

Lecture 8

CS 621

Mobile Computing

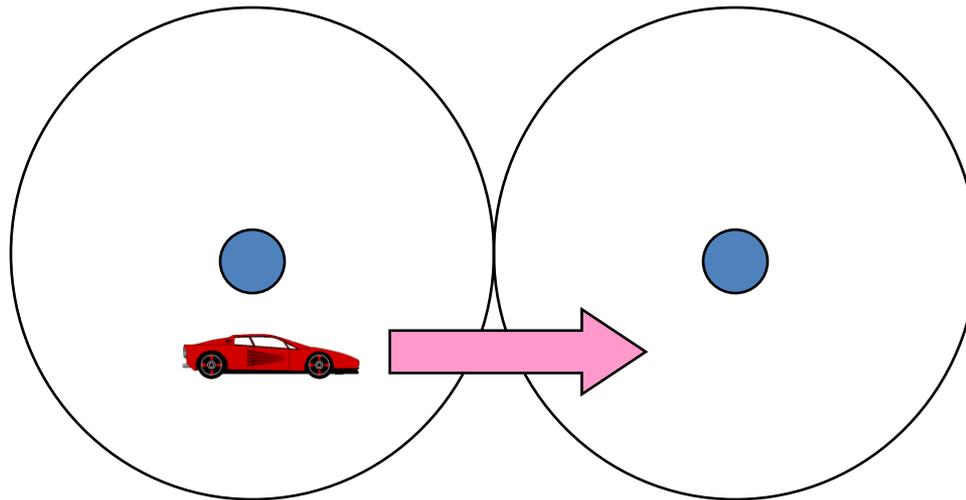
Mobile Cellular Systems

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Several slides and images in this presentation have been taken from Prof. Nityananda Sarma's class notes/ppt.
Several images have been taken from the book Mobile Communication by Jochen Schiller.

Handoff in Cellular Systems

- Handoffs occur when a mobile host starts communicating with a new base station.
- Continuation of an active call when the mobile is crossing cell boundaries



Parameters:

Minimize Forced Termination Probability

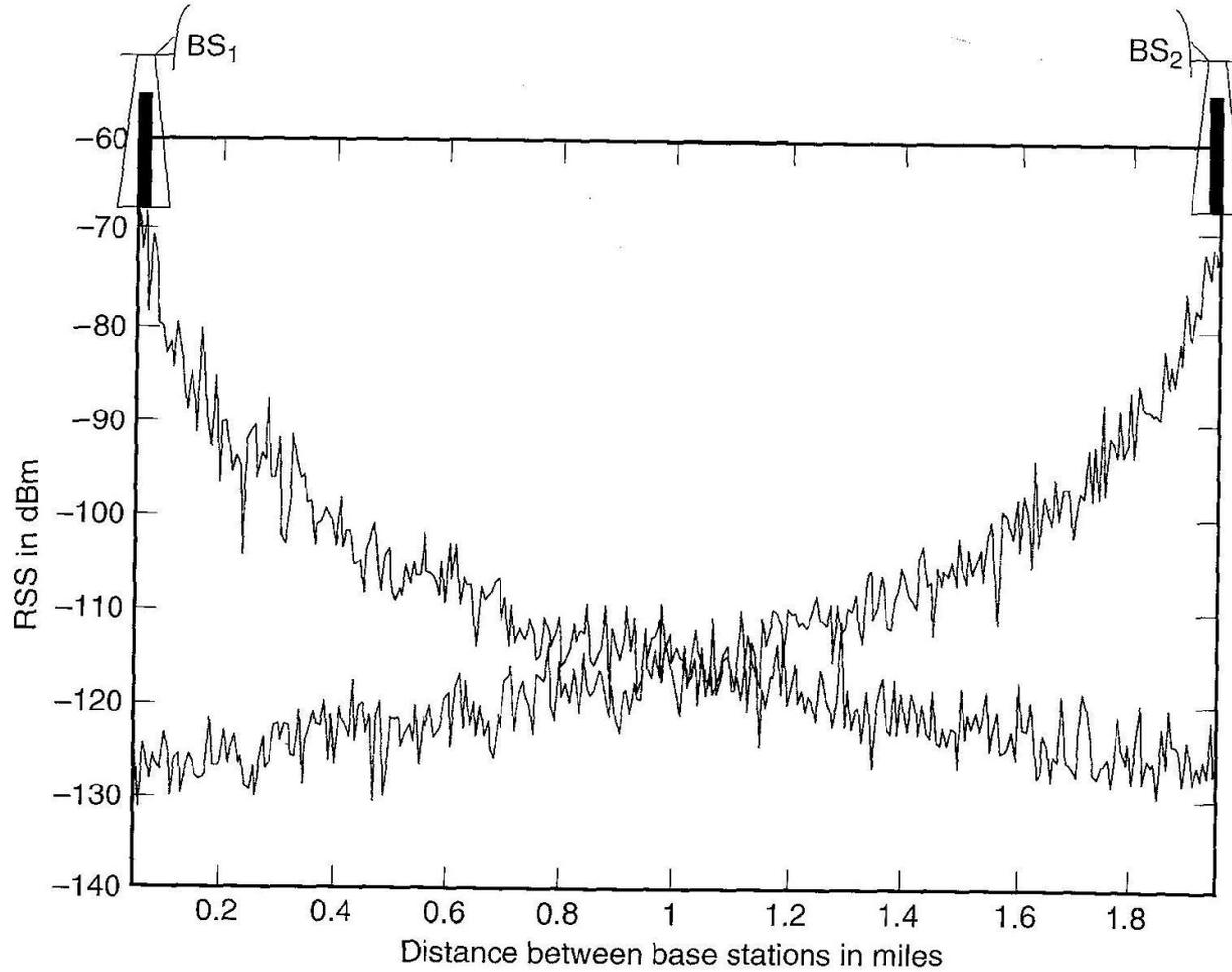
Minimize Call Blocking Probability

More handoffs means more FTP

Handoff (HO) Decisions

- Usually based on **received signal strengths (RSS) from Current BS** and **neighboring BSs**.
 - Handoff occurs when the signal from the serving BS is weak while the signal from a neighboring BS is strong.
 - The received signal strength is averaged over time using an averaging window to remove momentary fading due to geographical and environmental factors.
 - This is to avoid unnecessary HO while ensuring that necessary HO are completed before a call is terminated.
 - Dwell time (time over which a call may be maintained within a cell, without handoff) is also important for HO decisions.
- **Ping Pong Effect (unnecessary HO)**
 - Signal strength fluctuates randomly
 - Several handoffs occur back and forth between two BSs.

Sample RSS



Traditional Handoff Algorithms

Choose B_{new} (i.e. handoff from B_{old} to B_{new}) if

1. $P_{new} > P_{old}$

Relative Signal Strength: The RSSs are measured over time and the BS with strongest signal is chosen to handoff. **Due to signal fluctuations, several handoffs can be requested while B_{old} 's RSS is still sufficient to serve the Mobile Station (MS). So, more Ping-Pong effect and more FTP.**

2. $P_{new} > P_{old}$ and $P_{old} < T$

Relative Signal Strength with Threshold: Introduces a threshold value to overcome the ping-pong effect. Handoff process is initiated if B_{new} 's RSS is stronger than B_{old} 's RSS and B_{old} 's RSS is lower than the threshold (T).

**** Here, P_{new} : B_{new} 's RSS by MS and P_{old} : B_{old} 's RSS by MS**

Traditional Handoff Algorithms

3. $P_{new} > P_{old} + H,$

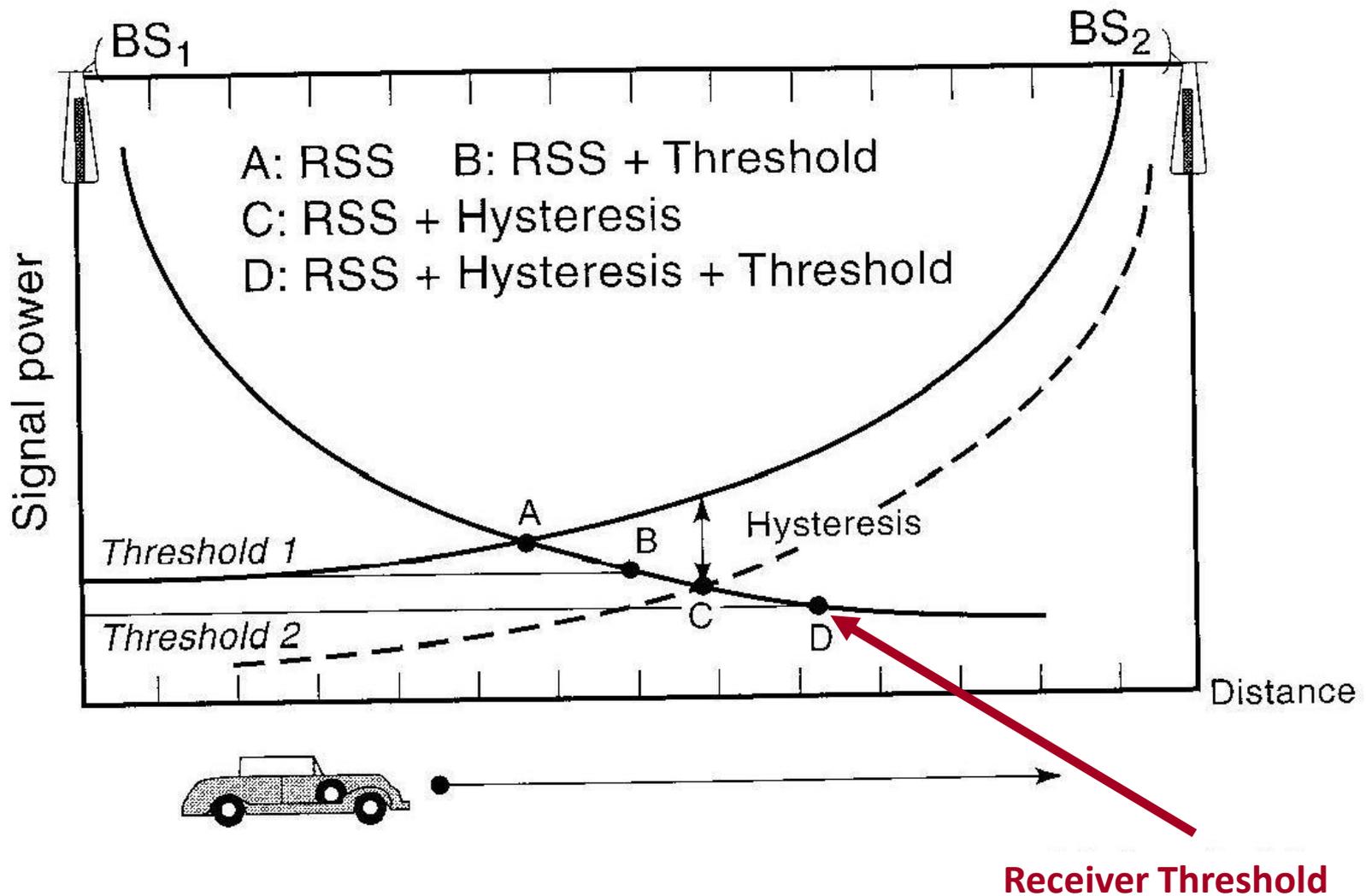
Relative signal strength with Hysteresis: Handoff process is initiated when the B_{new} 's RSS exceeds the B_{old} 's RSS by the hysteresis value H .

4. $P_{new} > P_{old} + H$ and $P_{old} < T,$

Relative Signal Strength with Hysteresis and Threshold: Combines both the threshold and hysteresis values concepts to come with a technique with minimum number of handoffs. The handoff is requested when the B_{old} 's RSS is below the threshold (T) and B_{new} 's RSS is stronger than B_{old} 's RSS by the hysteresis value H .

All the above techniques should ensure initiation of handoff before the B_{old} 's RSS falls below **Receiver Threshold** (minimum acceptable RSS for call continuation). Otherwise ongoing call is dropped.

Example



Handoff

- What happens when a user is mobile?
 - Especially when crossing a cell boundary while continuing the call.
- Handoff strategy is invoked.
 - Find a new base station, allocating new voice and control channel of the new BS
 - Process handoff
 - higher priority over new call invocation, when allocating unused channels in a cell
 - Optimal received signal level to initiate a handoff.
 - **Delta** = $P_{\text{handoff}} - P_{\text{usable}}$, should not be too small or large
 - Large -> unnecessary handoff, small->insufficient time to complete handoff before a call is lost due to weak signal
 - Dropped call also due to excessive delay by MSC (loads, no channels free in nearby cell)

Who and When

- Who initiates handoff
 - **Network Controlled Handoff (NCHO):** Each BS constantly monitors the RSSI of ongoing call (reverse channel) within the cell.
 - A locator receiver (a spare receiver) in BS is used to scan and determine signal strength of mobile users in neighboring cells.
 - MSC decides whether handoff is required or not based on RSSI values from locator receivers.
 - Used in AMPS (1G). Load on network is high. Typically needs 5-10 secs.
 - **Mobile Assisted Handoff (MAHO) :** Each mobile periodically measures the received power from surrounding BSs and continually reports the results to the serving BS.
 - Handoff initiated when the recv power from a neighboring BS exceeds the power recv from the current BS (by a certain amt or for a certain period of time),

Who and When

- MSC decides when to handoff. Used in GSM.
- MAHO enables calls to be handed over between BSs at much faster speed since MSC is not involved in RSSI measurements
- Typically suitable for microcells where HO are more frequent (needs ~ 1sec.)
- **Mobile Controlled Handoff (MCHO):**
 - MS determines handoff.
 - MS make necessary measurements and if the RSS of a surrounding BS exceeds a threshold, it initiates handoff.
 - Used in DECT. Typically needs ~ 100ms.

Who and When

- When to initiate handoff (the reasons for handoff)
 - When the mean signal (over some predetermined time) from the current BS is below some threshold (or by using any one of the previous 4 methods). **That is to avoid termination of calls.**
 - **To release some channels in the current cell, so that new calls can be accommodated**
 - channel used by a mobile affected by another phone using the same channel in a different cell, then the call is transferred to a different channel of the same cell or on a different channel in another cell to avoid interference.
 - To reduce potential interference to other cells/users in Micro cell/ Macro cell based system

Types of Handoff

- **Hard handoff**

- Mobile user is passed between disjoint towers that assign different frequency or adapt different air-interface technology.
- Communication channel is released first and the new channel is acquired later from the neighboring cell.
- Service disruption, reduction in QoS
- Used by systems which use TDMA and FDMA such as GSM and GPRS

- **Soft handoff**

- Mobile user communicates to two or more towers simultaneously and the signal is treated as a multipath signal
- Can establish multiple connections with neighboring cells.
- Used in CDMA systems, where the cells use same frequency band using diff code words.
- Each MS maintains an active set of BSs, where BSs are added and removed based on 2 RSS thresholds. So addition or removal of a BS to the active set is called Soft handoff.
- Used by IS-95 and WCDMA

- **Without handoff**

Types of Handoff

- **Horizontal handoff**

- Mobile user is passed between towers of homogeneous networks
- Example: handoff involving two GSM cells.

- **Vertical handoff**

- Handoff between towers of different types of networks.
- Handoff in heterogeneous networks. More complex compared to Horizontal handoff.
- Example: handoff from one GSM based cell to one WCDMA-based cell .

High priority for Handoff

- In non-prioritization schemes, new calls and handoff calls are treated the same way. Idle channels of BS are assigned due to FCFS basis.
- Does not provide lower forced termination prob
- In order to provide lower forced termination prob, prioritization schemes assigns more channels to the handoff calls.
- Two prioritization schemes are: **Guard Channels (GC)** and **Queuing Handoff calls (QHC)**.

Guard Channels(GC)

- Reserves some fixed or adaptively changing number of channels for handoff calls only.
- The rest of the channels are used by new and handoff calls.
- Forced termination prob (FTP) is decreased.
- *Cost is an increase in call blocking prob, decrease in total carried traffic.*
- BSs can get number of MSs in pre handover zone (PHZ) from neighboring BSs and accordingly reserve that many number of guard channels.
- Assign number of channels adaptively. When FTP exceeds a predefined limit, the guard channel no is increased. The no of guard channels is decreased, in case BS does not use reserved guard channels significantly.

Queuing Handoff Calls (QHC)

- Queues the handoff calls when all of the channels are occupied in a target BS. (Queuing does not guarantee a zero FTP, since large delays will cause RSS to drop below receiver threshold)
- When a channel is released, it is assigned to one of the handoff calls in the queue.
- A new call request is assigned a channel if the queue is empty and if there is at least one free channel in the BS.
- Time interval between handoff initiation and receiver threshold makes it possible to use queuing handoff calls.
- QHC can be used with or without guard channel scheme.

Queuing Handoff Calls (QHC)

- QHC can be timer based:
 - when a channel is released at BS, a timer is started. If a handoff request is done before the timer expires, channel is assigned to it. Otherwise, channel can be assigned to new or handoff calls depending on their arrival order.

Queuing Handoff Calls (QHC)

- **QHC can be Measurement based (MBPS):**
 - Handoff calls are assigned priority dynamically based on the power level they have. Calls with power level close to receiver threshold have the highest priority. Provided better results from FCFS basis. More control overheads.
- **QHC can be Most Critical First based (MCF):**
 - determines the first handoff call that will be cut off and assigns the first released channel to that call. Use simple radio measurements to predict the first cut off call.

Queuing Handoff Calls (QHC)

- QHC can be with guard channels:
 - Both new calls and Handoff calls are queued. A number of guard channels are reserved for handoff calls. When new calls are congested, a channel from guard channels is used if it is available. Decreases CBP while increasing FTP slightly.
- QHC can also be used in 2-tier cellular networks using microcell/macrocell tier. FIFO queue can be used in either microcell or in macrocell.

Other problems with handoff

- High speed vehicles can cross many “small” cells in a short time (**due to wide range of mobile velocities**).
 - Umbrella cell which is co-located with some smaller microcells. Large cell with a powerful tower to handle high speed vehicles (Macrocell/Microcell concepts).
 - **No. of handoff is minimized for high speed devices and provide additional microcell channels for pedestrian users.**
- **Another problem is called cell dragging.**
 - Happens when the user (in Line of Sight) moves slowly away from the cell and the tower didn't recognize it due to strong average signal. (**RSS at B_{old} may be above handoff threshold, so no HO**)
 - Creates interference and traffic management problem because users has meanwhile traveled deep within the neighboring cell.

THANKS!