Unit-1 (PART-I)

* Limitations of conventional mobile Telephone systems

-> Conventional mobile telephone systems also known as 2G, 3G, 4G systems, have several limitations

-> capacity Limitations
- Limited voice capacity
- Limited data capacity

-> performance Limitations
- -> poor voice quality
- -> slow data speeds
- -> Dropped calls

-> Economic Limitations
- High operational costs
- High infrastructure costs.

-> Technical Limitations
- -> data speed Limitations
- -> coverage issues.
- -> Interference
- -> security concerns.

* Basic cellular mobile system:

-> A basic cellular mobile system is made up of three main subsystems, they are
- mobile unit
- cell site
- MTSO

- **Mobile unit** : contains a control unit, transceiver, and antennia system.

- **cell site** : provides the interface btwn the mobile unit and mobile telephone switching office (MTSO).
  - -> It includes control unit, antennas, power plant etc.

- **MTSO** :
  - -> Mobile Telephone switching office
  - -> This is central coordinate element for all cell sites.
  - -> It includes cellular processor, switch, etc.

- **connections** : The radio and high speed data links connects the three subsystems.

- **Basic cellular system**

-> The MTSO is the heart of the analog cellular mobile system.
- -> It processor provides central coordination and cellular administration.
- -> The cellular switch be either analog (or) digital.
- -> It also contains data links.

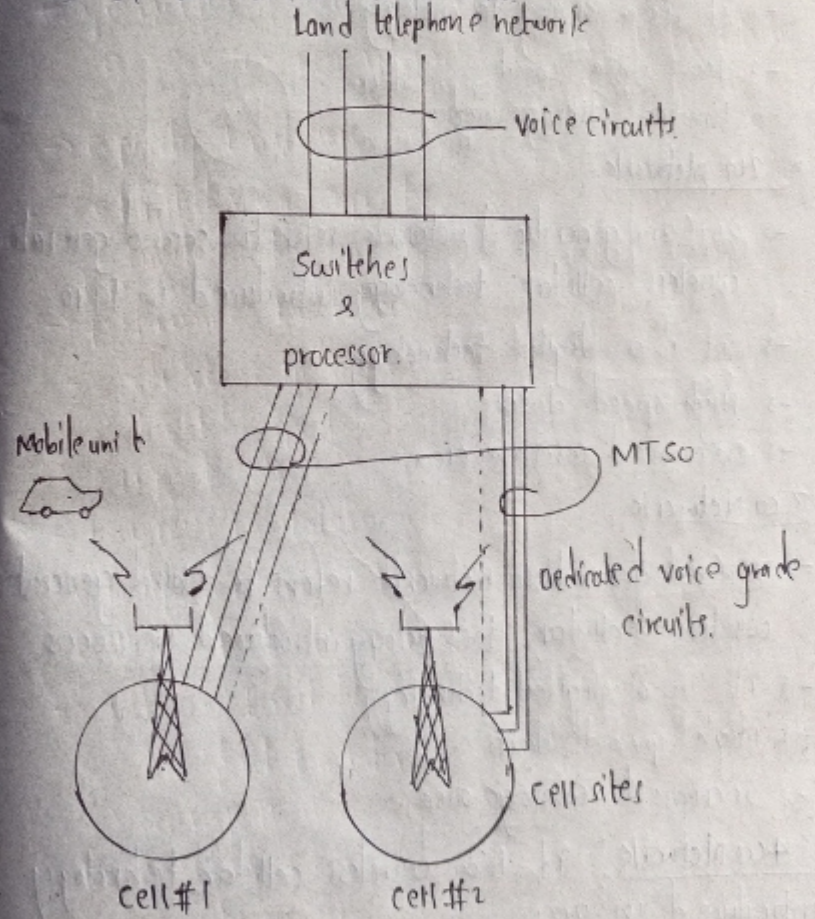


Fig: Basic cellular system.

-> (1G, 2G, 3G and 4G Networks)

o 1G Network

-> 1G (first generation) network refers to first generation wireless cellular technology, introduced in 1980s

-> It is a analog technology

-> Low data speed

-> Limited coverage area

o 2G Network

-> 2G (2nd generation) network refers to second generation wireless cellular technology, introduced in 1990s

-> It is a digital technology

-> High speed data

-> Increased coverage area

3. G Network

-> 3G (3rd generation) network refers to third generation wireless cellular technology, introduced in 2000s

-> It is a digital technology

-> High speed data

-> Increased coverage area

4. 4G Network: It is a wireless cellular technology introduced in 2000s.

-> High speed data

-> Digital technology.

-> Increased capacity

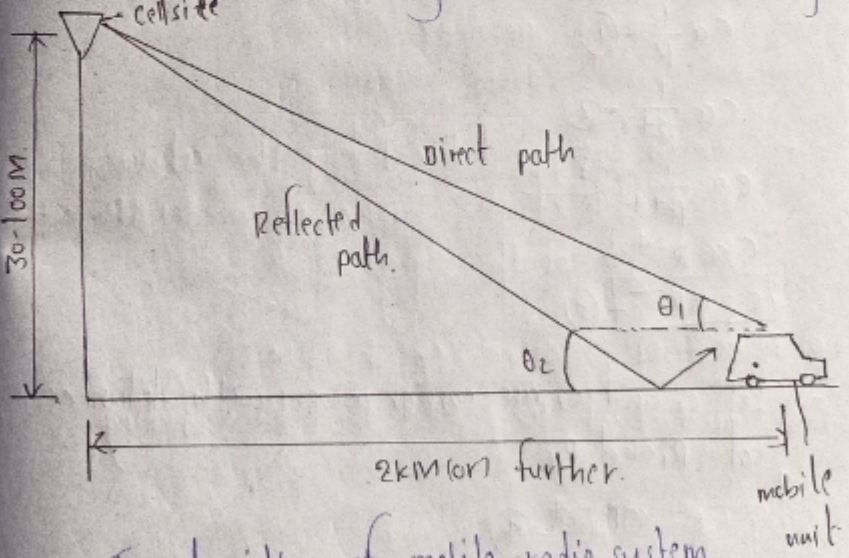
* The uniqueness of mobile Radio Environment

-> The uniqueness of mobile radio environment can be classified as.

- o Description of mobile radio system
- o model of a transmission medium
- o Mobile fading characteristics

o Description of mobile Radio system:

-> The mobile Radio system shown in below fig.

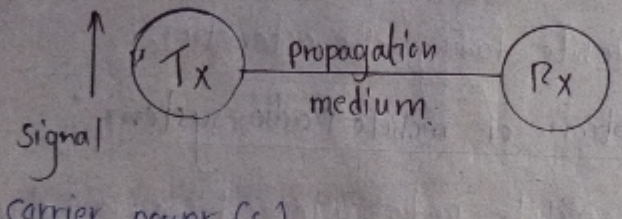


-> The description of mobile radio system consist of

- o propagation attenuation
- o Fading.

○ propagation Attenuation

Def prog propagation attenuation refers to the loss of signal power (or) intensity as it travels through a medium such as air, water, etc.



carrier power (c)

$C \propto \frac{1}{R}$ -(1)

$C \propto \frac{1}{R^{+\gamma}}$ -(2)

$\gamma = 4$

$C \propto \frac{1}{R^{+4}}$

$C \propto R^{-4}$

$\boxed{C = \propto R^{-4}}$ -(3)

→ let C_1 and C_2 are carrier powers with distances of R_1 and R_2

$C_1 = \propto R_1^{-4}$ -(4)

$C_2 = \propto R_2^{-4}$ -(5)

$\frac{C_2}{C_1} = \left[\frac{R_2}{R_1}\right]^{-4}$ -(6)

The difference b/w two carrier powers is

$\Delta C = C_2 - C_1$

ΔC is in terms of dB

$\Delta c(dB) = 10\log\frac{C_2}{C_1}$

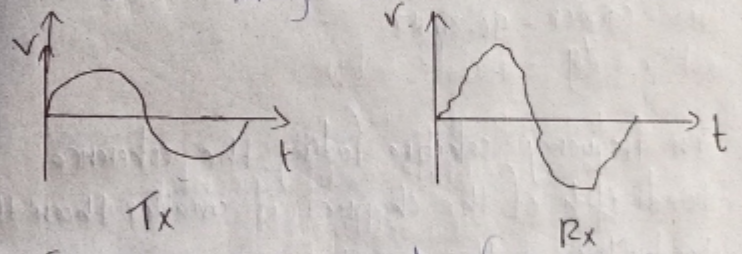
$= 10\log\left[\frac{R_2}{R_1}\right]^{-4}$

$= -40\log\left[\frac{R_2}{R_1}\right]$

$\Delta c(dB) = 40\log\left[\frac{R_2}{R_1}\right]$ -(7)

○ Fading

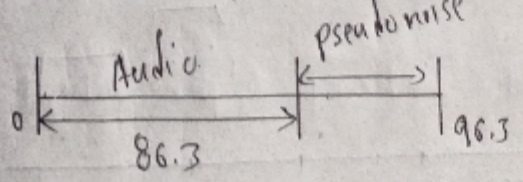
: If any changes occur in the signal parameters then we can say fading occurs.



Def: Fading is the random fluctuations in signal strength, phase, (or) magnitude due to various factors. is called fading

→ Types ○ Flat Fading
○ Frequency selective fading.

○ Flat Fading :

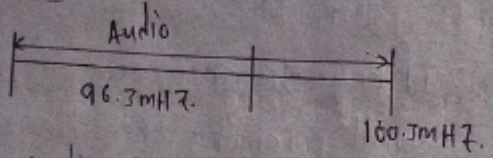


Audio - 86.3 MHZ

Carrier s/g - 96.3mHZ

-> In flat fading, the coherence bandwidth of the channel is larger than the bandwidth of the signal.

o Frequency selective fading.



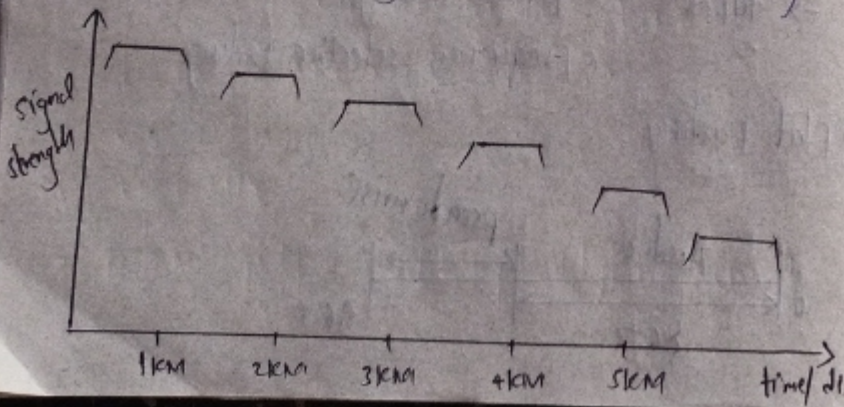
Audio - 100.3 mHZ.

Carrier - 96.3mHZ.
s/g

-> In frequency selective fading, the coherence bandwidth of the channel is smaller than the bandwidth of the signal.

o Model of Transmission medium

-> product of long and short term fading.



$r(t) = m(t) \cdot r_0(t)$

m(t): long term fading

r(t): short " "

⑧ Mobile fading characteristics

- The radius of active scatter region
- standing wave expressed in normal & log scale
- Delay spread and coherence bandwidth.
- Noise level in cellular system
- Direct path, obstractive path.

* operatin of cellular systems

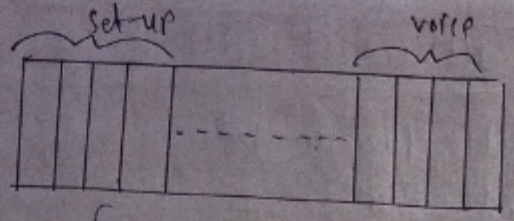
Cellular systems operate by dividing geographic areas into smaller cells, each served by base-station. That communicate with mobile devices.

1. Mobile unit initialization :

-> switch on mobile unit.

-> scan the signal from nearest base station

-> ||| - signal strength bar -> set up.



-> It consist of two channels 1. set-up channel
2. voice channel

② mobile unit originate a call

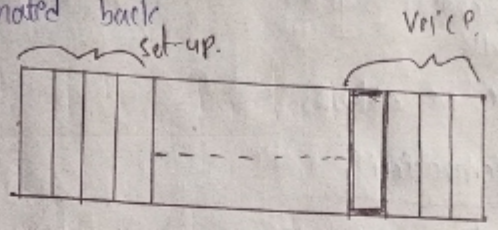
-> Dial a number
-> (Tx) M.S -> B.S -> MSC/MTSO -> B.S -> M.S (Rx)
-> voice channel
-> voice Tx.
-> where M.S = mobile station
B.S = Base "
M.S.C = Mobile switching center
Tx = Transmitting
Rx = Receiving

③ Landline phone originate a call:

-> Dial a number at landline phone
-> PSTN -> MSC/MTSO -> B.S -> M.S
-> voice channel.
-> voice Tx
-> PSTN - public switching Telephone Network

④ call Termination

-> once the call is terminated, it should be terminated back

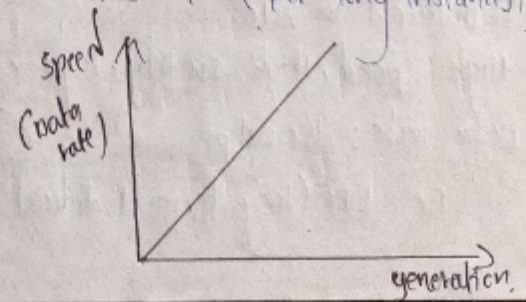


X Evolution of cellular systems:

-> The Evolution of cellular systems has transformed mobile communication, from analog voice-only services to high-speed digital data networks.
-> The evolution of cellular systems depends on
- Generation
- Speed (Data rate)

-> In 1880 -> wired telephone
1920 -> wireless - AM (More noise)
1945 -> wireless - FM (For long distances)

-> For internet
-> 1G
-> 2G
-> 3G
-> 4G
-> 5G



-> 1G (1st generation)

-> Introduced in between 1970 to 1980.
-> Analog radial signal
-> Voice calls
-> Data rate i.e 24kbps

-> second generation

-> Introduced in 1990.
-> voice and data signals
-> security and privacy
-> Roaming.
-> SMS, conference calls
-> Data rate : 144kbps

-> Third generation

-> Introduced in 2001.
-> Increase data transmission at low cost
-> More security
-> video calls, conference calls
-> Data rate : 14mbps

-> Fourth generation

-> Introduced in 2010.
-> High speed, High quality, high capacity to users
-> Data rate : 100mbps

Ex: LTE (long term Evolution)

-> Fifth generation

-> Introduced in 2021.
-> Main benefit is increased connectivity. Fast speed. more quality etc.
-> Data rate i.e 10Gbps - 10000Gbps.

Unit-I (PART-I)

* concept of frequency reuse

o Frequency Re-use Frequency re-use a technique used in cellular systems to increase capacity and efficiency by re-using frequencies. is called frequency Re-use.

o Frequency re-use pattern :

Frequency reuse patterns are configurations in cellular networks where the same set of radio frequencies is reused across different cells.

-> uses
- o optimize spectrum utilization
- o efficient use of frequency.
- o minimizes interference.

-> By using equation of frequency reuse pattern we can measure the following.

-> The distance between core channel cells.

$D = \sqrt{3k} \cdot R$

$D = \sqrt{3(i^2+j^2+ij)} \cdot R$

{ k = cluster size
$k = i^2+j^2+ij$

-> The No. of cells in a cluster.

○ Frequency reuse ratio

-> Frequency reuse ration is used for core channel interference region.

$$q = \frac{D}{R}$$

$$= \frac{\sqrt{3k} \cdot R}{R}$$

$$\boxed{q = \sqrt{3k}}$$

(P) Design a cell layout for $i=2, j=2$

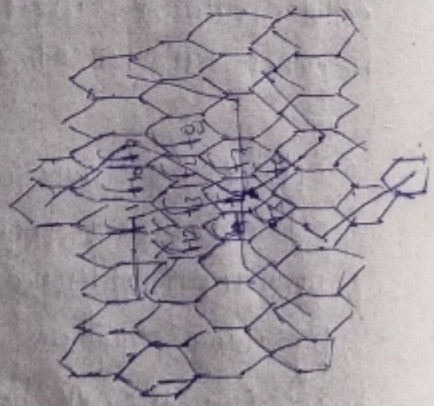
Sol $i=2,\ j=2$

$k = i^2+j^2+ij$

$= (2)^2+(2)^2+[2][2]$

$= 4+4+4$

$\boxed{k = 12}$



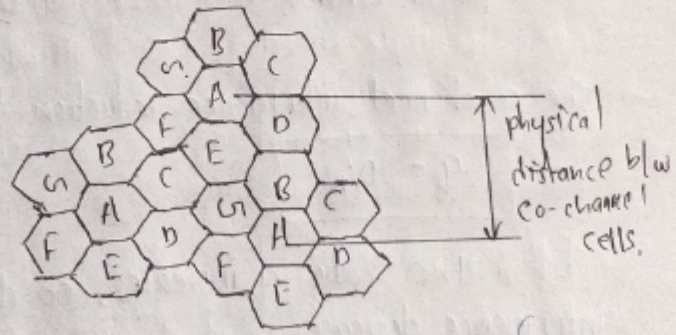
✗ Co-channel Interference

Def; co-channel Interference occurs when two (or) more cellular systems use the same frequency channel, causing interference with each other is called CCI.

-> In co-channel interference, the systems are clustred close together.

-> The reasons behind CCI;-

- ○ Bad weather condition
- ○ poor frequency
- ○ Design issues



-> we can reduce co-channel interference in cellular-communication.

- ○ proper planning & implementation.
- ○ The frequency reuse technique.

* co-channel interference reduction Factor

-> The co-channel interference reduction factor q, is a parameter that decreases co-channel interference as it value increases.

-> It is the ratio of signal power to the interference power.

$$CIRF = \frac{\text{Signal power}}{\text{Interference power.}}$$

- units = Decibles (dB)

-> ways to reduce co-channel interference
  - Sectoring
  - cell splitting
  - power control

-> The co-channel interference reduction factor

$$\boxed{q = D/R}$$

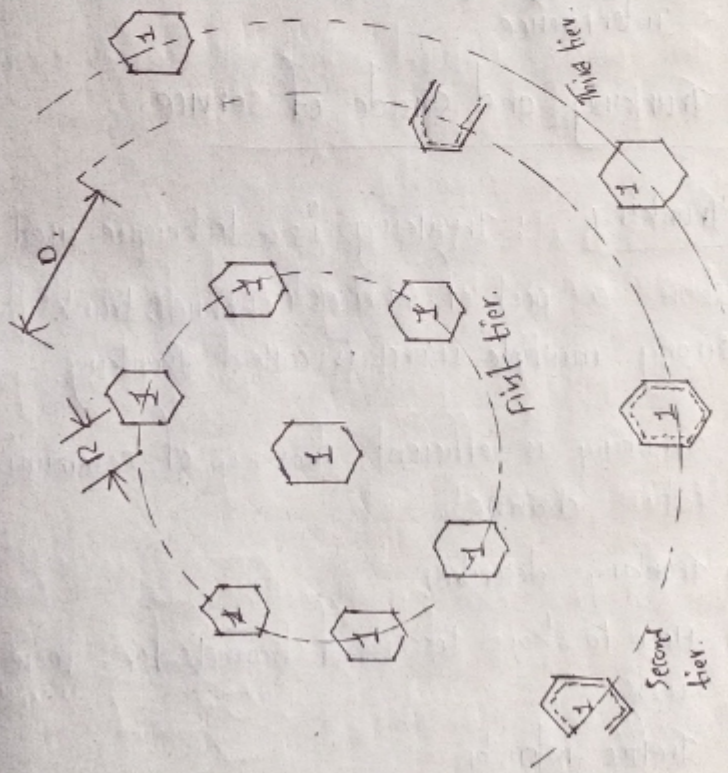
when the ratio q increases, co-channel interference decreases.

->
$$\boxed{D = f\left(\frac{K, C}{I}\right)}$$

$$\frac{C}{I} = \frac{C}{\sum_{k=1}^{k=I} I_k}$$

$$\frac{C}{I} = \frac{1}{\sum_{k=1}^{k=I} \left(\frac{D_k}{R}\right)^{-\gamma}} = \frac{1}{\sum_{k=1}^{k=I} (q_k)^{-\gamma}}$$

$$\boxed{q_k = \frac{D_k}{R}}$$



* System capacity

System capacity refers to the maximum no of users that a cellular system can support while maintaining a quality of service is called system capacity.

-> Factors effecting system capacity
- o No. of cells
- o Cell shape.
- o Frequency reuse.
- o Interference.

* Trunking and Grade of service

o **Trunking** : Trunking is a technique used to share a pool of services (channels, trunks) among multiple users is called Trunking.

-> Trunking is efficient sharing of communication channels.

-> Trunking describes
- o How to share less no. of channels for more users
- o Traffic intensity

-> Trunking is depends upon traffic intensity

Advantages

-> optimize resources
-> maximize channel usage

o Grade of service (GOS)

-> GOS measures the quality of telecommunications services, focusing on availability, reliability, and capacity is called GOS.

-> GOS is calculated by using Erlang-B formula.

-> GOS is a important metric.

-> GOS is expressed as decimal.

-> GOS can be measured for incoming (or) outgoing calls

-> GOS metrics
- o GOS = 1 - (pb)
- o Erlang-B formula
- o Erlang-C formula

-> Types of GOS
- o Network GOS
- o cell GOS
- o User GOS

-> Factors affecting Cros
- Cell size
- Antenna characteristics
- power control

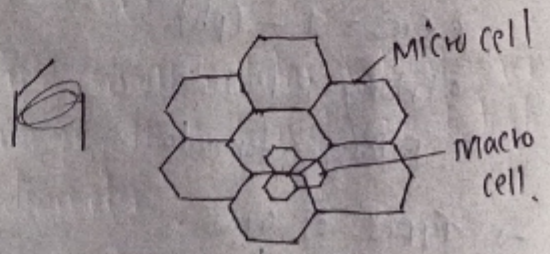
Improving capacity of a cellular systems

* Cell splitting

Cell splitting is a technique used in cellular networks to increase capacity and coverage by dividing a cell into smaller cells is called cell splitting.

-> This process is used when cell becomes congested
-> Benefits of cell splitting
- Increases capacity
- No. of channels increases
- Reduces antenna height and transmitting power.

-> cell splitting expands the capacity of the system



-> cell splitting technique utilizes omnidirectional Antenna

-> cell splitting is of two types
- permanent cell splitting.
- Dynamic cell splitting

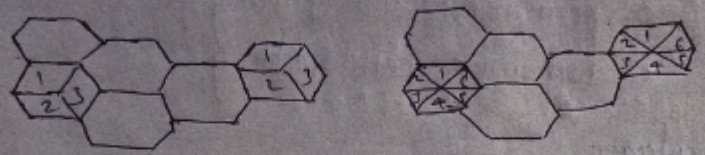
Advantages

-> Increases the capacity of the channel
-> " " frequency reuse factor.
-> " " signal-to Noise-ratio.
-> Reduces interference

* cell sectoring

-> cell sectoring is a technique used in cellular systems to increase capacity and coverage by dividing a cell into sectors is called cell sectoring.
-> This process is used when cell becomes congested
-> Benefits of cell sectoring
- Increases capacity.
- less expensive
- Interference reduces

-> cell sectoring expands the capacity of the system.



-> cell sectoring technique utilizes directional Antennas

-> cell sectors is of two types.

i 120° sector.

ii 60° sector.

Advantages

-> Increases the channel capacity.

-> " " frequency reuse factor.

-> Assigning a channel is easier.

* Microcell Zone concept

Microcell zone is a small cellular network coverage area, typically ranging from 100meters to 1 kilometer in diameter.

(or)

The microcell zone concept is a cellular network technique that improves coverage and capacity by dividing cells into smaller zones is called microcell zone concept.

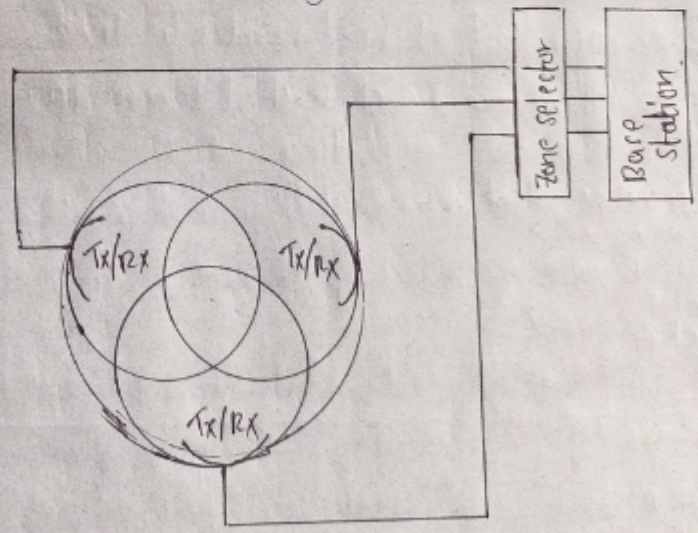
-> Benefits

- Reduces interference.
- " handoff load.

-> It improves signal quality and network capacity.

-> It connects three (or) more zone sites to a single base station.

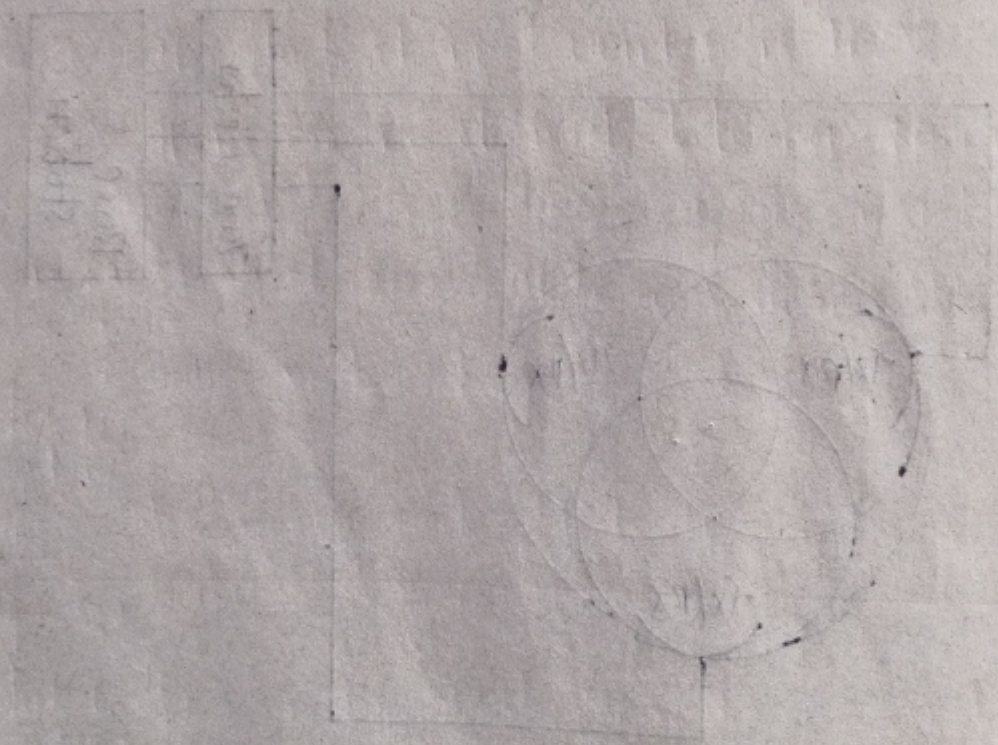
-> Superior to cell sectoring.



-> It requires more Antennas.

-> Small cell size
High capacity
low power transmission
Low interference

-> It is used in urban and Rural areas.



Unit - II (PART - II)

* Space diversity Antennas

-> space diversity antennas are used in cellular and mobile communication to improve the quality and reliability of wireless links.

-> space diversity uses multiple antennas that are separated by some distance to create different propagation paths for the signal.

-> space diversity can increase the signal-to noise ration and Bit error rate of the system.

-> space diversity antennas requires more space, hardware, power consumption than a single antenna system.

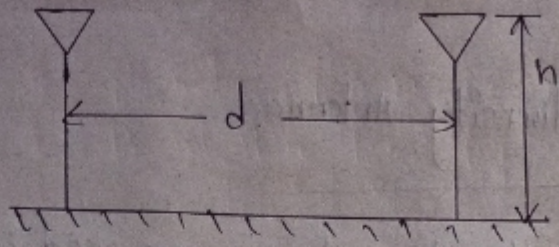
-> Equation $n = h/D = 11$

where, h = antenna height

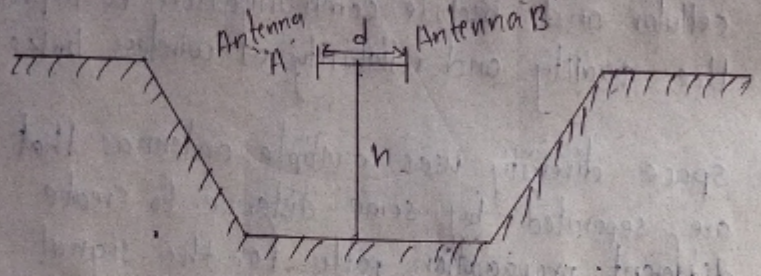
D = separation.

$d \geq 8\lambda$ need for 100ft antenna.

$d \geq 14\lambda$ need for 150 ft antenna.



(a)



(b)

-> Fig a is $n = h/d$

-> Fig b is proper arrangement with two antennas.

* Umbrella pattern Antennas

-> An umbrella pattern antenna is a type of monopole antenna with a top disk that controls energy in a confined area.

-> umbrella pattern antennas should be used for the cell site antennas.

-> umbrella antennas are used as transmitting antennas in the LF, MF, VLF bands.

-> An umbrella pattern antenna is a type of wire monopole antenna.

-> Above figure shows vertical-plane patterns of quarter-wavelength stub antenna on infinite ground plane and finite ground plane.

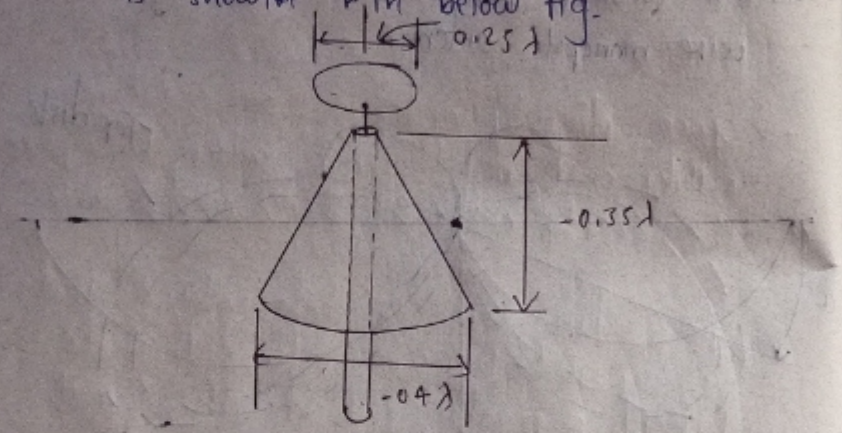
1. Normal umbrella pattern Antenna

-> For controlling the energy in a confined area.

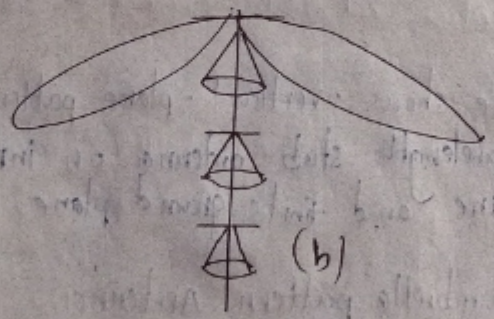
-> The umbrella pattern antenna can be developed by using a monopole with a top disk.

2. Broadband umbrella-pattern Antenna

-> The parameters of a Discone antenna is shown in below fig.



(a)



(b)

-> Fig (a) show single antenna.

-> Fig (b) shows array of antennas.

3. Interference Reduction Antenna

-> A design for a antenna configuration that reduces interference in two critical directions.

4. High gain broadband umbrella-pattern Antenna

-> A high gain Antenna can be constructed by vertically stacking a no. of umbrella pattern antennas.

$$E_o = \frac{\sin[(Nd/2\lambda)\cos\phi]}{\sin[(d/2\lambda)\cos\phi]} \cdot (\text{Individual umbrella pattern})$$

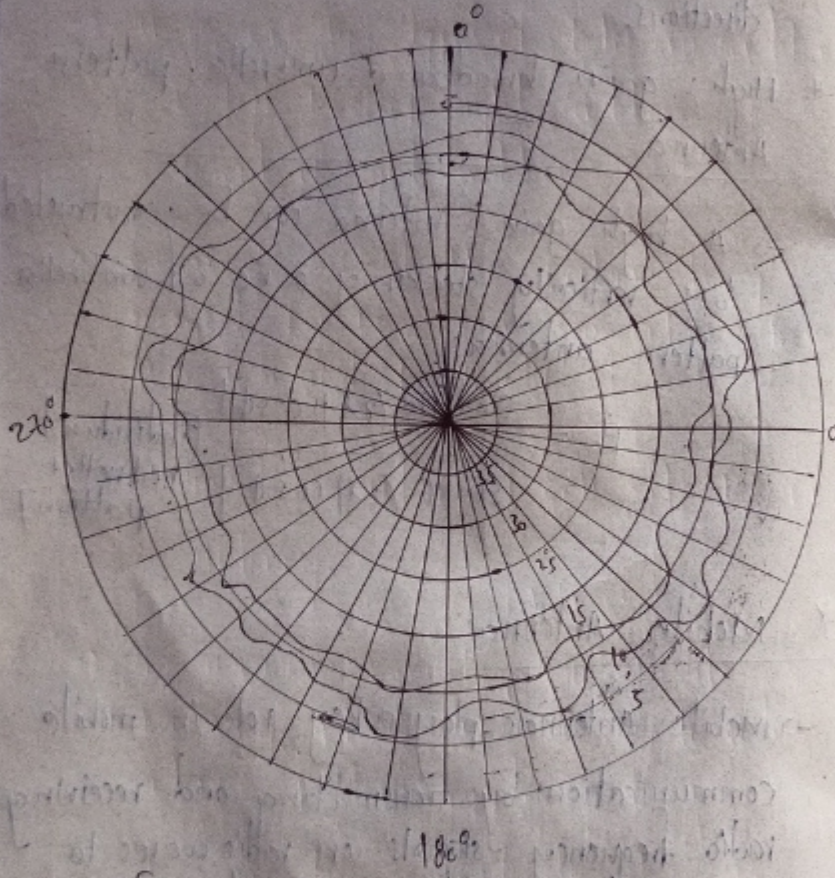
* Mobile Antennas

-> Mobile Antennas play a key role in mobile communication by transmitting and receiving radio frequency signals or radio waves to nearby mobile phones is called mobile Antennas.

-> The requirement of mobile Antenna is a omnidirectional Antenna

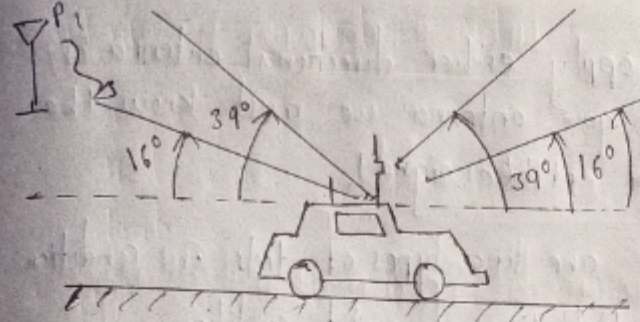
-> mobile antenna is of two patterns

-> generally, the antenna should atleast clear the top of the vehicle.



1. Roof Mounted Antenna

-> The antenna pattern of a roof-mounted antenna is less (or) more uniformly distributed around the mobile unit.



-> vertical angle of signal arrival.

-> The 3-dB high-gain antenna shows a 3-dB ~~because the cell-site~~ gain over quarter-wave antenna.

2. Glass-Mounted Antenna

-> There are many kinds of mobile ~~ante~~ glass-mounted antennas.

-> Energy is coupled through the glass.

-> The antenna gain range is 1 to 3 dB. depending on the operating frequency.

-> The position of glass-mounted antenna is lower than that of the roof-mounted antenna.

3. Mobile high gain Antennas:

-> In the directional antenna, the pattern is supressed horizontally, in the gain antenna the pattern is supressed vertically.

-> To apply either directional antenna (or) high gain antenna we must know the origin of the signal.

-> There are two types of tests (or) conditions.
- high line-of-sight condition
- out-of sight condition

-> we may calculate the portion being received by the high gain antenna from the measured bandwidth.

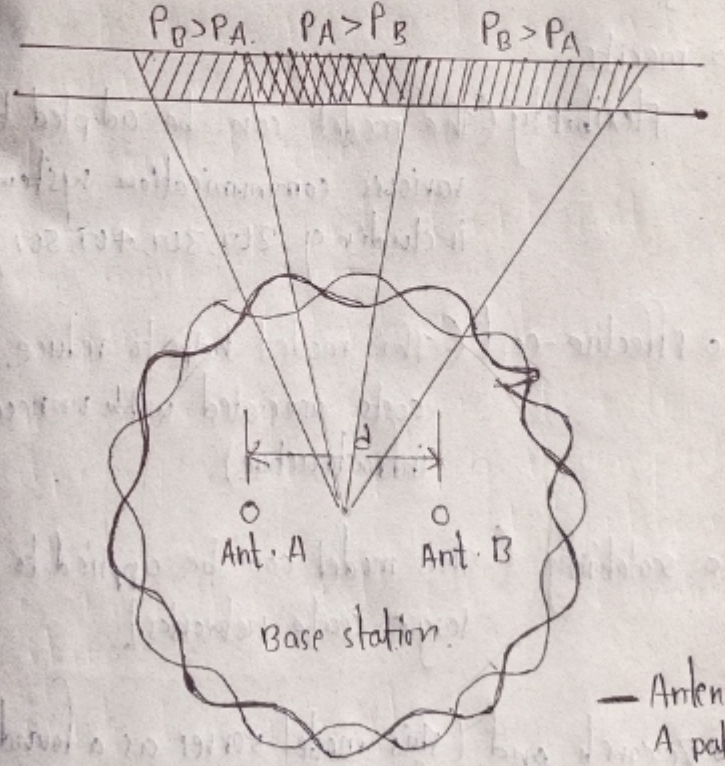
* Minimum separation of cell-site Receiving Antennas

-> The minimum separation between two cell-site receiving antennas is necessary to reduce antenna pattern ripple effects.

-> The separation required depends on the following factors.
- Antenna height
- Antenna connection
- Frequency
- Mobile unit location.
- power difference

-> Separation b/w two transmitting antennas should be minimized to avoid inter modulation.

-> The minimum separation b/w transmitting and receiving antenna is necessary to avoid receiver desensitization.



-> Above figure shows Antenna pattern ripple factor.

Unit - II (PART - I)

* merits of Lee Model

-> The lee model is a mathematical model used to predict the coverage area of cellular and mobile communication systems.

-> merits

- Flexibility (The model can be adopted to various communication systems including 2G, 3G, 4G, 5G.)
- Effective-cost (This model helps to reduce costs associated with unnecessary infrastructure.)
- scalability (This model can be applied to large scale networks.)
- Research and development (This model serves as a foundation for research and development in mobile communication.)
- Reduced Interference (This model helps to minimize co-channel interference.)
- simple & intuitive : (This model is relatively easy to understand.)

Unit-3 (PART-I)

* Measurement of Real-time co-channel interference

Real-time co channel interference is a type of electromagnetic interference that occurs when two signals on the same channel compete with each other.

→ It can happen when radio transmitters use the same channel.

$$e_1 = s(t) \sin(\omega t + \phi_1) \quad \text{(signal)}$$

$$e_2 = I(t) \sin(\omega t + \phi_2) \quad \text{(Interference)}$$

→ The received signal is

$$e(t) = e_1(t) + e_2(t) = R\sin(\omega t + \psi)$$

where,

$$R = \sqrt{[s(t)\cos\phi_1 + I(t)\cos\phi_2]^2 + [s(t)\sin\phi_1 + I(t)\sin\phi_2]^2}$$

$$\psi = \tan^{-1} \frac{s(t)\sin\phi_1 + I(t)\sin\phi_2}{s(t)\cos\phi_1 + I(t)\cos\phi_2}$$

$$R^2 = [s^2(t) + I^2(t) + 2s(t)I(t)\cos(\phi_1 - \phi_2)]$$

$$X = S^2(t) + I^2(t)$$

$$Y = 2S(t)I(t)\cos(\phi_1 - \phi_2)$$

$$\overline{X} = \overline{S^2(t)} + \overline{I^2(t)}$$

$$\overline{Y}^2 = 4\overline{S^2(t)}\overline{I^2(t)}(1/2)$$

$$\overline{Y^2} = 2\overline{S^2(t)}\overline{I^2(t)}$$

-> The signal to interference ratio(r)becomes

$$r = \frac{\overline{S^2(t)}}{\overline{I^2(t)}} = k + \sqrt{k^2 - 1}$$

$$k = \frac{\overline{X^2}}{\overline{Y^2}} - \overline{I}$$

$$S(t) \approx S(t+\Delta t) \qquad I(t) \approx I(t+\Delta t)$$

$$E\left[\cos[\phi_1(t) - \phi_2(t)]\cos[\phi_1(t+\Delta t) - \phi_2(t+\Delta t)]\right] \approx 0$$

* Design of omni-directional Antenna system

The design of omni-directional antenna system in cellular and mobile communication is critical because 'signals' can be transmitted and received from all directions.

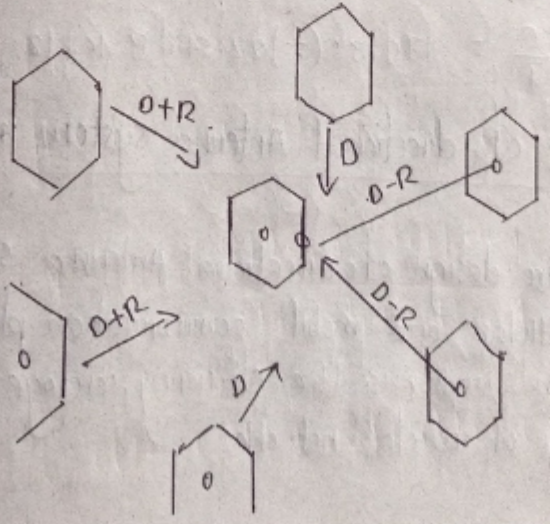
-> This is essential in mobile communication

$$C \propto R^{-4} \qquad I \propto D^{-4}$$

-> The carrier to interference ratio is

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

$$= \frac{1}{2(q-1)^{-4} + 2(q)^{-4} + 2(q+1)^{-4}}$$



-> Above figure shows co-channel interference (worst case)

-> $q = 4.6$ substitute $q = 4.6$ in above equation, we obtain $C/I = 54$ (or) 17 dB which is lower than 18 dB.

$$\frac{C}{I} = \frac{R^{-4}}{6(D-R)^{-4}} = \frac{1}{6(q-1)^{-4}} = 28$$

$$= 14.47 \text{ dB}$$

$$q = \begin{cases} \frac{D}{R} = \sqrt{3k} \\ 5.2 \quad k = 9 \\ 6 \quad k = 12 \end{cases}$$

sub q value in above equation

$$\frac{C}{I} = 84.5 (=) 19.25 \text{ dB} \quad k = 9$$

$$\frac{C}{I} = 179.33 (=) 22.54 \text{ dB} \quad k = 12$$

* Design of directional Antenna system in

The ~~dise~~ design of a directional Antenna system in cellular and mobile communication play a key role in improving the efficiency, coverage and capacity of wireless networks

-> The directional antenna focus the signal in particular direction.

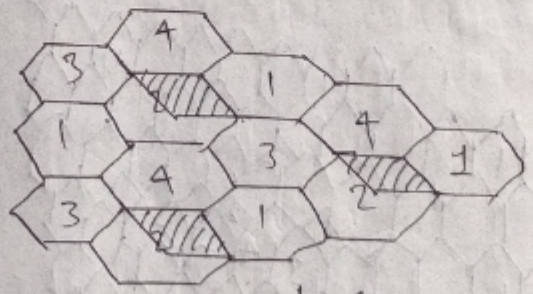
-> It provides stronger transmission and reception compared to omnidirectional antenna.

o $k = 4$

-> Three sector case

- To obtain carrier to interference ratio, we use the same procedure as in $k = 7$ cell pattern system
- The 120° directional antennas used in the sectors.
- For $k = 4$, $q = \sqrt{3k} = 3.46$;

$$\frac{C}{I} \text{ (worst case)} = \frac{1}{(q+0.7)^{-4} + q^{-4}} = 97 = 20 \text{ dB}$$



$k = 4$

-> Above figure shows interference with frequency re-use pattern $k = 4$

- If 6dB is substracted from result of above equation the remaining 14dB is unacceptable.

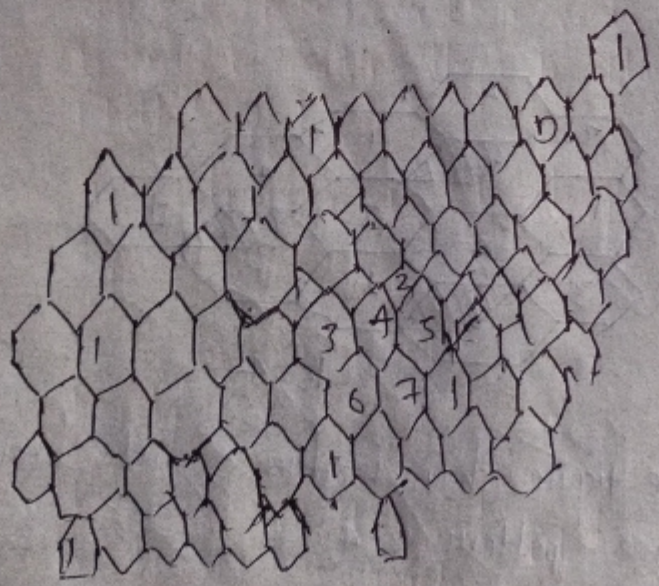
→ six sector case

- The carrier to interference ratio is given by

$$\frac{C}{I} = \frac{R^{-4}}{(D+R)^{-4}} = \frac{1}{(q+1)^{-4}} = 355 = 26\,dB$$

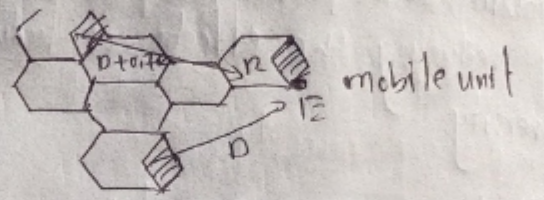
- If dB is substracted from result of above equation the remaining 21 dB is adequate.

$0 k = 7$

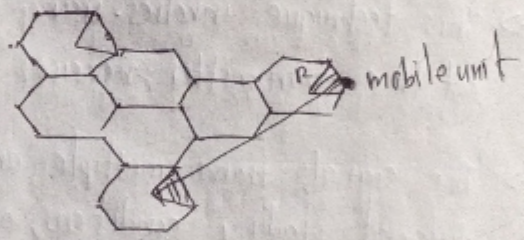


$$\frac{C}{I} = \frac{R^{-4}}{(D+0.7R)^{-4} + D^{-4}}$$

$$= \frac{1}{(q+0.7)^{-4} + q^{-4}}$$



(a)



(b)

$$\frac{C}{I} = 285 (= 124.5\,dB)$$

* Diversity Techniques

Diversity techniques are used in cellular and mobile communication to improve the reliability and performance of wireless signals by reducing the effects of fading. is called Diversity.

1. Spatial (or) space Diversity

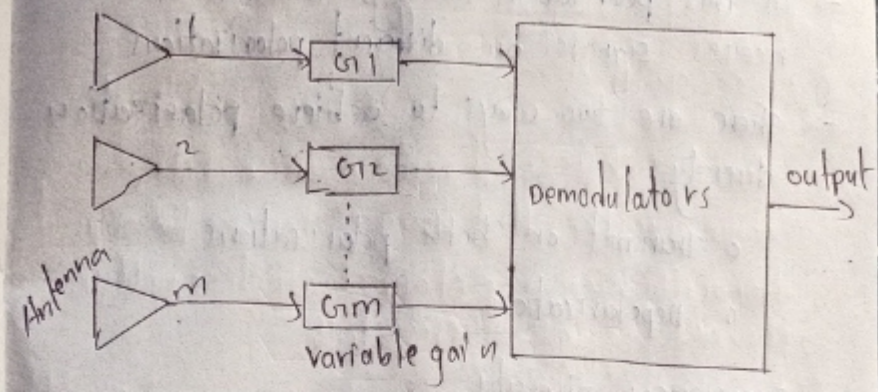
-> This technique involves using multiple antennas at the transmitter, receiver (or) both.

-> The signals from multiple antennas experience different fading conditions, and allowing receiver to combine them to obtain a more reliable signal.

-> This technique is used to strengthening the signal.

-> space diversity is also known as antenna diversity.

-> It is one of the most popular form of diversity used in wireless communication.



-> Above figure shows generalized block diagram of space diversity.

2. polarization Diversity

-> polarization Diversity require two transmitter and two receiving antennas with different polarization.

-> polarization diversity uses half power by dividing the power between two different polarized antennas.

-> This can involve receiving vertically and horizontally polarized.

-> It is requires limited space.

-> It is less cost.

-> In this polarization diversity, Transmits and receives signals on different polarizations.
-> There are two ways to achieve polarization diversity.
  - Transmit on both polarizations
  - Depolarization

3 Frequency diversity

-> Frequency diversity is a technique in wireless communication that involves transmitting the same message signal on multiple carrier frequencies is called F.D
-> It can be used in cellular and mobile communications.
-> The received signal to be statistically independent or uncorrelated.
-> In frequency diversity only one antenna is needed.
-> It requires large bandwidth and more number of receivers.
-> It is high cost.

4 Time Diversity

-> Time diversity is obtained by re-transmitting the same signal at seperate interval of time. is called Time diversity.
-> The retransmission interval should be less than coherence time.
-> Time diversity does not require any increase in the transmission power.
-> Time diversity can be realized in different ways.
  - Repetition coding.
  - Automatic Repeat request
  - combination of interleaving and coding.

Unit-3 part-II

* Cross Talk

-> Cross Talk is a phenomena in mobile communication that occurs when a ~~the~~ signal transmitted on one channel effects another channel is called cross talk.

-> Crosstalk can be intelligible or unintelligible.

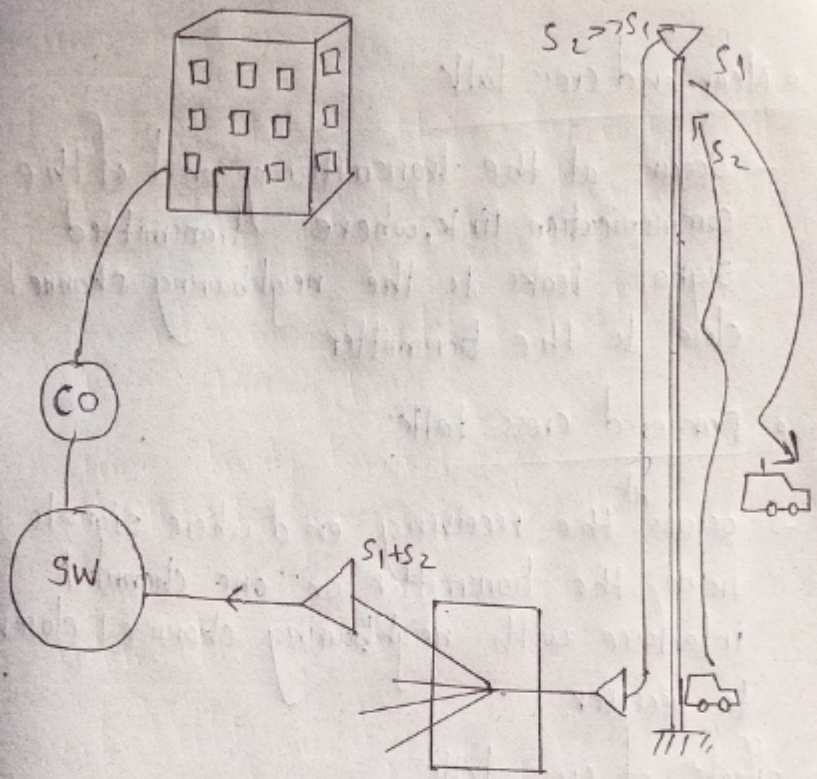
-> Cross-talk in mobile communication caused by co-channel interference.

-> It is caused due electrostatic or Electromagnetic induction.

-> It is one of the major issue in mobile communication.

-> Suppose if we dail or call to ~~our~~ whom we we want to talk. sometime call connects to another unknown persons, this is crosstalk.

-> Cross-talk phenomena



Demultiplexer.

-> causes of crosstalk

- Electromagnetic interference.
- Improper shielding
- Frequency reuse.
- Poor circuit design.

Types of crosstalk:

- Near-end cross talk

→ occurs at the transmitting end of the communication link, where transmitted signal leaks to the neighbouring channel close to the transmitter.

- Far-end cross-talk:

→ occurs at the receiving end, where signals from the transmitter on one channel interfere with neighbouring channel closer to receiver.

→ effects of cross talk

- Reduced call quality
- Data errors
- Dropped calls.

* Effects on coverage and interference by power decrease

→ In cellular and mobile communication, power decrease refers to the reduction of transmission power from base stations or mobile devices.

→ power decrease can significantly effects the coverage and interference.

effects on coverage

- Reduced cell size
  - loss of service.
  - Increased handover failures.
  - Decreased signal-to-Noise Ratio
  - Increased call edge interference

Effects on interference

- Increased co-channel Interference
- Increased Adjacent " "
- " Inter-cell "
- " multipath "
- Reduced Network capacity.

Unit - 4

Frequency Management:

Frequency manament in cellular systems is the process of dividing the avaliable channels into subsets and assignmenting them to cells. is called frequency management

channel Assignment

channel Assignment is the process of assigning frequencies to radio cells to reduce interference and improve network performance is called channel Assignment.

* Numbering and grouping

Numbering the channels

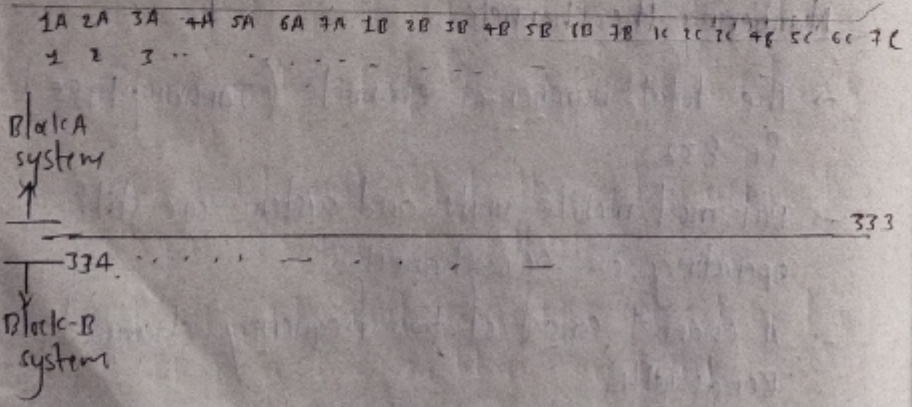
-> The total number of channels (January 1988) is 832.

-> But most mobile units and systems are still operating on 666 channels.

-> A channel consist of two frequency channel Bandwidths

- one in the low band
- one in the High band.

-> Two frequencies in channel 1 are
  - 825.030 MHz (Mobile transmit)
  - 870.030 MHz. (cell-site transmit)
-> Two frequencies in channel 666 are
  - 844.98 MHz (mobile transmit)
  - 889.98 (MHz (cell site transmit)
-> The 666 channels are divided into two groups
  - Block A system.
  - Block B system.
-> Additional channels will be numbered up to 849 MHz.
-> The last channel number is 1023.
-> There are no channels between 799 and 991.



-> Each Block has 333 channels.
-> channels 313 - 333 block A
-> channels 334 - 354 block B
-> channels 1-312 (voice channels.)
-> channels 355 - 666 (voice channels

Grouping into subsets

-> voice channels of each system is 312.
-> we can group these into any no of subsets
-> 21 set-up channels for each system.
-> It is logical to group 312 channels into 21 subsets
-> Each subset consist of 16 channels
-> In a seven cell system pattern each cell contains three subsets, iA+iB+iC, where i is an integer. from 1 to 7.
-> For example 1A+1B+1C +4A+4B+4C

* set-up channels

-> set-up channels are also called as control channels, are designed to set up calls.
-> A call always need a set-up channel.
-> set up channels are classified into two types
  - Access channels
  - paging channels

-> An access channel is used for mobile calls.
-> An paging channel is used for land calls.
-> In the most common type of cellular systems, one set-up channel is used for both access and paging.
-> The forward set-up channel functions as paging channel for responding to the mobile calls.
-> The reverse set up channel functions as the access channel for responding to paging calls.
-> The forward set-up channel is transmitted at the cell site and reverse set-up channel is transmitted at the mobile unit.

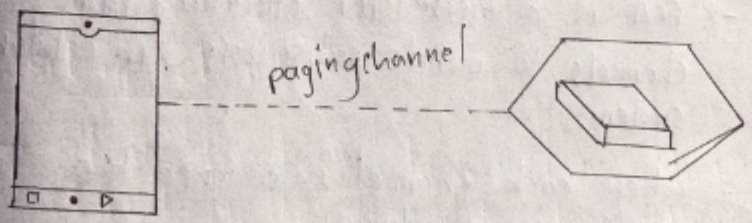
o Access channels

-> In mobile originating calls, the mobile unit scans it's 21 set-up channels and chooses stronger one.
-> Because each set-up channel is associated with one cell.
-> The mobile unit detects the system information transmitted from the cell site.
-> when mobile unit scans the 21 set-up channels is block A, two conditions can occur.

-> operational functions are described as follows
1. The power of forward set-up channel
2. The set-up channel Received level.
3. change power at the mobile unit
4. o Mobile station control message.
   o system parameter control message
   o control-filler message.
5. Direct calls. Retry.

o paging channels

-> paging channels main objective is to send out pages, that is, notifications of incoming calls, to the mobiles.
-> Each cell site has been allocated it's own set-up channel.



-> paging channel is used by base-station to transmit information and message.
-> The drawback is that response time is something too long.

X channel Assignment

-> In cellular concept, channel assignment strategies are used for efficient utilization of avaliable radio spectrum.

-> channel assignment is the process of assigning frequencies to radio cells to reduce interferance and improve network performance is called C.A.

-> Types of channel Assignment
- o Fixed channel Assignment
- o Non-fixed channel Assignment

o Fixed channel assignment :

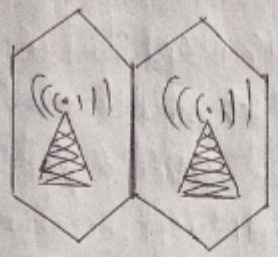
-> Each cell is allocated a fixed number of voice channels.

-> FCA is a method for allocating radio channels to mobile subscribers in cellular systems.

-> where each channel is assigned to a specific user (or) device

-> FCA is simple to implement.

-> FCA may leads to issues like network partitions.



Barrowing strategy

-> In this method, a cell is allowed to borrow channels from a neighbouring cell if all its own channels are occupied.

Acceptor cell :- cell that accepts the channels.

Donar cell :- cell that donates the channels.

Mobile switching center (msc)

Msc moniters the barrowing procedures to ensure that the borrowing channel does not distrupt (or) interfere the progress in donar cell.

-> The fixed channel assignment is not much flexible with users.

o Non-fixed channel Assignment

-> voice channels are not allocated to the cells permanently.

-> Based on the call traffic, the channels will be allocated to the cell.

- High traffic - more channels
- low traffic - less channels
- channel allocation takes as per the need of the cell

Advantages

- To increase channel utilization
- To decrease the probability of blocked call

Drawback

- Increases the storage & load.

Fixed channel Assignment

• Adjacent channel Assignment

-> Adjacent channel Assignment includes both the neighbouring and next-channel assignment.

-> It refers to the process of assigning radio channels that are next to each other

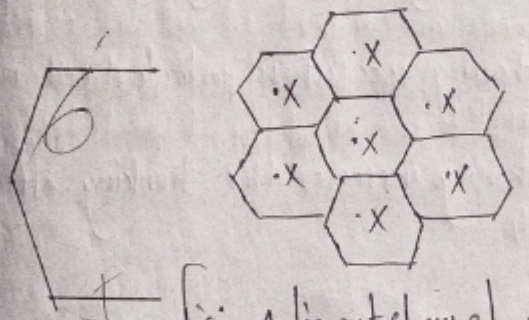


fig: Adjacent channel assignment for omnidirectional cells.

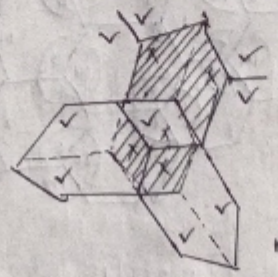


fig: Adjacent channel assignment for directional Antenna cells

-> In omnidirectional cell system, if one channel is allocated to the middle cells of seven cells, then the next channel can't be assigned.

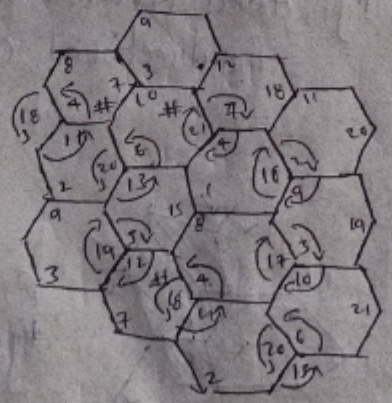
-> In directional cell system, if one channel is assigned to a face, next channels cannot be assigned to same face.

* channel sharing

-> channel sharing is temporary traffic-relief system

-> channel sharing uses when particular cell needs more channels

-> channel sharing increases the trunking efficiency of channels



-> Above figure shows channel borrowing algorithm

* channel Borrowing

channel borrowing is a technique in cellular networks that allows a cell to borrow a channel from a neighboring cell when it is needed.

-> In borrowing a cell is allowed to borrow channels from a neighbouring cell if all its own channels are already occupied.

-> channel borrowing is the one of the most straightforward hybrid allocation schemes

* sectorization

-> sectorization is a technique used in cellular communication to increase the capacity of a network by reducing interference b/w cells is called sectorization.

-> The total number of available channels can be divided into subgroups depending on the sectorization of the cell configuration.

- The 120° - sector.
- The 60° - sector.
- The 45° - sector.

-> The sector angle can be reduced in order to assign more channels in one sector.

Sectorized cells

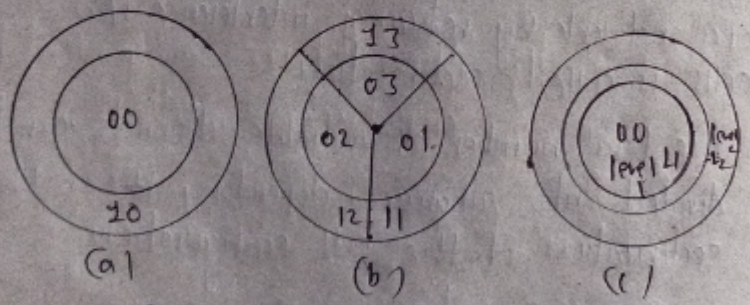
-> The 120°-sector cell is used for both transmitting and receiving sectorization.

-> The 60°-sector cell is used for both transmitting and receiving sectorization.

-> The 120° or 60° sector cell is used for ~~the~~ receiving sectorization only. In this case transmitting antenna is omnidirectional.

* overlaid cells

-> overlaid cells are a part of cellular system that can be characterized by multilayered, multisized, and use of different ~~de~~ technologies.



(a) (b) (c)

-> Above figure shows underlaid-overlaid cell arrangements.

(a) underlay-overlay in omnicell

(b) underlay-overlay in sectorized cell

(c) Two level handoff scheme.

* Non-fixed channel Assignment

o Fixed channel Assignment:

-> The fixed channel Assignment algorithm is the most common algorithm adopted in many cellular systems.

o Dynamic channel Assignment:

-> In dynamic channel assigment no fixed channels are assigned to each cell.

-> The channel is directly assigned to mobile unit.

o Hybrid channel Assigument

-> It is the combination of FCA, and DCA

-> Total frequency channels will use FCA and the rest will use DCA

o Barrowing channel Assignment

-> Barrowing channel assigument uses FCA as a normal assignment condition

o Forcible Barrowing channel Assignment:

-> FBCA is a dynamic channel allocation technique used in cellular networks ~~to~~

Unit-5 (PART-I)

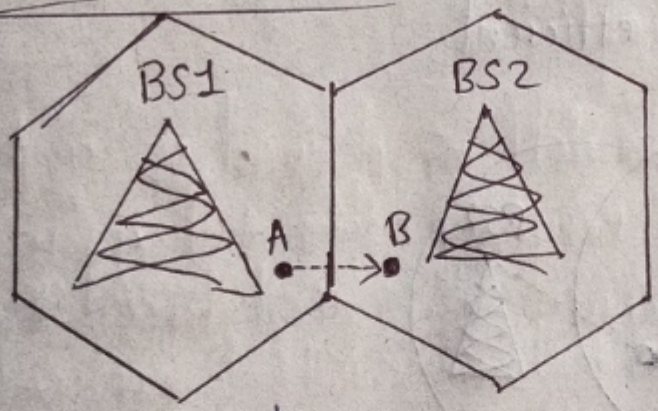
Handoff Initiation

Handoff initiation in cellular communication is the process of deciding when to request handoff, (or) transfer of an active call from one cell area to another. is called H.I.

→ Handoff can be either synchronous (or) asynchronous

→ Handoff is the process of changing the channel time slot, spreading code.

~~Types of Handoff~~



→ when a mobile user A moves from one cell to another cell the BS1 signal strength loses for the mobile user A and signal strength of BS2 increases.

Types of Handoffs

1 Hard Handoff

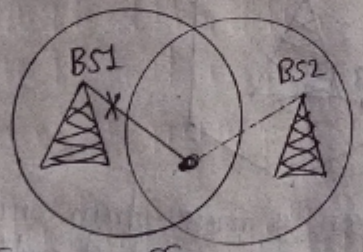
-> Hard handoff is a technique used in cellular networks to transfer a call from one cell to another by breaking the connection to the existing base station before switching to new one. is called Hard handoff.

-> It is also known as "break-before-make" handover.

-> Hard handoff is used in FDMA and TDMA.

-> It is cheper in cost as compared to soft handoff.

-> It is more efficient.



2. Soft Handoff

-> soft handoff is a technique that allows a mobile user to switch to a new base station while still connected to an existing one. is called soft handoff.

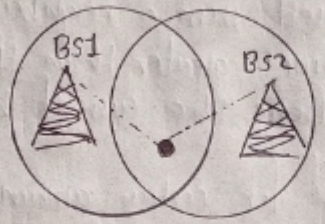
-> It is also known as make-before break" handoff.

-> soft handoffs are only possible blw Base stations that use the same frequency.

-> It is costlier as compared hard handoff.

-> It is less efficient.

-> It has high transmission speed.



3. Delayed Handoff

-> Delayed handoff is a technique that occurs when no base station is available for accepting the transfer is called delayed handoff.

-> The call continues until the signal strength reaches a threshold and after that call is dropped.

-> It happed when user is out of the network coverage area.

4. Mobile-Assisted Handoff

-> Mobile assisted handoff is a technology that allows a mobile device to transition smoothly from one base station to another while maintaining a call or data connection.

-> It is used in TDMA, 2G, 3G, GSM, CDMA etc.

5. power difference Handoff:

-> The power difference handoff is a process in mobile communication that occurs when the power received from a neighbouring base station becomes greater than the power received from the current base station.

-> This can happen for certain amount of time

-> This algorithm is not based on the received signal strength level.

6. Forced Handoff:

-> A forced handoff is defined as a handoff that would normally occur but prevented from happening. Is called forced handoff.

7. Inter system Handoff:

-> Inter system Handoff is a procedure that allows a mobile device to move from one cellular system to another without dropping a call is called Inter system handoff.

-> It occurs when mobile unit is in the middle of a call and moves from one cellular system to another i.e controlled by MTSO.

-> Intersystem handoff is a type of interfrequency handoff.

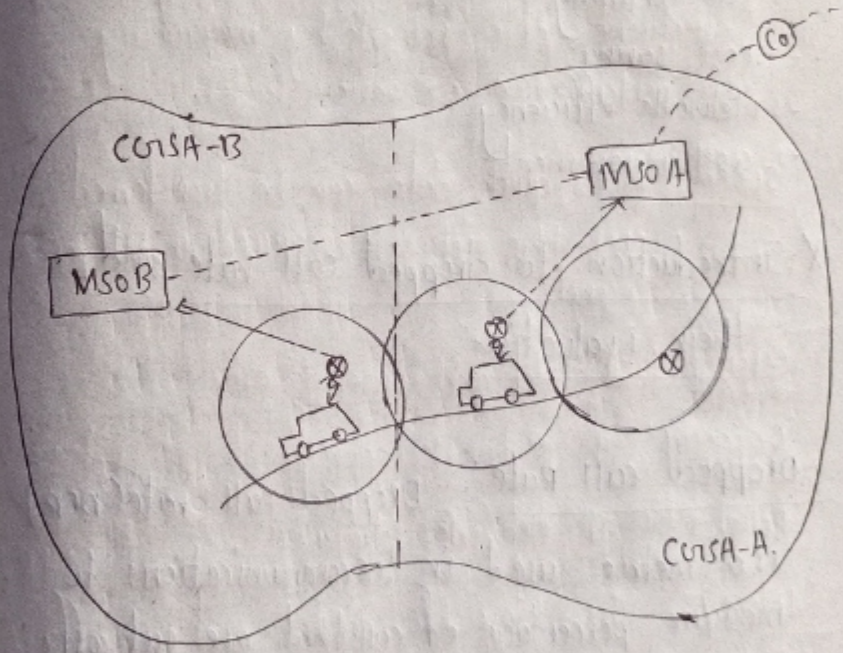


fig: Intersystem Handoff.

* Advantages of Handoff

-> consistent communication.
-> Mobility
-> seamless transitions
-> Reliable connectivity
-> call continuity.
-> cost savings
-> Network efficiency
-> QoS improvement.

* Introduction to dropped call rate and their Evaluation

Dropped call Rate: Dropped call rate (DCR) is a metric used in telecommunications to measure percentage of calls that are cut off before the conversation is complete.

-> DCR is usually calculated as the percentage of all calls
-> DCR is an indicator of technical issues or coverage gaps.

-> It important to keep DCR low, especially of call centers, acceptable DCR is under 3%
-> Low DCR will Result in better voice quality
-> The dropped call rate can be calculated by using following factors
  - o signal coverage.
  - o co-channel and adjacent channel interference levels.
  - o The response time of timeoff.
-> Dropped call rate can be calculated by using the formula

$$\text{Call drop Rate} = \frac{\text{No. of dropped calls}}{\text{Total No: of sucessfully established calls}} \times 100$$

Unit-5 (PART-II)

* performance Evaluation

-> performance evaluation in cellular communication is the process of assessing the effectiveness of a network by measuring it's performance on various factors.

Speed: How quick data can be transfered over the network, measured in bits per second

Coverage: The Network's coverage area.

Capacity: The Network's capacity.

Reliability: The Network's reliability.

Latency: The delay b/w sending and receiving data, measured in milliseconds

-> Techniques used for measuring performance Evaluation

- o Benchmarking
- o simulation
- o Analytical modeling.

* Blockage

Def: Blockage refers to the obstruction of cellular signals, causing complete loss of communication, is called Blockage.

-> Blockages can be permanent (or) temperory.

-> Blockages can be caused by Network congestion, software errors, interference, densely located buildings etc.

Types of Blockages

1. physical Blockage: Buildings, hills, trees etc
2. Enviromental Blockages: weather conditions (rain, fog, snow)
3. Man-made Blockages: construction, urbam planning etc.
4. Radio-frequency interference: co-channel and adjacent channel interference

Blockages

* Signaling Evaluation

o False Rate Alarm

False Rate Alarm measures the probability of incorrectly detecting a signal (or) event when none exists leading to unnecessary network actions is called False Rate Alarm

-> FAR is important in mission critical surveillance applications.

-> FAR is also known as Miss alarm rate, False positive rate, False match rate etc.

-> FAR can be sensitive to threshold level

-> FAR can also negatively correlated False Rejection Ratio (FRR), it means not possible to lower both FAR and FRR values at the same time.

-> FAR calculation

$$FAR = \frac{\text{No. of false Alarms}}{\text{Total No. of detected events}}$$

o Word Error Rate considerations and calculations

-> In cellular and mobile communication, the word error Rate (WER) is a critical performance metric especially in voice and data transmission

-> WER measures ratio of incorrectly received words to the total no. of words transmitted during communication

Considerations

1. channel conditions

Noise: Mobile communication channels are prone to noise, which increase the errors.

Fading: signal fading due to distance, motion effect signal strength and increas WER

Multipath propagation: Reflected signals arriving at the receiver can leading to errors

2. signal-to-Noise Ratio (SNR)

-> A higher SNR generally leads to a lower WER, as signal strength relative to noise is higher.

3. Bandwidth and Interference

-> Limited bandwidth (or) congestion in the network can cause increased interference and WER.

-> strategies like frequency hoping and advanced receiver designs are employed to reduce error rates.

4. Impact on QoS

-> Higher WER negatively impacts the quality of services like voice calls, video streaming (or) data transmission leading to buffering (or) distorted audio.

5. Latency

-> High latency in communication systems can lead to out-of-order packet delivery that increases the word errors.

-> Managing WER is critical in cellular communication and advanced error correction strategies are being developed.

WER calculation

-> The word error rate is typically calculated by using the formula;

$$WER = \frac{\text{No. of incorrect words}}{\text{Total No. of transmitted words}}$$

-> In mobile communication words typically refers to blocks of bits (or) data packets depending on application.

Steps for calculating WER

-> Determine the total number of transmitted words. (W_total).

-> Indentify the no of incorrect words. (W_error).

-> compute WER

Example Let's Assume

- Total transmitted words (W_total) = 10,000
- No. of incorrect words (W_error) = 250.

$$WER = \frac{250}{10,000} = 0.25 \text{ (or) } 2.5\%$$

* Measurement of Average Received signal level and level crossings

-> In cellular and mobile communication, the measurement of average received signal level and level crossings is crucial for signal quality, coverage, overall system performance level

o Average Received signal (RSL) Measurement:-

-> The Received signal level is the power of the signal received by a mobile device (or) a base station from a transmitting source

-> The RSL is measured in dBm, where 0dBm represents 1 milliwatt of power.

-> The RSL varies due to distance, interference, environmental conditions.

-> Methods of Measuring RSL:

- o Drive testing
- o Network based measurement.
- o User equipment Reporting.

o level crossing measurement:

-> level crossing rate (LSR) refers to the rate at which the received signal level crosses a certain threshold.

-> A level crossing occurs when the received signal strength crosses a predefined threshold in their direction.

-> Methods of measuring LCR:

- o threshold setting
- o Fading analysis
- o Reliability and Link quality