Handover in Mobile systems
Agenda

• Introduction
• Handover theory
• GSM Handover
• UMTS Handover
• Inter RAT Handover
• Handover and performance
Introduction

What is Handover (Handoff)?

• Changing the point of connection while communicating
• In another words:

  When a mobile user travels from one area of coverage or cell to another cell within a call’s duration the call should be transferred to the new cell’s base station

Why handover is needed?

• Mobility
• User preferences
Introduction – Use Case 1

1. Connect to BS1 and start conversation
2. Moving out of BS1’s coverage – connect to BS2
3. Moving out of BS2’s coverage – connect to BS3
4. Conversation ended – still within BS3’s coverage
Handover

- When will a handoff occur?
  - Initiated when received signal level drops below a certain threshold value.
  - Not as simple as it seems
  - Actually consider a time average of the received signal instead of the instantaneous level.
Handover Theory

• Define
  • \( P_{\text{MIN-USABLE}} \) as the minimum usable signal level
  • \( P_{\text{HANDOFF}} \) as the threshold received signal level at which a handoff will be initiated
  • \( \Delta = P_{\text{HANDOFF}} - P_{\text{MIN-USABLE}} \)
Handover

• Must optimize $\Delta$.
  • Too large $\Rightarrow$ too many handoffs
  • Too small $\Rightarrow$ too many lost calls
• Value of $\Delta$ depends on
  • Environment
  • Expected mobile speeds
  • Time required to perform a handoff
Handover - Successful

![Diagram showing the concept of handover with signals levels and thresholds.](image)
Handover - Unsuccessful

- Received signal level
- Level at point A
- Handoff threshold
- Min. acceptable signal
- Level at point B
- Time

\( \Delta \)
Handover in GSM

GSM/GPRS reference model

- TE – Terminal Equipment
- PDN – Public Data Network
- SGSN – Serving GPRS Support Node
- GGSN – Gateway GPRS support Node
Handover in GSM

- Network-controlled, mobile terminal assisted handover
  - The network takes the handover decisions
  - The mobile terminal supervises and reports its signal quality

- Four types of handover
  - Intra BTS handover
  - Intra-BSC handover
  - Inter-BSC handover
  - Inter-MSC handover
Intra BTS Handover

- The ME remains attached to the BTS transciever.
- Changing just the frequency or the slot used by the ME

References: GSM Networks book by Heine, GSM book by Mouly and Pautet,
Intra BSC Handover

- Or named as Inter BTS Handover
- Occurs when moving from one BTS coverage area into another BTS
- Both BTS are controlled by the same BSC
- The BSC assigns the new channel and slot for the ME.
Inter BSC Handover

- Occurs when moving from one BTS coverage area into another BTS.
- Both BTS are controlled by different BSC.
- This Handover is managed by the MSC.
Inter MSC Handover

- Occurs when moving from one BTS coverage area into another BTS.
- Both BTS are controlled by **different** BSC.
- Both BSC are controlled by **different** MSC.
- The two MSC negotiate to handle the **handover**.

![Diagram of Inter MSC Handover]
Handover in UMTS

For purely inter W-CDMA technology, there are three basic types of handover:

• Hard Handover
• Soft Handover
• Softer Handover
Hard Handover

• Break Before Make
• The network decides a handover is required dependent upon the signal strengths of the existing link, and the strengths of broadcast channels of adjacent cells.
• The link between the existing NodeB and the UE is broken.
• A new link is established between the new NodeB and the UE.
Soft Handover

- Occurs when the ME is moving in the overlapping coverage area.
- The ME communicate and receive the signals from the NodeB’s which their signals are overlapping.
- The rake receiver is needed in the UE (ME) to combine the two signals.
- In the uplink, the best quality frame of the two signals is selected. The selection is made by the outer loop power control algorithm measurement.
- Negatives: It needs to indicate resources (capacity) on both NodeBs.
Softer Handover

- Softer handover is a special case of soft handover where the radio links that are added and removed belong to the same Node B.
- In softer Handover, the NodeB can receive the signal in macro diversity with maximum ratio combining.
- In soft handover macro diversity with selection combining is selected.
Softer Handover

Soft Handover
Handover between GSM-WCDMA

- Limited UMTS coverage
- UMTS network busy whereas spare capacity is available on GSM network
- Two types of Inter RAT handover:
  1. GSM to UMTS
  2. UMTS to GSM
UMTS to GSM handover

1- Compressed mode handover: Using compressed mode handover the UE uses the gaps in transmission that occur to analyse the reception of local GSM base stations. The UE uses the neighbour list provided by the UMTS network to monitor and select a suitable candidate base station. Having selected a suitable base station the handover takes place, but without any time synchronisation having occurred.

2- Blind handover: This form of handover occurs when the base station hands off the UE by passing it the details of the new cell to the UE without linking to it and setting the timing, etc of the mobile for the new cell. In this mode, the network selects what it believes to be the optimum GSM based station. The UE first locates the broadcast channel of the new cell, gains timing synchronisation and then carries out non-synchronised intercell handover.
Figure 2
Compressed mode creates gaps or idle spaces in time that WCDMA mobile terminals use to perform measurements on GSM cells.

Handover from WCDMA to GSM.

- Measurement report
- Relocation required (Inter-RAT handover info)
- Handover request (Inter-RAT handover info)
- Handover request ack (Handover command)
- Handover access
- Handover detect
- Handover complete
- lu release command
- lu release complete
GSM to UMTS

- **Handover from GSM to UMTS**: This form of handover is supported within GSM and a "neighbour list" was established to enable this occur easily. As the GSM / 2G network is normally more extensive than the 3G network, this type of handover does not normally occur when the UE leaves a coverage area and must quickly find a new base station to maintain contact. The handover from GSM to UMTS occurs to provide an improvement in performance and can normally take place only when the conditions are right. The neighbour list will inform the UE when this may happen.
Handover from GSM to WCDMA.
Handoff and performance

- Handoffs are expensive to execute, so **unnecessary handoffs should be avoided**.
- If the handoff criteria are not chosen appropriately, then in the overlapping region between the two BS coverage area boundaries, the call might be handed back and forth several times between them.
- If the criteria are too conservative, then the call may be lost before the handoff can take place.
- The handoff **decision-making criteria** become even **more critical with the evolution to smaller cell sizes**, which is happening to increase the capacity of systems and to reduce power requirements of MSs.
- Unreliable and inefficient handoff procedures will reduce the quality and reliability of the system.
Handoff Failures

• The reason of handoff failures
  • No channel is available on selected BS.
  • Handoff is denied by the network for reasons such as lack of resources. For example, no bridge or no suitable channel card; the MS has exceeded some limit on the number of handoffs that may be attempted in some period of time.
  • It takes the network too long to set up the handoff after it has been initiated.
  • The target link fails in some way during the execution of handoff.
Q&A

Thank You

UMTS handheld 2 frequencies
2700 MHz  60 MHz
UMTS 900
LTE 700
LTE 800, 900, 1800

Quality

PR
BER, FER
Interference