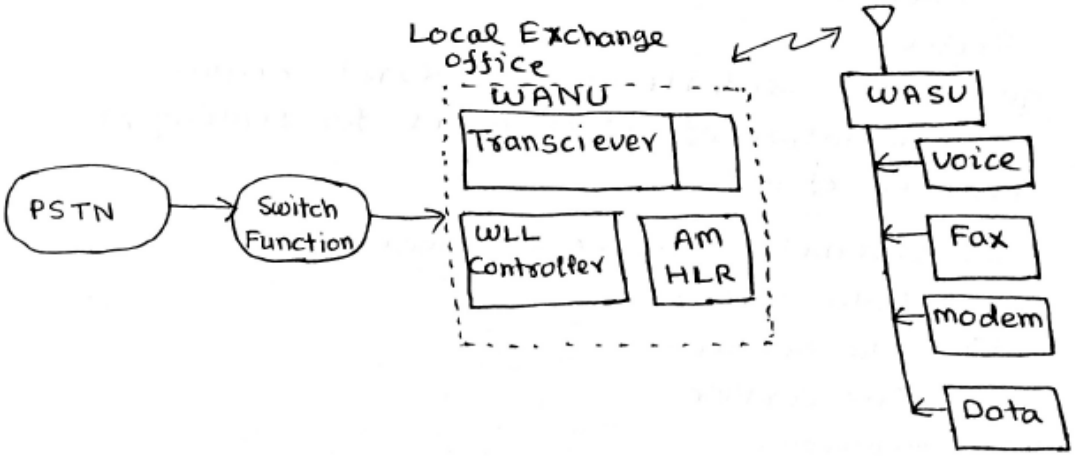
ANS:

Wireless Local Loop (WLL) -

* Local Loop is a circuit line from a subscribers phone to the local central office, but the implementation of local loop of wires is risky for the operators, especially in rural and remote areas due to less number of users and increased cost of installation. Hence, the solution for it is the usage of wireless local loop (WLL) which uses wireless links rather than copper wires to connect subscribers to the local central office.
* The wireless Local Loop (WLL) architecture replaces traditional copper wire with wireless links, connecting subscribers to local central office. It consists of several components, including PSTN, switch function, WANU (wireless Access Network Unit), and WASU (wireless Access Subscriber Unit).

The wireless Local Loop (WLL) architecture replaces traditional copper wire with wireless links, connecting subscribers to local central office. It consists of several components, including PSTN, switch function, WANU (wireless Access Network Unit), and WASU (wireless Access Subscriber Unit).

* The WANU takes care of authentication, operation, routing and data transmission, whare as WASU is installed at the subscriber location.
* with its cost-effectiveness, enhanced security through digital encryption and varicues features like internet access, voice services, data transfer capabilities and fax services, WLL proves to be a dependable solution for telecommunication requirement's specifically in remote or rural areas.



- The PSTN (Public Switched Telephone Network) serves as a circuit-switched network, while switch function manages connections between WANUs.

* The WANU takes care of authentication, operation, routing and data transmission, whare as WASU is installed at the subscriber location.
* with its cost-effectiveness, enhanced security through digital encryption and varicues features like internet access, voice services, data transfer capabilities and fax services, WLL proves to be a dependable solution for telecommunication requirement's specifically in remote or rural areas.

Advantages –

(i) It eliminates the first mile or last mile construction of network connection.

(ii) Low cost due to no use of conventional copper wires.

(iii) Much more secure due to digital encryption techniques.

(iv) Highly scalable as it does not require the installation of more wires for scaling it.

Features of WLL

(i) Internet connection via modem

(ii) Data services

(iii) Voice services

(iv) Fax service

WLL components-

(i) PSTN – (Public switched Telephone network)
It is a collection of world's interconnected circuit switched telephone network).

(ii) Switch Function – switch function switches the PSTN among various WANUs.

(iii) WANU (Wireless Access Network Unit).-
It is present at local exchange office. All Local WASUs are connected to it. Its function includes authentication, operation and maintenance, routing, transceiving voice and data. It consists of following subcomponents

- Transceiver → It transmits / Receives data
- WLL controller → It controls the wireless local loop component with WASU.
- AM (Access Manager) → It is responsible for authentication.

- HLR (Home Location Register) → It stores the details of all local WASUs.

(iv) WASU (Wireless Access Subscriber Unit) →
It is present at the house of the subscriber. It connects the subscriber to WANU.

Q11. Explain Long Term Evolution in wireless communication. [AKTU: 2018-19]
ANS:

Long Term Evolution (LTE) –

* In telecommunications, Long-term Evolution (LTE) is a standard for wireless broadband communication for mobile devices and data terminals, based on GSM/EDGE and UMTS/HSPA standards. It improves on those standard's capacity and speed by using a different radio interface and core network improvements.
* LTE is the upgrade path for carriers with both GSM/UMTS networks CDMA 2000 networks. Because LTE frequencies and bands differ from country to country, only multiband phones can use LTE in all countries where it is supported.

* LTE offers higher peak data transfer rates than 3G, up to 100 mbps downstream and 30 mbps upstream. It provides reduced latency, scalable bandwidth capacity and backward compatibility with the existing GSM and UMTS technology.
* Although LTE is commonly referred to as 4G LTE, but LTE is technically slower than 4G but still faster than normal 3G. While LTE speeds reach 100 mbps, true 4G offers speed upto 1000 mbps. However different versions of LTE meet 4G speeds, such as LTE-Advanced (LTE-A).

* An LTE network employs the multiuser variant of orthogonal Frequency division multiplexing (OFDM) modulation scheme, called orthogonal Frequency division multiple access (OFDMA) for its downlink signal. OFDMA enables the LTE network to transmit data from a base station to multiple users at higher data rates than 3G, with improved spectral efficiency. Single carrier FDMA is used for the Uplink signal, which reduce transmit power required by mobile terminal.

* LTE offers the following features for users —

(i) Audio and Video streaming — LTE has faster download and upload speeds than 2G and 3G.

(ii) Real-time connection to services — with Voice over LTE, users can talk to others without experiencing Lag or jitter.

(iii) Even faster speeds with LTE advanced — Download and upload speeds with LTE-Advanced are two to three times faster than standard LTE. All LTE Advanced devices are back-ward compatible with standard LTE.

(iv) Carrier aggregation — This LTE Advanced feature improved network capacity, adding bandwidth of up to 100 MHz across five component carriers (bands) with 20 MHz each. LTE-A handsets combine frequencies from multiple component carriers to improve signal speed and reliability.

Q12. Write a short note on mobile satellite communication.

ANS:

Mobile Satellite Communication -

* Mobile satellite communication provides two-way voice and data communications to global users who are on the go or in remote location. Typically providers of satellite mobile communications use Geostationary Orbit (GEO), Medium Earth Orbit (MEO) satellites to relay signals up from a handset or terminal and back down to earth station where the signal interfaces with public telephone system or the internet.

* The basic mobile satellite services are -

(i) Maritime mobile satellite service
(ii) Land mobile satellite service
(iii) Aeronautical mobile satellite service
(iv) Personal mobile satellite service
(v) Broadcast mobile satellite service

Maritime mobile satellite service -

This service consists of different types of earth stations such as mobile earth station, Ship earth station and communication earth station. This service is mainly used in shipyards and military ships.

Land mobile satellite service -

The Land mobile satellite service has a mobile earth station located on different types of trains and other transportation systems. This service consists of a personal location terminal that acts as an earth station. This service can be used in different applications such as military applications, remote and rural environments.

Aeronautical Mobile Satellite service — A mobile satellite service in which earth stations are located onboard aircraft, survival aircraft, airplanes and helicopters is known as aeronautical mobile satellite service.

Personal mobile Satellite Service -

This is communication service provided by the satellite for supporting mobile, fixed and broadband communication systems.

Broadcast Mobile Satellite Service -

A broadcast satellite system is a one way communication system that transmits signals by earth stations, and retransmits the signal by space station. It includes -

* Audio broadcasing
* Video broadcasting
* Data broadcasting

BUDDHA SERIES

(Unit Wise Solved Question & Answers)

Course – B. Tech (ECE)

College – Buddha Institute of Technology

(AKTU CODE-525)

Department: Electronics and Communication Engineering

Subject: Wireless & Mobile Communications (KEC076)

Faculty Name: AKC

Unit – 5

Q1. What do you understand by Mobile data network? Explain important features of Ad-Hoc networks. [AKTU 2016-17,17-18,18-19,21-22]

ANS:

Mobile ad hoc Network (MANET) or Wireless ad hoc Network (WANET) -

* A mobile Ad-hoc Network or (MANET) is the most dynamic and animated communication network of today as it uses movable wireless device. A mobile Ad-hoc network is a wireless network without any infrastructure. A MANET has a group of mobile nodes (such as Laptops, smartphones, PDAs or iPads) connected in an auto-configured and self healing wireless network, without any fixed infrastructure.
* The nodes attached to a MANET change rapidly and each of these nodes act as a router by forwarding packets to other nodes in the MANET.
* A wireless or mobile Ad hoc network (WANET or MANET) is a decentralized type of wireless network. The network is ad-hoc because it does not rely on a pre-existing infrastructure, such as routers or wireless access points. In ad-hoc network each node participates in routing by forwarding data for other nodes. The determination of which nodes forward data is made dynamically on the basis of network connectivity and the routing algorithm in use.
* Each device in MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router.

* The primary chalenge in building a MANET is equipping each decice to continuously maintain the information required to properly route traffic. This becomes harder as the scale of MANET increases due to-

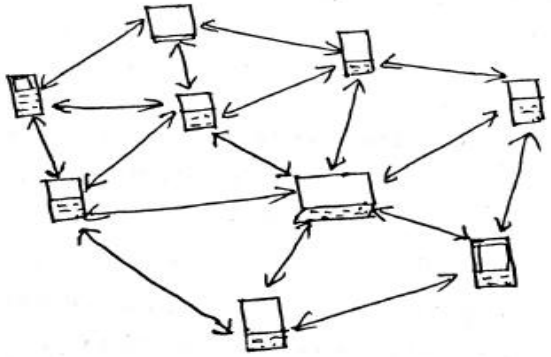
(1) the desire to route packets to/through every other node.

(2) The percentage of overhead traffic needed to maintain real-time routing status.

(3) Each node has its own goodput to route independent and unaware of other needs.

(4) All must share limited communication bandwidth.

* Such networks may operate by themselves or may be connected to the larger internet. They may contain one or multiple and different transceivers between nodes. This results in a highly dynamic, autonomous topology.



Mobile Ad-hoc Network

Example - Example of MANET is Vehicular Ad-hoc Network (VANET) in which communication decices are installed inside vehicles to share data of trafic among the cars. Also wireless sensor networks are another example of MANET.

Features of mobile Ad-hoc Networks-

* Mobile ad-hoc Networks are formed dynamically by an autonomous system of mobile nodes that are connected via wireless links.
* No existing fixed infrastructure or centralized administration and no base station.
* Mobile Nodes are free to move randomly.
* Network topology changes frequently.
* Each nodes work as router.
* Distributed operation and multihop routing.
* Self repairing
* Auto configured
* The devices can join or leave the network any time.

Applications of mobile Ad-hoc Networks-

Military - to maintain a network among all the soldiers, vehicles and headquarters.

Emergency services -

(i) Search and rescue operation in desert and in mountain.

(ii) Replacement of fixed infrastructure in case of environmental disasters.

(iii) Because it is easy to create, it can be used in time of crisis to send emergency signals.

Medical Application – It can be used to monitor patient, supporting doctors and nurses in hospitals

Environmental Applications – It can be used to check weather condition, forest fire, tsunami etc

Personal Area network – It is a short range, local network where each nodes are usually related with a given range.

Chalenges in Mobile Ad-hoc Networks –

(i) Data Interception – on an open network, an attacker can easily intercept the data that you can send and receive, including sensitive information like credit card numbers and passwords.

(ii) Malware Distribution – Attackers can also use open networks as a platform for distributing malware, infecting connected devices.

(iii) Unauthorised Accen – with no security barriers, attackers can accen the devices through the network and can manipulate data and settings.

Q2: Write a short note on 'Bluetooth' **[AKTU 2021-22]**

ANS:

Bluetooth – Bluetooth is a short range wireless technology standard that is used for exchanging data between fixed and mobile devices over short distances and building personal area networks (PANs)

* In the most widely used mode, transmission power is 2.5 milliwatts, giving it a very short range of up to 10 meters. It employs UHF radio waves from 2.402 GHz to 2.48 GHz.

* It is mainly used as an alternative to wire connections, to exchange files between nearby portable devices and connect cell phones and music players with wireless headphones.

* Bluetooth is developed by Bluetooth special interest group Bluetooth was introduced in 1998.

* Bluetooth compatible hardwares are — personal computers, smartphones, Gaming consoles, Audio devices, Embedded devices

* Physical Range — Typically less than 10 m; upto 100 m.
Bluetooth 5.0: 40 — 400 m.

* Bluetooth uses a radio technology called frequency hopping spread spectrum. Bluetooth divides transmitted data into packets, and transmits each packets on one of 79 designated bluetooth channel Each channel has a bandwith of 1 MHz. It usuall performs 1600 hops per second. Bluetooth Low energy uses 2 MHz spacing which accommoda 40 channels.

Q3. Explain Wi-Fi Standard. **[AKTU-2021-22]**

ANS:

Wi-Fi Standard - Wi-Fi stands for wireless Fidelity, and it is developed by IEEE (Institute of Electrical and Electronics Engineers). They set standards for the Wi-Fi system.

Each Wi-Fi network standard has two parameters

1. Speed
2. Frequency

* Wi-Fi uses two bands of frequencies. These are 2.4 GHz and 5 GHz. Wi-Fi routers that come with 2.4 GHz or 5 GHz are called the single band routers. But a lot of new routers supports both 2.4 GHz and 5 GHz frequency they are called dual-band routers.
* The 2.4 GHz transmits data at a slower speed than 5 GHz but have a longer range than 5 GHz

Parameter	2.4 GHz	5 GHz
Speed	Comparatively Low	High
Range	High	Comparatively Low

Different Standards of Wi-Fi —

(i) IEEE 802.11

* It was developed in 1997
* Speed is about 2 mbps

(ii) IEEE 802.11 a -

* This standard is developed in 1999
* It works on 5 GHz frequency
* Its maximum speed is 54 mbps
* This standard was made to avoid interference with other devices which use 2.4 GHz band
* Useful for commercial and industrial purpose.

(iii) IEEE 802.11 b-

* This standard is also developed in 1999.
* The difference is that it uses a 2.4 GHz frequency band.
* Its maximum speed is 11 mbps.
* Useful for home and domestic use.

(IV) IEEE 802.11 g-

* This standard is developed in 2003.
* Basically, it has combined the properties of both 802.11 a and 802.11 b
* The frequency band used in this is 2.4 GHz for better coverage.
* Its maximum speed is 54 mbps.

(V) IEEE 802.11 n-

* This standard is developed in 2009.
* operates on both 2.4 and 5 GHz frequency band
* Data transfer rate is around 600 mbps.

(VI) IEEE 802.11 ac –

* Introduced in 2013
* Works on 5 GHz band
* Maximum speed is 1.3 Gbps
* It gives less range but presently most of the devices are working on 802.11n and 802.11 ac standards.

(VII) IEEE 802.11 ax–

* It is introduced in 2019.
* Operates on both 2.4 GHz and 5 GHz, for better coverage as well as better speed.
* Maximum speed is 10 Gbps.

New Naming scheme for wi-Fi standards–

Network	wi-Fi standard
IEEE 802.11 b	wi-Fi 1
IEEE 802.11 a	wi-Fi 2
IEEE 802.11 g	wi-Fi 3
IEEE 802.11 n	wi-Fi 4
IEEE 802.11 ac	wi-Fi 5
IEEE 802.11 ax	wi-Fi 6

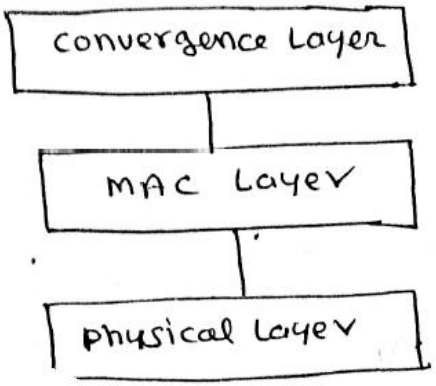
Q4: Explain WiMax Standard. **[AKTU 2021-22]**

WiMAX Standards –

* Wimax stands for "worldwide Interoperability for microwave access". It is based on IEEE 802.16 standard.
* IEEE 802.16 is IEEE standard for wireless Metropolitan Area Network (wireless MAN).
* It specifies the air interface for fixed, portable and mobile broadband wireless access (BWA) systems supporting multimedia service.

* Range of WiMAX is upto 50 Km. Its maximum data transmission rate is 70 mbps.
* The various IEEE 802.16 standards related to WiMAX are given in following table

Parameter	802.16	802.16 a	802.16 e
Spectrum	10 – 66 GHz	2 – 11 GHz	< 6 GHz
configuration	Line of Sight	Non Line of Sight	Non Line of sight
Bit Rate	32 to 134 mbps	≤ 70 or 100 mbps	Upto 15 mbps
Mobility	Fixed	Fixed	≤ 75 MPH
modulation	QPSK, 16-QAM 64-QAM	256 Sub-carrier OFDM using QPSK, 16-QAM 64-QAM, 256-QAM	same as 802.16 a
Channel	20, 25, 28 MHz	Selectable 1.25 to 20 MHz	5 MHz (Planned
Cell Radius	1-3 miles	3-5 miles	1-3 miles
Introduced	Dec, 2001,	Jan, 2003	2nd half of 2005



* Physical Layer specifies frequency band, synchronization between transmitter and receiver data rate and multiplexing scheme.
* MAC Layer provides interface between convergence layer and physical layer. It provides point-to-multipoint communication and is based on CSMA/CA.
* This layer provides the information of the external network.

Q5. Write the difference between WiFi and WiMax.

Difference between 802.16 (WiMAX) and 802.11 (Wi-Fi)

802.16 (WiMAX)	802.11 (Wi-Fi)
1. It is designed for long distance / wide area	It is designed for short distance / limited area
2. Coverage range is 7 km to 50 km	Coverage range is 30 m to 100 m.
3. Used for outdoor usage	It is used for indoor usage.
4. It operates on frequency 2.4 GHz, 5 GHz	It operates on frequencies of 2.5 GHz, 3.5 GHz and 5.8 GHz
5. It provides a data rate of 100 Mbps in a 20 MHz channel	It provides a rate of 54 mbps in 20 MHz channel.
6. Large number of customers are connected to this	Limited number of customers are connected to this.

7. Bandwidths varies dynamically as per user requirement from 1.5 MHz to 28 MHz.	Bandwidth variants are 20 MHz, 40 MHz, 80 MHz and 160 MHz.

Q6. Write a short note on Li-Fi communication. [AKTU 2021-22]

Li-Fi Communication -

* Li-Fi (Light-Fidelity) is a wireless communication technology which utilizes light to transmit data between decices. Li-Fi is a light communication system that is capable of transmitting data at high speeds over the visible light, ultraviolet and infrared spectrum.
* Light Fidelity is modern wireless communication technology that enables remote transmission of data using LED Light. This means that light bulbs can bring not only light but wireless connection at same time anywhere where LED's are used.

Generally speaking, Wi-Fi plays an efficient role in wireless data coverage within breildings, while using Li-Fi we can procide excellent density data coverage in particular location without any radio interference issues.

* Li-Fi procides better latency, performance, accessibility and security than wi-Fi and under Laboratory conditions has reached extreme speeds greater than 1 Gbps.
* Li-Fi technology is mainly focussed on use of visible light between violet (800 THz) and

red (400 THz). Li-Fi is based on propagation of information in defined and uniform fashion via amplitude modulation of light supply. There is LED transmitter (Light emitting) on one end and photo detector (Light sensor) on other. Li-Fi operates very simple and fast.

* The data input to LED transmitter is encoded into light by varying the flickering rate at which binary code (1s and 0s) is generated by LED's flicker 'on' and 'OFF'. LED transmitter ON/off operation is invisible to human eye as speed of LEDs is less than microsecond. For binary 1, LED is switched 'ON' and for binary 0, LED is switched 'OFF'.

Advantages-
(i) High data speed
(ii) High security
(iii) Low power consuption
(iv) RF spectrum saving
(v) Less harmful to human
(vi) Easy to install

Disadvantages-
(i) Internet can be used only when Light source is available
(ii) Short range
(iii) Interference from sunlight
(iv) Higher initial cost.

Applications-
(i) Li-Fi live streaming
(ii) Home and building automation
(iii) Underwater communication
(iv) In Aviation
(v) In Hospital
(vi) Industrial automation
(vii) Advertising

Q7. Write a short note on Ultra Wideband Communication.

Ans:

Ultra-wideband (UWB) communication-

Ultra-wideband communication is wireless communicatio that uses the ultra-wideband frequency bandwidth. Its main feature is that it enables high-precision positioning. UWB wireless communication has spread to consumer equipment in recent years. For example, UWB communication is being equipped to smart-phones to prevent loss and for other purpose and is being equipped to... smart-keys of luxury cars. It is expected that UWB wireless communication will spread to many fields in the future. The main features of UWB communication are-

* High-precision ranging and positioning
* High security
* Low interference with other communications
* Low power consumption.

* In UWB wireless communication, pulses with a duration of 2 ns (nanoseconds: 10^{-9} seconds) are sent as data. These short duration pulses have the property of high resolution with respect to ranging and positioning.
* on the other hand, a small pulse duration in time domain means that the power spectrum in frequency domain occupies a wideband.

Applications of UWB communication-

(1) Real time location
(2) Automation and robotics
(3) Worker safety and proximity sensing
(4) Asset tracking and management.

(5) Secure building and room entry and exit –

* It is possible to build a hands free and secure building and room entry and exit system by using smart phones and other devices equipped with UWB modules

(6) Hands-free Payment and Fee-Billing –

(7) Radar

(8) Smart keys

(9) making in-vehicle Networks wireless –

Advantages of UWB communication –

(1) Ability to provide precise location data, even in crowded environments. This makes it ideal for applications such as assets tracking and indoor positioning.

(2) Low power consumption. It can provide accurate tracking while conserving battery life.

(3) High data transfer rate. This property provides fast and reliable communication.

Disadvantages –

(1) Limited range compared to other wireless technologies.

Q8. Write a short note on 4G mobile communication system.

[AKTU 2017-18, 18-19, 21-22]

Introduction to 4G wireless mobile communication

* The 4G wireless cellular standard was defined by the International Telecommunication Union (ITU) and specifies the key characteristics of the standard, including transmission technology and data speeds.

* Every generation of wireless cellular technology has introd... increased bandwidth speeds and network capacity. 4G users get speed of up to 100 mbps while 3G only promised a peak speed of 14 mbps.

* The transmission and receiving capabilities of 4G are powered by MIMO (multiple input multiple output) and Orthogonal Frequency Division Multiplexing (OFDM) technologies. Both MIMO and OFDM enable more capacity and bandwidth in comparision to 3G.
* OFDM provides more speed than the 3G technology which include TDMA and CDMA. With MIMO, 4G reduces network congestion in comparision to 3G, because more users can be supported.

* 4G is an all IP (Internet Protocol) based standard for both voice and data, different from 3G which uses IP for data, while enabling voice with a circuit switched network. As an all IP network, 4G is more efficient for mobile network providers to operate and optimize than managing different network technologies for voice and data.
* The features of 4G are-
  (i) Supports much higher data rate upto 1 Gbps.
  (ii) Enhanced security and mobility.
  (iii) Supports High-definition video streaming and gaming.
  (iv) Uses IP Packets for voice.
  (v) Easy acess to internet, social networks, streaming media, video calling.
  (vi) Higher bandwidth.

Q9. Write a short note on 5G mobile communication system. [AKTU 2021-22]

Introduction to 5-G Mobile Communication-

5G is the fifth generation of wireless cellular technology, offering higher upload and download speeds, more consistent connections, and improved capacity than previous networks. 5G is much faster and more reliable than 4G networks and has the potential to transform the way we use the internet to accen

transform the way we use the internet to accen applications, social networks, and information. For example like self-driving cars, advanced gaming applications and streaming media that require very reliable, high-speed data connections are set to benefit greatly from 5 G connectivity. With the high speed, large capacity and low latency, 5 G could help to support several applications like cloud-connected traffic control, drown delivery, video chatting, and console-quality gaming on the go. From global payments and emergency response to distance education and mobile workforce, the benefits and applications of 5 G are limitless.

* Important features of 5 G wirelen communication system are—
  (i) Supports ultra fast mobile internet upto 10 Gbps.
  (ii) Low Latency in milliseconds.
  (iii) Total cost reduction for data.
  (iv) Higher security and reliable networks.
  (v) Uses technologies like small cells and beamforming to improve efficiency.
  (vi) Cloud based infrastructure offers power efficiency, easy maintenance and upgradation of hardware.
  (vii) Higher bandwidth.
  (viii) On demand network capacity can be increased.

* 5 G technology uses OFDM that encodes high-band radio waves incompatible with 4 G and offers lower latency and improved flexibility compared with LTE networks.

* 5G technology uses smaller transmitters placed on buildings and other infrastructures. The ability to run the network from small cell sites will support many devices at superior speeds.
* Many network operators use 5-G technology to deploy multible independent virtual networks over the same infrastructure.

Q10. Discuss the Next Generation Network (NGN) systems for mobile communication.

[AKTU 2016-17,17-18,18-19]

Next Generation Network (NGN) –

* Next Generation Network (NGN) refers to a packet-based network and it can be used for both telecommunication services as well as data and it supports mobility.
* It is able to use multible broadband capabilities, especially Quality of services (QoS) enabled transport technologies where the service related functions are independent of the underlaying transport-related technologies.
* The main goal of Next generation Network (NGN) is to serve/work as an replacement of Public Switched Telephone Network (PSTN) and Integrated Service Digital Network (ISDN).
* Nowdays there exist different networks for different purpose like voice, data, video, audio etc. The telephone, Internet, and cellular networks refer to different domains and each has its own

protocol and services. The idea behind the Next Generation Network (NGN) is that one network which transports all types of data and provides services in the form of packets similar to those which is used on Internet. commonly NGNs are built around Internet Protocol (IP). That's why sometimes NGN is called as an all-IP network to describe the transformation towards Next Generation Network.

Features of NGN

* Packet based transfer
* Decoupling of service and network, and provision of open interface (I/F)
* A wide range of services like (Real time/ streaming / Non Real time / multimedia)
* Support of Generalized mobility.
* Support to unrestricted access by users to different service providers.
* Seperation of control functions for bearer capabilities, call/session-service.

Services supported to NGN

* Data communication services
* Multimedia services
* Public interest services
* Public switched Telephone Network (PSTN)/ Integrated services Digital Network (ISDN) simulation services.

Advantages of NGNs -

1. Advanced services such as high speed internet access, voice, and video calling and multimedia applications.
2. cost effective
3. NGNs are highly scalable and can easily accomodate a growing number of users and devices without significant changes to the network infrastructure.
4. NGNs are highly flexible and can be easily adapted to support new services and applications.
5. NGNs enable global reach and provide connectivity across different geographic locations.

Disadvantages of NGNs

1. NGNs are vulnerable to security threats such as hacking, malware and viruses.
2. Dependence on technology.
3. complexity
4. Regulatory chalenges
5. Compatibility issues.