UNIT V

HANDOFF AND DROPPED CALLS

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HANDOFFS

- The handoff is an important cellular concept that is implemented on voice channels.
- To maintain a call in progress in spite of movement of subscriber from one cell to another cell handoff is applied.
- Handoff is required in two main situations.
  1) At a cell boundary (Signal strength – 100dB)
  2) Whenever the mobile reaches a hole/gap within the cell.

HANDOFF INITIATION

- In the cell site the signal strength is continously monitored using a reverse voice channel. Depending on the strength the decision for handoff is made.
- If the signal strength reaches a level that is higher than the threshold level set for minimum voice quality, cell site will request the switching office (MTSO) for handoff to continue the call.
- Occurance of handoff either earlier or later can be determined by intelligence within the call site also.
- Now two points have to be considered and they should be avoided,
  1) An unnecessary handoff will be requested if the handoff decision is very early.
  2) A failure handoff would result if the handoff decision is very late.
- Thus the decision for a handoff on call should be perfect depending on accuracy of signal strength measured.
- The threshold can be determined by two parameters namely velocity of vehicle 'v' & the pathloss 'r' in the pathloss curve.

- Assume the threshold level is -100 dBm at cell boundary. To have a handoff here the signal strength level should be higher than -100 dBm (Δ).
- If signal strength is = -100 dBm + Δ dB then a request for handoff will be initiated. The value of Δ should not be too large or too small so that proper handoff initiation at right time will be made.
- we can calculate the velocity V of the mobile unit based on the predicted level-crossing rate (LCR) at a -10 dB level with respect to the root-mean-square (rms) level, which is at -90 dBm; thus

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

where η is the LCR (crossing per second) counting positive slopes and λ is the wavelength in feet.

$$V(\text{mi/h}) \approx \eta\,(\text{crossings/s}) \text{ at } 850\,\text{MHz} \text{ & } -10\text{-dB level.}$$

- Handoff may be necessary but can't be done at following cases
  1) mobile is at signal strength hole & not at cell boundary.
  2) If the mobile is at cell boundary but no channel in the new cell is available to make handoffs.
- In these cases MTSO has to take step to make handoff faster before a dropped call occurance.

Type of HANDOFF

There are two main types of handoff available.

a) Handoffs based on the Signal strength (SS)

b) Hand off based on the carrier-to-interference (C/I)

- In Type(a), the signal-strength threshold level for handoff is -100dBm in noise-limited systems and -95dBm in interference limited systems.
- In Type(b) the value of C/I at the cell boundary for handoff should be 18dB in order to have toll quality voice.
- Received Signal Strength (RSS) = C + I

  where C → Carrier Signal power

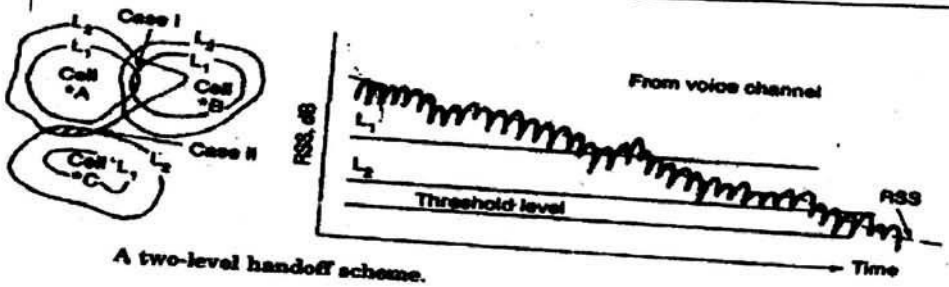
  I → Interference level
- If C/I drops in a cell and if the occurance of handoffs is dependent on C/I then in this case as a response to drop C/I either the propagation distance or interference will increase.

> Delayed Handoff.

- when a base station wants to handover the call to the base station of new cell where the Subscriber enters, the new base station will accept it & takes call control.
- This Smooth handoff is possible only if the new cell is free to take it. If there the cell not available (free) then the handoff will be delayed. This is known as delayed handoff.

Two-handoff-level algorithm

- The purpose of creating two request handoff level is to provide more opportunity for a successful handoff.



A two-level handoff scheme.

- The plot of average signal strength is recorded on the channel received signal-strength indicator (RSSI) 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 (a weak spot in a cell) or a neighbouring cell is busy, then 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 handles the handoff call first and the originating calls second. If no neighboring cells are available ~~could~~ once after the second handoff level is reached, the call continues until the signal strength drops below the threshold level; then call is dropped. If the Supervisory Audio tone (SAT) is not sent back to the cell site by the mobile unit within 5s the cell site turns off the transmitter.

Advantages of Delayed handoff

1) If the neighbouring cells are busy delayed handoff helps to continue the call in progress smoothly till the new cell gets free

2) In two-handoff-level algorithm only after the second handoff the call will be dropped. Thus probability of call blocking is very less.

3) This algorithm also makes handoff to take place at correct location

4) The algorithm minimizes interference in the system.

> FORCED HANDOFFS.

- A forced handoff is defined as a handoff which would normally occur but is prevented from happening, or a handoff that should not occur but is forced to happen.

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.
- Thus handoff threshold level in cell site may be high or low according to the order of MTSO given to cell sites. Depending upon the instructions of MTSO either earlier or delayed handoff would take place in the cell.

- The advantage of this method is to have an efficient mobility management.

Mobile Assisted Handoff

- The mobile assisted handoff (MAHO) provides the biggest advantage of faster handoffs than normal handoff procedure.
- MAHO is much suitable to microcellular arrangements where the number of handoffs are more. The handoff decisions in MAHO are mobile assisted.

Principle of MAHO

- Here the mobile stations calculates the power received from its surrounding base station and it reports the measured results to its serving base station.
- when the power received from a neighbouring cell's base station exceeds the power level of the currently serving base station then a handoff will be initiated
- The MAHO techniaue enables faster handoffs in digital cellular systems & efficient than IG analog systems.
- In normal handoff method the handoff request depends on the supervisory audio tone (SAT) or the signal strength at the cellsite
- The signal strength of setup channel are being monitored in digital systems. The MSC has to select the appropriate neighbouring cell to handover the call with the help of intelligent information.

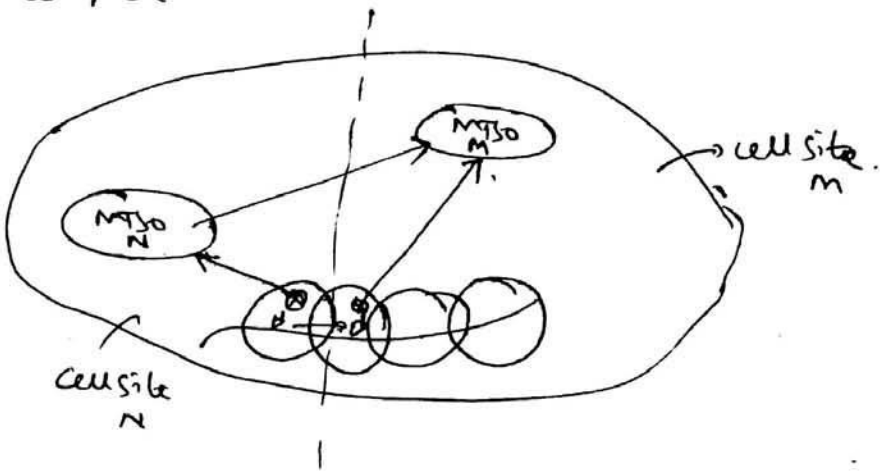
Soft handoff

- The soft hand is applied to the CDMA digital cellular standards. In these CDMA standards they use same carrier frequency.
- Every subscriber is assigned a uniaue code. The CDMA guarantees high degree of security.
- The value of frequency reuse factor N is one in cellular systems using CDMA technique.
- The change is from one code to another code and not from one frequency to another frequency since same carrier frequency is being used. Here no hard handoff is used.
- The handoff in CDMA systems are known as soft handoff.
- If two CDMA Radio frequencies are operated in one cell then soft handoff from cell to cell may be difficult and such cases an intra-cell hard handoff followed by inter-cell soft handoff technique will take place.

Intersystem Handoff

- when a call handoff can be transferred from one system to another system to continue a call in progress it is called as intersystem handoff
- The MTSO maintains a software to take care of this handoff situation linking two different systems.
- Consider the following example. A subscriber in a vehicle moves from one system(M) to another(N).
- A MTSO M is linked to the current base station & call is initiated.
- But as the system enters another system before termination the handoff is transferred to the new system & new MTSO

N receives the handoff control from MTSO M.
- Thus handoff is transferred from cellsite M to cellsite N.
- For doing this operation first the MTSO M searches for the right cellsite, and makes a handoff request to it, now MTSO N provides a dedicated line for the handoff and helps to complete the handoff successfully.



- Thus before implementing inter-system handoff the compatibility of the MTSO's has to be checked in the design level itself.

Dropped call

- It is after the call is established but before it is smoothly terminated
- That is a completely established call by set-up channel is dropped out before the smooth termination.
- when their is no voice channel availability, a call can't progress. Such a condition is known as blocked call since it has not received a free channel. But dropped call is different from blocked call. occurance of dropped call is an undesirable cellular situation which we donot want in a system.

Dropped call Rate

- If the no. of dropped calls are more in a system it expresses a less efficient cellular system. Thus the cellular system should try to avoid dropped calls and it should serves all the call communications.
- The dropped call rate deals with the number of dropped call in a time 't' in the cellsite. It is a parameter to measure system efficiency.
- The dropped call rate increases due to any one of the following reasons.
  (i) The mobile unit is not functioning correctly.
  (ii) If the subscriber doesn't know how to operate
  (iii) If the subscriber operates the unit in a moving vehicle.
- The voice quality of the speech signal is inversely proportional to the dropped call rate. The dropped call rate has to be designed for having desired voice quality. Some of the factors to be dealt in this connection are listed below.
  a) percentage of signal coverage
  b) calculation of adjacent channel interference and co-channel interference in worst case of interference during busy hour.
  c) Response time of handoff in the system.
  d) Handoff signalling & MAHO measurements.

Analysis

- Let radio capacity be 'r'

It is given by $r = \dfrac{B_T/B_C}{\sqrt{\frac{2}{3}\left(\frac{C}{I}\right)_s}}$ (for six co-channel interference)

where B_T/B_C is total no. of the voice channels.

- The equation of 'r' mentioned above is for a worst case of six interference in busy hour.
- The 'r' is rewritten in terms of (C/I) as

$$m^2 = \frac{(B_T/B_c)^2}{\frac{2}{3}(C/I)_s}$$

$$\left(\frac{C}{I}\right)_s = \frac{(B_T/B_c)^2}{(2/3)} \cdot \frac{1}{m^2}$$

$$= \frac{3}{2}\left(\frac{B_T}{B_c}\right)^2 \frac{1}{m^2}$$

Thus the voice quality is based on C/I

→ If measured C/I < designed $(C/I)_s$.

Then there will be both dropped calls & poor voice quality taking place.

Total dropped - call Rate

- let the handoff blocking be B_1, the probability of the lost supervisory audio tone calls be B_2, and the probability of occurance of unsuccessful handoff be B_3. The total dropped call rate (B_{dc}) in this case would be

$$B_{dc} = B_1 + B_2(1-B_1) + B_3(1-B_1)(1-B_2)$$

In general the dropped call rate will be < 5%.