Unit - IV

Handoffs and Dropped Calls

Concept of Handoff

→ Once a call is established, the set-up channel is not used again during the call period.

→ Therefore, handoff is always implemented on the voice channel.

→ The value of implementing handoffs is dependent on the size of the cell.

→ Handoff is needed in two situations where the cell site receives weak signals from the mobile unit:

1] at the cells boundary, say, -100 dBm, which is the level for requesting a handoff in a noise-limited Environment; and

2] when the mobile unit is reaching the signal-strength holes within the cell site.

Two types of handoff (Two decision making Parameters)

→ There are two types of handoff:

1] that based on signal strength and

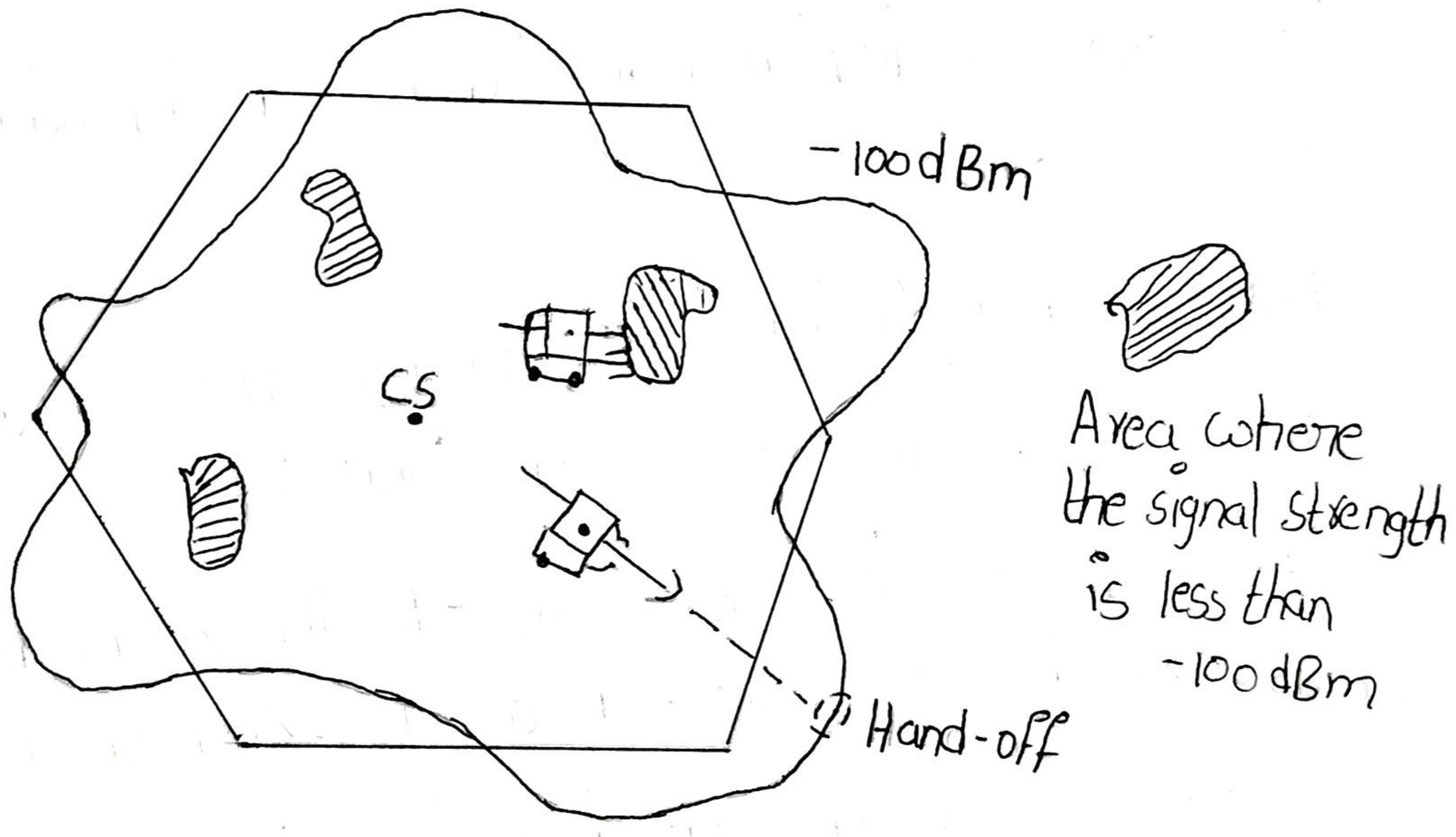
2] that based on carrier-to-interference ratio.

→ The handoff criteria are different for these two types.

→ In type 1, the signal-strength threshold level for handoff is -100dBm in noise-limited systems and -95 dBm in interference-limited systems.

→ In type 2, the value of C/I at the cell boundary for handoff should be 18dB in order to have toll quality voice.

→ Sometimes, a low value of C/I may be used for capacity reasons.



→ Type 1 is Easy to implement.

→ The location receiver at each cell site measures all the signal strengths of all receivers at the cell site.

→ However, the received signal strength itself includes interference.

$$RSS = C + I$$

→ where C is the carrier signal power and I is the interference

→ Suppose that we set up a threshold level for RSS; then, because of the I, which is sometimes very strong, the RSS level is higher and far above the handoff threshold level.

→ In this situation handoff should theortically take place but does not.

→ Another situation is when I is very low but Rss is also low.

→ In this situation, the voice quality usually is good Even though the RSS level is low, but since Rss is low, unnecessary handoff takes place.

→ Therefore it is an Easy but not very accurate method of determining handoffs.

→ Some systems use SAT information together with the received signal level to determine handoffs.

→ Type 2 Handoffs can be controlled by using the carrier-to-interference ratio C/I, which can be obtained as described.

$$\frac{C+I}{I} = \frac{C}{I}$$

→ In we can set a level based on C/I, so C drops as a function of distance but I is dependent on the location.

→ If the handoff is dependent on C/I, and if the C/I drops, it does not so in response to increase in

1] Propagation distance &
2] interference.

→ In both cases, handoff should take place.

→ In today's cellular systems, it is hard to measure C/I, during a call because of analog modulation.

→ Sometimes we measure the level I before the call is connected, and the level C+I during the call.

→ Thus [C+I]/I can be obtained.

Initiation of a Handoff

→ At the cell site, signal strength is always monitored from a reverse voice channel.

→ When the signal strength reaches the level of a handoff, then the cell site sends a request to the mobile telephone switching level for a handoff on the call.

→ An intelligent decision can also be made at the cell site as to whether the handoff should have taken place earlier or later.

→ If an unnecessary handoff is requested, then the decision was made too early.

→ If a failure handoff occurs, then a decision was made too late.

→ The following approaches are used to make handoffs successful and to eliminate all unnecessary handoffs.

→ Suppose that -100dBm is a threshold level at the cell boundary at which a handoff could be taken.

→ Given this scenario, we must set up a level higher than -100dBm - say, -100dBm + ΔdB - and when the received signal reaches this level, a handoff request is initiated.

→ If the value of Δ is fixed and large, then the time it takes to lower -100dBm + Δ to 100-dBm is longer.

→ During this time, many situations, such as the mobile unit turning back toward the cell site or stopping, can occur as a result of the direction and the speed of the moving vehicles.

→ Then the signals will never drop below -100dBm.

→ Thus, many unnecessary handoffs may occur simply because we have taken the action too early.

→ If Δ is small, then there is not enough time for the call to hard off at the cell site and many calls can be lost while they are handed off.

→ Therefore, Δ should be varied according to the path-loss slope of the received signal strength and the level-crossing rate of the signal strength.

→ Let the value of Δ be 10dB in the example given in the preceding paragraph.

→ This would mean a level of -90dBm as the threshold level for requesting a handoff.

→ Then we can calculate the velocity v of the mobile unit based on the predicted [illegible] at a [illegible]dB level with respect to the

root-mean-square level, which is at -90dBm; thus

$$V = \begin{cases} \frac{n\lambda}{\sqrt{2\pi}(0.27)} & \text{ft/s} \\ & \text{mi/h} \end{cases} \quad \text{at -10-dB level}$$

where n is the LCR counting positive slopes and λ is the wavelength in feet.

→ Equation can be simplified as

$$v[(mi/h) \approx n[crossings/s)] \text{ at } 850 \text{ MHz and a -10-dB level}$$

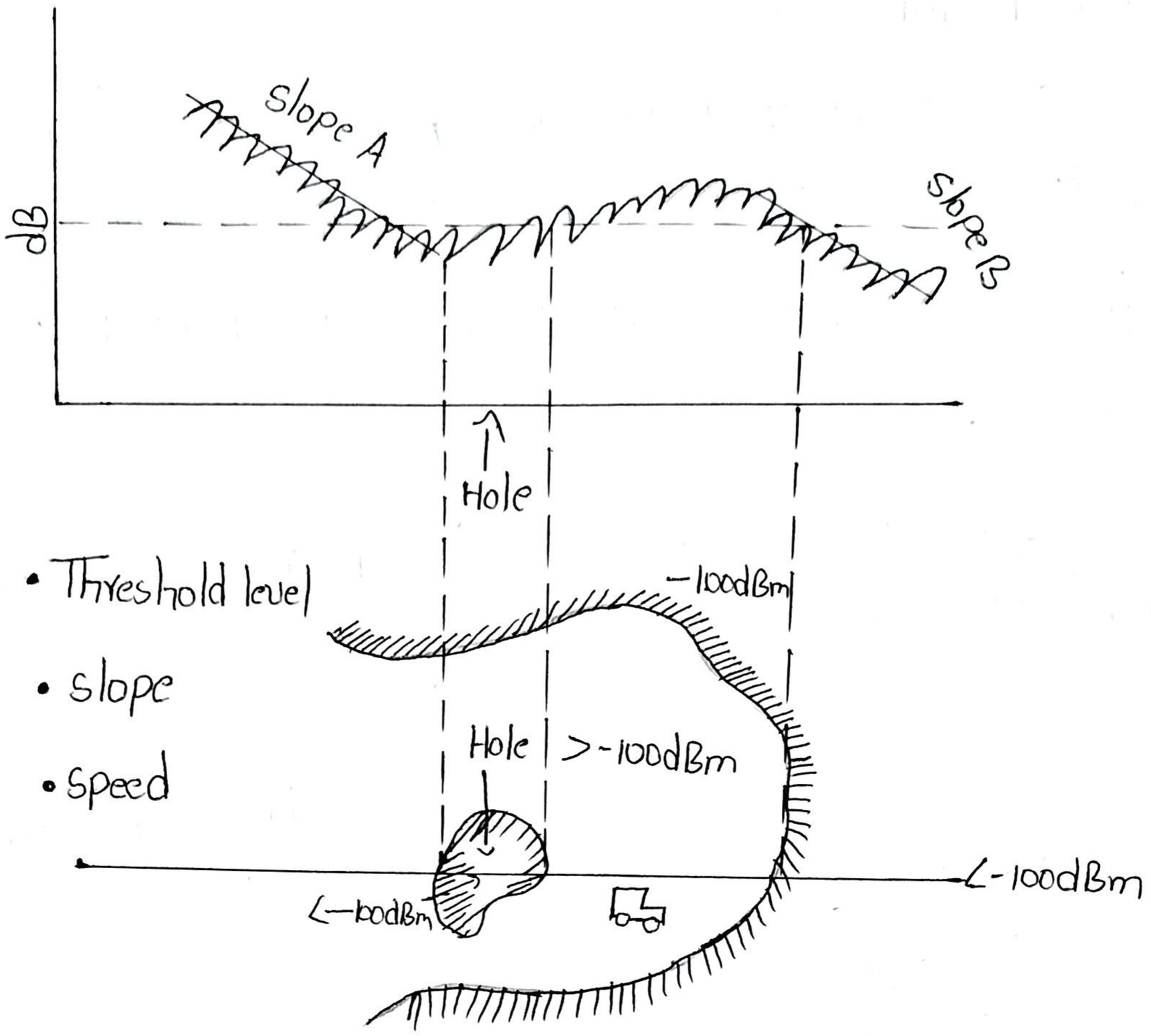
→ Here, two pieces of information, the velocity of vechicle V and the pathloss slope γ, can be used to determine the value of Δ dynamically so that the number of unnecessary handoffs can be reduced and the required handoffs can be completed successfully.

→ There are two circumstances where handoffs are necessary but cannot be made:

1] when the mobile unit is located at a single-strength hole within a cell but not at the boundary and

2] when the mobile unit approaches a cell boundary but no channels in the new cell are available.

→ The MTSO usually controls the frequency assignment in each cell and can rearrange channel assignments or split cells when they are necessary.



Delaying a Handoff

Two-handoff-level algorithm

→ In many cases, a two-handoff-level algorithm is used.

→ The purpose of Creating two request handoff levels is to provide more opportunity for a successful handoff.

→ A handoff could be delayed if no available cell take the call.

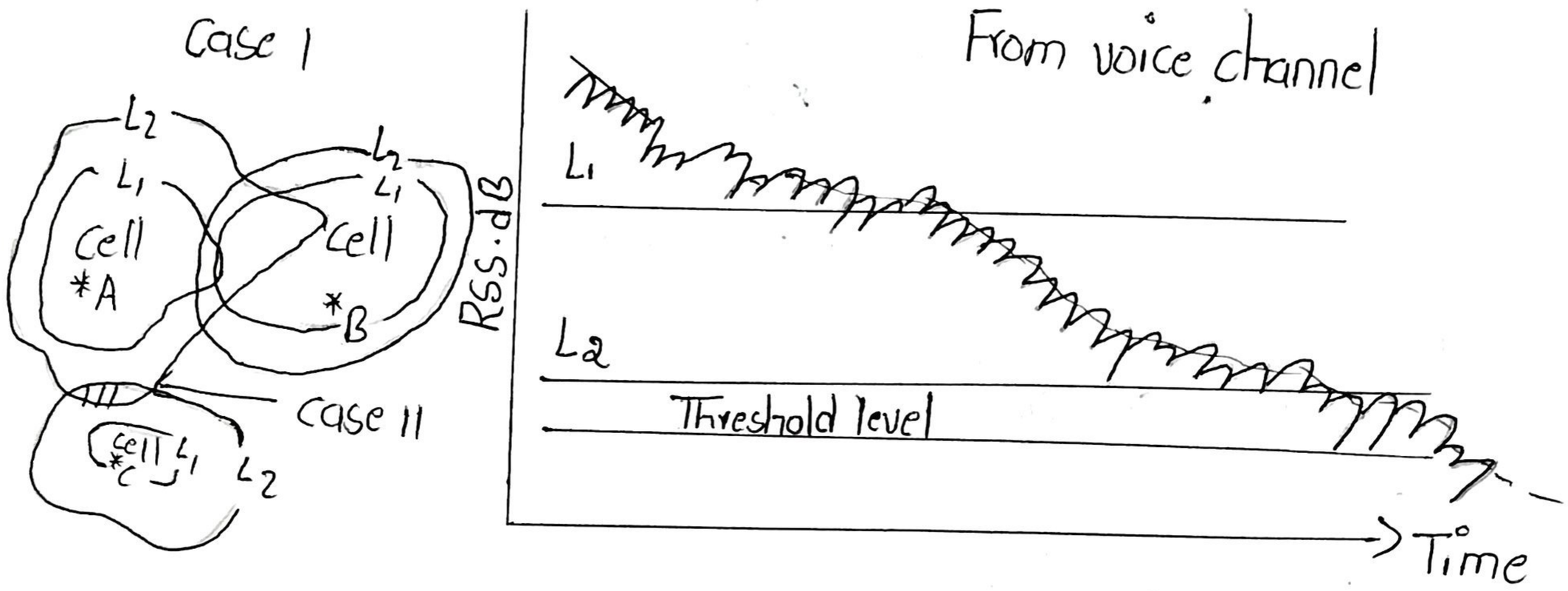
→ The plot of average signal strength is recorded on the channel received signal-strength indicator which is installed at each channel receiver at the cell site.

→ When the signal strength drops below the first handoff level, a handoff request is initiated.

→ If for some reason the mobile unit is in a hole or a neighboring cell is busy, the handoff will be requested periodically every 5s.

→ At the first handoff level, the handoff takes place if the new signal is stronger.

→ However, when the second handoff level is reached, the call will be handed off with no condition.



→ The MTSO always handless the handoff call first and the originating calls second.

→ If no neighbouring calls are available after second handoff level is reached, the call continues until the signal strength drops below the threshold level; then the call is dropped.

→ If the supervisory audio tone is not sent back to the cell site by the mobile unit within 5s, the cell site turns off the transmitter.

Advantage of delayed handoffs

→ Consider the following Example.

→ The mobile units are moving randomly and the terrain contour is uneven.

→ The received signal strength hole for less than 5s at the mobile unit fluctuates up and down.

→ If the mobile unit is in a hole for less than 5s, the delay can Even circumvent the need for a handoff.

→ If the neighbouring cells are busy, delayed handoff may take place.

→ In principle, when call traffic is heavy, the switching processor is loaded, and thus a lower number of handoffs would help the processor handle call processing more adequately.

→ of course, it is very likely that after the second handoff level is reached, the call may be dropped with great probability.

→ The other advantage of having a two-handoff-level algorithm is that it makes the handoff occur at the proper location and eliminates possible interference in the system.

Forced Handoffs

Controlling a handoff

→ The cell site can assign a low handoff threshold in a cell to keep

- a mobile unit in a cell longer or assign a high handoff threshold level to request a handoff Earlier.

→ The MTSO also can control a handoff by making Either a handoff Earlier or later, after receiving a handoff request from a cell site.

Creating a handoff

→ In this case, the cell site does not request a handoff but the MTSO finds that some cells are too congested while others are not.

→ Then the MTSO can request cell sites to Create Early handoffs for those congested cells.

→ In other words, a cell site has to follow the MTSO's order and increase the handoff threshold to push the mobile units at the new boundary and to hand off Earlier.

Mobile Assisted Handoff

→ In a normal handoff procedure, the request for a handoff is based on the signal strength or the SAT range of a mobile signal received at the cell site from the reverse link.

→ In the digital cellular system, the mobile receiver is capable of moinitoring the signal strength of the set up channels of the neighbouring cells while serving a call.

→ For instance, in a TDMA system, one time slot is used for serving a call, the rest of the time slots can be used to monitor the signal strengths of setup channels.

→ When the signal strength of its voice channel is weak, the mobile unit can request a handoff and indicate to the switching office which neighbouring cell can be a candidate for handoff.

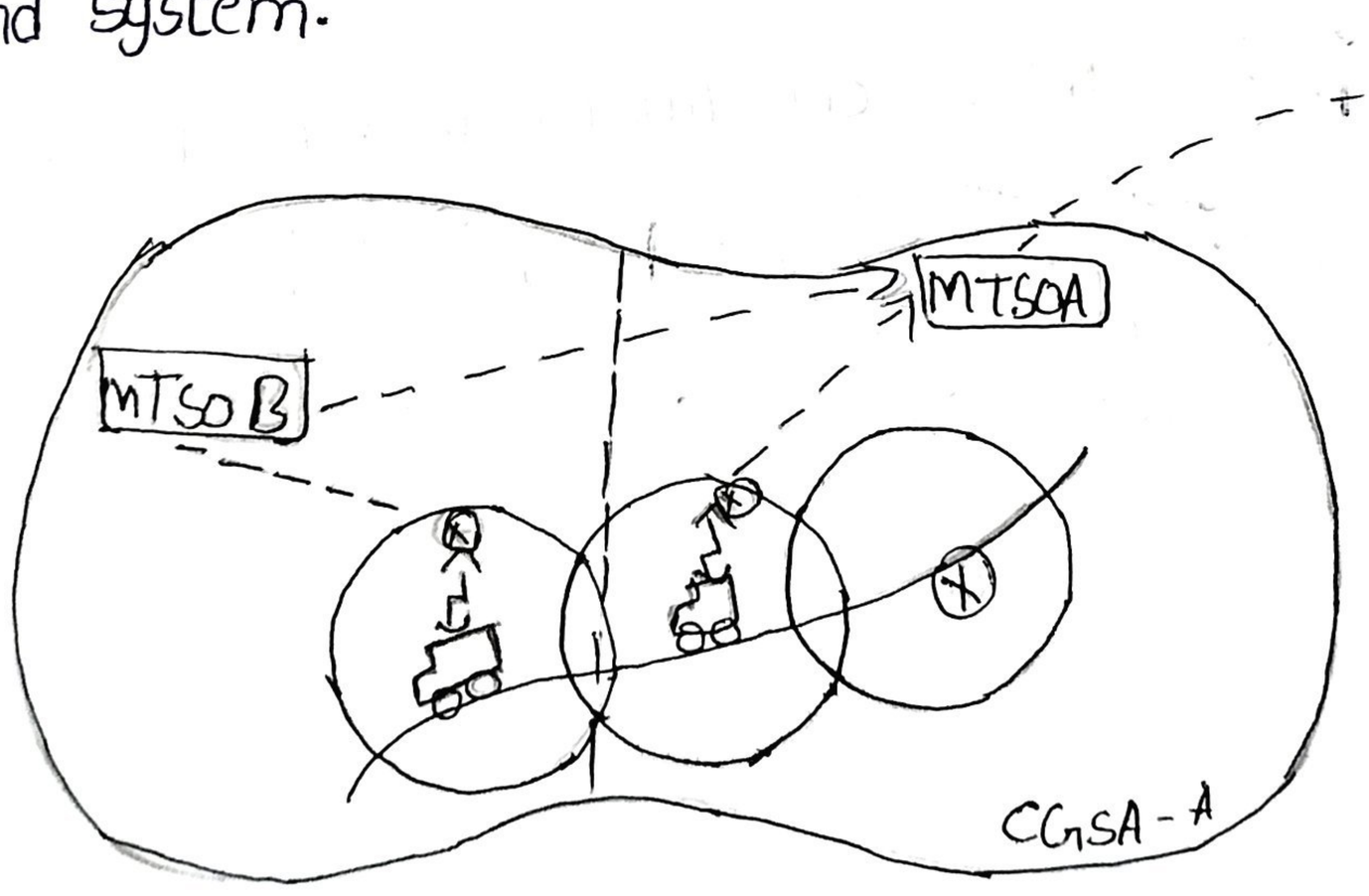
→ Now the switching office has two peices of information, the signal strengths of different both forward and reverse setup channels of a neighbouring cell or two different neighbouring cells.

→ The switching office, therefore, has more intelligent information to choose the proper neighbouring cell to handoff to.

Intersystem Handoff

→ Occasionally a call may be initiated in one cellular system and enter another system before terminating.

→ In some instances, intersystem handoff can take place; this means that a call handoff can be transferred from one system to a second system so that the call be continued while the mobile unit enters the second system.



→ The car travels on a highway and the driver originates a call in system A.

→ Then the car leaves cell site A of system A and Enters cell site B of system B.

→ cell site A and B are Controlled by two different MTSOs.

→ When the mobile unit signal becomes weak in cell site A, MTSO A searches for a candidate cell site in its system and cannot find one.

→ Then MTSO A sends the handoff request to MTSO B, and MTSO B makes a complete handoff during MTSO A and MTSO B, and MTSO B makes a complete handoff during the call conversation.

→ This is just a one-point connection case,

→ There are many ways of implementing intersystem handoffs, depending on the actual circumstances.

→ For instance, if two MTSOs are manufactured by different companies, then the compatibility must be determined before implementation of intersystem handoff can be considered.

Types of Handoff

→ Hard handoff

→ Early systems used a hard handoff

→ In a hard handoff, a mobile station only communicates with one base station.

→ When the mobile station moves from one cell to another, communication must first be broken with the previous base station before communication can be Established with the new one.

→ This may Greate a rough transition.

→ The mobile Ends Communication with the old base station before beginning Communication with the new one.

Soft Handoff

→ New sly's use a soft handoff

→ In this case, a mobile station can communicate with two base stations at the same time.

→ This means that during handoff, a mobile station may continue with the new base station before breaking off from the old one.

→ The mobile begins communication with the new base station before Ending communications with the old.

→ It can be only be used b/w CDMA channels having identical frequency assignments.

→ It provides diversity of forward and reverse traffic channel paths on the boundaries between base stations.

Soften hand :- refers to mobile that communicates with two sectors within cell

Vehical locating methods

→ By locating the vehicle and calculating the distance to it, we can obtain information useful for assigning proper frequency channels.

→ There are many vehicle-locating methods,
In general we can divide these into two categories
1] Installation of Equipment in the vehicles
2] Installation of Equipment at the cell site.

1. ## Installation of Equipment in the vehicles

Triangulation

→ Three or more transmitting antennas are used at different cell sites.

→ Since the locations of the sites are known, the vehide's location can be based on identification of three or more sites.

Fifth-wheel & gyroscope Equipment

→ A gyroscope and a fifth wheel are used for determining the direction & distance a vehicle has traveled from a predetermined point at any given time.

The Globe Position Satellite [GPS]

→ At least three or more GPS satellites should be seen in space at anytime, so that a GPS receiver can locate its position according to the known positions of the GPS satellites.

→ Under this condition, we need at least 18 GPS's but only 7 GPS's are in space today. The GPS location is very accurate, generally within 6m.

→ when for GPSs are in space, we can measure three dimensions, i.e latitude, longitude & altitude.

2. Installing Equipment at the cell site

→ In general, either of the following three methods alone can not provide sufficient accurancy for locating vehicles a combination of two or all three methods is recommended.

Triangulation based on signal strength

→ Record the signal strength received from the mobile unit at each all site and then apply the triangulation the mobile unit triangulation based on angular arrival.

→ Record the direction of signal arrival at each cell site and then apply the triangulation method to find the location of the MU.

Triangulation based on the respone time arrival

→ Send a signal to the mobile unit.

→ It will return with a time delay or a phase change measurement of time delay or phase change at each site can indicate the distance from that site.

Dropped call rates and their Evaluation

→ The definition of the call is Established means that the call is set up completely by the setup channel.

→ If there is a possibility of call drop due to no available voice channels, this is counted as blocked call not a dropped call.

→ If there is possibility that a call will drop due to the poor signal of the assigned voice channel, this is considered a dropped call.

→ This case can happen when the mobile or portable units are at a stand still and the radio carrier is changed from a strong set up channel to a weak voice channel due to the selective frequency fading phenomenon.

→ The perception of dropped call rate by the subscribers can be higher due to

1. The subscriber unit not functioning properly.

→ 2. The user operating the portable unit in a vehicle.

3. The user not knowing how to get the best reception from a portable unit.

→ The dropped call rate can be calculated by taking the following factors into considerations.

1. Signal coverage that all the received signal will be above a given signal level.

2. Co-channel and adjacent channel interference levels.

3. The response time of the handoff.

4. Signaling of the handoff and the MATTO algorithm.

→ The relationship among the voice quality, system capacity and cell dropped rate can be Expressed through a common parameter C/I.

→ Radio capacity m is Expressed as follows

$$m = \frac{B_T/B_C}{\sqrt{\frac{2}{3}(C/I)_S}}$$

→ where B_T/B_C is the total number of voice channels.

→ $[C/I]_S$ is a required C/I for designing a system

$$[C/I]_S = \frac{3}{2}\left[\frac{B_T/B_C}{m}\right]^2 = \frac{3}{2}\left[\frac{B_T}{B_C}\right]^2 \cdot \frac{1}{m^2}$$

Formula of dropped call rate :-

→ The general formula of dropped call rate p in a whole system can be Expressed as

$$p = 1 - \left[\sum_{n=0}^{N} \alpha_n x^n\right] = \sum_{n=0}^{N} \alpha_n \cdot P_n$$

where $P_n = 1 - x^n$

And $x = [1 - S)(1 - M)(1 - \theta_T)(1 - B]^2$

→ P_n is the probability of a droppedcall when the call has gone through 'n' handoffs and

S = Probability that the signal is below the specified receive threshold. (in- noise limited system)

M = Probability that the signal is below the specified cochannel interference (in an interference limited system)

T = Probability that no traffic channel is available upon handoff attempt when moving into a newcell.

θ = Probability that the call will return to the original cell.

B = Probability of blocking circuits between BSC & MSC during handoff.

d_n = The weighted value for those calls having n handoff's

$$\sum_{n=0}^{N} \alpha_n = 1$$

N = N is the highest number of handoffs for those calls.