Lecture 7: Frequency Reuse Concepts

Dwell Time

Dwell time is the time that an active call is maintained within a cell without handing it off to another cell or dropping it. Dwell time is a form of statistics that are very useful for determining the proper time of performing a handoff. Consider for example the case where the dwell time of all calls in a specific cell is 5 minutes (this is just a theoretical assumption). Such information tells us that any call will certainly have to be handed off after 5 minutes. If the dwell time of the cell is a random number between 4 and 5 minutes, this will inform us that no handoffs should take place before 4 minutes and all remaining calls must be handed off once they reach 5 minutes. This is a clear indication of the importance of the dwell time in determining proper handoff times.

The dwell time is determined by:

- Propagation path
- Interference
- Distance to base station (tower)
- Speed of mobile station
- Many other time varying factors

Dwell time may be finite even for stationary mobile units because of other objects around the tower or mobile phone moving.

We usually notice two dwell time situations:

1. For mobile units traveling on a highway
   - These mobile units usually receive good coverage
   - Speeds are usually constant
   - Mobile units usually face no obstacles
   - Mobile units travel over fixed and well defined paths

   Because of these, the towers covering highways usually have random dwell times that are concentrated around the average dwell time.

2. For mobile units in dense environments:
   - Mobile units often move randomly inside the cell
   - No clear paths for mobile units are defined
   - Some mobile phones may never leave the coverage area of the cell for very long periods of time (the owner of the phone lives in the cell)

   For these points, the towers covering dense environments have dwell times that are widely spread around the average dwell time.

Handoffs in First Generation Mobile Systems

First generation mobile systems had the following:

- Only base stations made signal strength measurements using reverse channels
- Another receiver (called locator receiver) made signal strength measurements on mobile units in adjacent cells and reported to MSC
- The MSC monitored the signal strengths from all base stations and determined relative location of mobile units
- MSC determined which mobile units to handoff, to which cell will handoff go, and at what time.
- Due to large number of measurements and high computational load, the MSC was computationally overloaded and handoff sometime took 5 to 10 seconds to complete resulting in relatively high rate of dropped calls.

Handoffs in Second Generation Mobile Systems

Second generation mobile systems had the following:

- Every mobile measures signal power from surrounding towers using forward control channel and reports this information to the tower it is connected to. This results in what we call Mobile Assisted Handoff (MOHA) where the mobile phone contributes a significant part of the handoff process by performing the power measurements.
- The power measurements are sent to the MSC for processing.
- Handoff occurs when $P_{\text{neighbor}} > P_{\text{current cell}}$ by a specific value or for a specific period of time (to avoid fast fluctuations in signal strengths).
- No power measurements are done by towers.
- MAHO results in reducing the computational power on the MSC significantly and therefore handoffs in second generation systems take 1 to 2 seconds.
- Because of high speed of handoffs, this system is suitable for micro-cell systems

Handoff between Different Systems

When mobile stations move from the home network to another region that is not covered by the home network, an inter-system handoff may occur. Several points must be considered in such a handoff:

- The different networks have different MSCs.
- The mobile unit searches for a tower that belongs to its network first. If it cannot find one, it may request a handoff to a tower of the other network (when the mobile connects to a non-home network, it is said to be ROAMING).

- A local call may become a long distance call or an international call.

Prioritizing Handoffs

As mentioned before, most systems give high priority to handoffs over initiating calls. In this case, the system must make measures that will allow handoffs to be done more than allowing new calls to start. There are several strategies for prioritizing handoffs. Here we briefly discuss two strategies:

1. Guard Channel Concept: in this strategy, each cell of the system reserves few channels for handoffs that are never used for initiating a call. When an handoff becomes necessary to a particular cell, it uses one of these reserved channels for the handoff as long as one of them is still available. If non of them are available but there are other free channels in the cell, a handoff can still take place using one of these channel. However, if all the channels of the cell are fully occupied including the reserved channel, the handoff fails and the call is dropped. The reservation of few channels for handoff reduces the system capacity because of the possibility of all cell channels being occupied while the reserved channels being free but they cannot be used because they are reserved for handoffs.
2. Queuing of Handoff requests: in this strategy, once the received signal power drops below the handoff threshold, a handoff request is initiated. If an available channel exists, the handoff is completed. If there are no available channels, the call is queued waiting for a channel of the system to become free. If a channel becomes available before the signal power drops below the minimum power needed to maintain a call, the handoff is completed. If, however, no channel becomes available before the power level drops significantly, the call gets dropped.