GSM Network
RF Optimization Workshop
AGENDA

- Introduction
- Single Band Optimization Philosophy
- Network Optimization Process
- Optimization Phases
- Lucent BSS Optimization Parameters
- Cell Selection/Cell Reselection
- Power Control
  - Procedures
- Handover
  - Procedures
- Drive Testing and Analysis
- Drive Test Equipment
Introduction

● What is Optimization?

  - Activity of achieving and maintaining the required quality as designed

● Why Optimization?

  - Deviations between plan and reality
What is Optimization?

- Design
- Planning
- Implementation
- Optimization
Why Optimization?

- **Inaccuracy of radio planning**
  - Statistical variations in the path loss characteristics
  - Finite terrain database resolution

- **Implementation**
  - Antenna radiation pattern and effective radiated power
  - Antenna pattern distortion

- **Environment**
  - Seasonal environmental changes, e.g. trees, leaves
  - Environmental changes such as new highways, new buildings
**Single Band Optimization Philosophy**

- **Coverage** - Good signal level across the whole cell, coverage holes within a cell's service area must be minimized.

- **Interference** - A reasonable level of interference must be contained at cells service area in order to provide a quality air-interface.

- **Handover Behavior** - The quality of the air-interface in a cell with respect to handover behavior is good, no unnecessary handovers, Rx quality at acceptable level, BTS & MS use minimum transmit power.

- **Traffic Distribution** - The quality of the air-interface in a cell with respect to traffic distribution is good, maximum amount of traffic can be handed.
**Optimization Phases**

- **Initial Optimization**
  - Site Audit
  - Proper Parameters use
  - Verify Neighbors list
  - Reviewing Frequency Plan
  - Verify existing coverage, site design objectives
  - Analysis & Identification of Problem areas/cells
    - from PMS & drive test statistics,
    - customer complaints
  - Prioritization of problems
  - Identify Solution and Implement
  - Retest the problem areas
  - Consistency Check of the OMC database
  - Fine-tuning of parameters

- **Primary Optimization**

- **Maintenance Optimization**
  - On going process, weekly optimization
  - Database maintenance and consistency audits

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Slide No.7
**BSS parameters related to Optimization**

- CELL (RE) SELECTION
- POWER CONTROL
- HANDOVER CONTROL
Areas of improvement:

- Minimization of interference
- Handover behavior improvement
- Traffic distribution
Cell (Re)Selection

2 cell (re)selection criteria:

C1 & C2
Cell (Re)Selection

C1 Criteria
Used for cell selection and re-selection

C2 Criteria
Used in a *hierarchical* cell structure for re-selection only
Cell (Re)Selection

C1 = (A - Max(B, 0))

where:

A = Received Level Average - RXLEV_ACCESS_MIN
B = MS_TXPWR_MAX_CCH - max.output power of the MS

Criteria met if C1 > 0. MS will camp on to the cell with the highest C1 value.
Cell Reselect Hysteresis

LAC 1

Location Update 1

Location Update 2

LAC 2
Cell Reselect Hysteresis

Reselect Hysteresis LAC1

Reselect Hysteresis LAC2
<table>
<thead>
<tr>
<th>Signal Level</th>
<th>Range (in dBm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$Rx_{level} &lt; -110$</td>
</tr>
<tr>
<td>1</td>
<td>$-110 &lt; Rx_{level} &lt; -109$</td>
</tr>
<tr>
<td>2</td>
<td>$-109 &lt; Rx_{level} &lt; -108$</td>
</tr>
<tr>
<td>3</td>
<td>$-108 &lt; Rx_{level} &lt; -107$</td>
</tr>
<tr>
<td>..</td>
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<tr>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>62</td>
<td>$-49 &lt; Rx_{level} &lt; -48$</td>
</tr>
<tr>
<td>63</td>
<td>$Rx_{level} &gt; -48$</td>
</tr>
</tbody>
</table>

**SIGNAL LEVELS**
## SIGNAL QUALITY LEVELS

<table>
<thead>
<tr>
<th>Signal Quality</th>
<th>Range (in BER)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>BER &lt; 0.2</td>
</tr>
<tr>
<td>1</td>
<td>0.2 &lt; BER &lt; 0.4</td>
</tr>
<tr>
<td>2</td>
<td>0.4 &lt; BER &lt; 0.8</td>
</tr>
<tr>
<td>3</td>
<td>0.8 &lt; BER &lt; 1.6</td>
</tr>
<tr>
<td>4</td>
<td>1.6 &lt; BER &lt; 3.2</td>
</tr>
<tr>
<td>5</td>
<td>3.2 &lt; BER &lt; 6.4</td>
</tr>
<tr>
<td>6</td>
<td>6.4 &lt; BER &lt; 12.8</td>
</tr>
<tr>
<td>7</td>
<td>BER &gt; 12.8</td>
</tr>
</tbody>
</table>
Handover Control

TYPES OF HANDOVERS

- Mandatory HO
  - RXQUAL
  - RXLEVEL
  - DISTANCE

- Power Budget HO

- Duration of stay counter (Hierarchical Cell)

Preprocessing to support the following handover types:

- Internal Intra-Cell Handover (BSC-controlled)
- Internal Inter-Cell Handover (BSC-controlled)
- External Inter-Cell Handover (MSC-controlled)

- Inter Cell Handover may occur from:
  - SDCCH to SDCCH
  - SDCCH to TCH (directed retry)
  - TCH to TCH
Handover Control

Rxlevel (received by MS)

SERVER

NEIGHBOR

Handover Margin

Power Budget Handover Margin
## Handover Procedures

### HO Process
- BTS measures the UL and DL measurements every 480 ms.
  - RXLEV-XL
  - RXQUAL-XL
  - RXLEV-NCELL(1-6)
  - DIST (timing advance)
- BTS reports measurements to BSC.
- BSC calculates the averaged parameters using a sliding window:
  - AV-RXLEV-HO
  - AV-RXQUAL-XL-HO
  - AV-RXLEV-SCELL
  - AV-RXLEV-NCELL(I)
  - AV-DIST
- BSC decides the HO execution by comparing with threshold values.

### Handover Algorithm Basic Steps
- HO Measurement Averaging (Preprocessing)
- HO Threshold Comparisons
- HO Target Cell Identification
- HO Decision (BSC internal or MSC)
- HO Execution (BSC internal or MSC)
**BSS Optimization Parameters**

### Performance Determinants
- Coverage
- Interference
- Handover Behaviour
- Traffic Distribution

### Optimization Solutions
- Enable/Disable GSM features
- BSS parameters
- Neighbour cell lists
- Antenna tilt, height & azimuth
- Frequency changes

### Discontinuous Transmission
- Decreases interference level
- Saves battery power (uplink)

### Frequency Hopping
- Decrease interference
- Suppress Rayleigh Fading

### Power Control
- Saves battery power
- Decrease interference level
### Network Parameter and Performance Determinants

<table>
<thead>
<tr>
<th>Performance Determinants</th>
<th>Adjustments</th>
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<tbody>
<tr>
<td><strong>Coverage</strong></td>
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<tr>
<td><strong>Interference</strong></td>
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<tr>
<td><strong>HO Behavior</strong></td>
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<tr>
<td><strong>Traffic Distribution</strong></td>
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<tr>
<td><strong>Enable GSM Features</strong></td>
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<tr>
<td><strong>BSS Parameters</strong></td>
<td></td>
</tr>
<tr>
<td><strong>N'bour Cell List</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Antenna Tilt, etc</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Frequency Change</strong></td>
<td></td>
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<td>Traffic Distribution</td>
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Drive Testing and Analysis

• **Trouble Ticket**

  - Is a document by which various problems reported by customers are passed along through the organization

  - Must reply upon experience and knowledge to determine which option to overcome the problem

  - Different scenarios can be followed to solve the problem, such as drive testing, parameters changes, antenna adjustment, etc..

  - To verify if the problem is not related to MS itself
Drive Testing and Analysis

- Air Interface Information
  - RXLEVEL
  - RXQUALITY
  - BCCH, BSIC of the serving cell
  - BCCH, BSIC and RXLEVEL of the 6 best neighbours
  - TIMING ADVANCE
  - GSM BEST SERVER
Drive Testing and Analysis

- Drive Testing
  - Propagation Measurements

- Mobile Network Performance Monitoring
  - Quality Assessment
  - Optimization
Drive Testing and Analysis

**Drive Tests for Optimization**

- Initial network coverage verification and benchmarking
- Verification before and after changes
- Locating and measuring interference
- Locating areas where traffic problems exist
- Locate coverage holes
- Preventive maintenance
- Simultaneous measurements of the other networks
Drive Testing and Analysis

Drive Test Data Collection

- CELL ID including BSIC, LAC, and time slot
- RXLEVEL for the serving and the neighbour cells
- RXQUALITY for the serving cell
- BCCH, BSIC for the serving and the neighbour cells
- TIMING ADVANCE
- TRANSMIT POWER
- GPS POSITION DATA
- TIME STAMPS
Drive Testing and Analysis

Drive Test Route Planning

- **Primary route (street level)**
  Includes all major roads, highways and wide thoroughfares

- **Secondary route (street level)**
  Includes all streets, subdivisions and compounds when accessible

- **Miscellaneous routes (in-building and special locations)**
  Includes golf courses, beach resorts, shopping malls, department stores, convention centers, hotels and resorts
Drive Testing and Analysis

Performance Problems that often encountered:

- Cell Dragging
- Dropped Calls
- Ping-Ponging
- System Busy
- Handover boundary
**Drive Testing and Analysis**

**Cell Dragging** - Calls may drag a cell beyond the desired handover boundary. This might result dropped calls or bad Rx quality.

**Suggestions:**

- Create an appropriate neighbour cell list
- Change HO parameters such as thresholds, margin, cell baring, etc
- Check serving cell’s cell identifier in the neighbour cell’s neighbour list
- Check neighbour cell’s BCCH, BSIC, LAC, Cell ID, etc
Drive Testing and Analysis

**Dropped Calls** - Caused by either RF environments or incorrect system parameters

**Suggestions:**

- Check if an appropriate neighbour cell list is defined
- Check HO parameters
- Existing or new coverage holes
- Interference, Co-channels, Adjacent channels or External interference
- Serving cells might go down, coverage smaller as before
- Abnormalities such as call setup failure
Ping Ponging - Serving keep changing and as a result of bad audio quality

Suggestions:

• Check if an appropriate neighbour cell list is defined
• Check HO parameters
• Interference, Co-channels, Adjacent channels or External interference
• Lack of dominant server
• Poor coverage
• Not optimal antenna configuration
Drive Testing and Analysis

System Busy - System busy on several call attempts and site appears consistently on the traffic report

Suggestions:

Short Term
• Reduce the traffic on the congested cell/site. However, the proposed changes MUST NOT create any unacceptable problems such as coverage holes, dropped calls, etc

Shot term solutions are re-design the antenna configuration, Add additional RTs, Change BTS configuration

Long Term
• Build a new cell site to off-load traffic
Handover Boundary - Handovers do not occur at the desired HO boundary, the result is an imbalance in traffic distribution across the system

Suggestions:
• Check if an appropriate neighbour cell list is defined
• Check HO parameters
• Inappropriate antenna configurations of the serving and neighbour cells
• Interference, Co-channels, Adjacent channels or External interference
• No TCH available (neighbour cells congestion)
Drive Test Equipment

Typical example of drive test equipment components:

- Test Mobile phone
- Scanning receiver
- Transceiver system
- Antennas
- GPS
- Visual display unit
- Microphone
- Loudspeaker box
- Laptop computer
**Drive Test Equipment**

**ERICSSON TEMS 900/1800**
- Test 2 Network simultaneously
- Full Layer 2 & 3 decoding
- Control of Layer 3 msg
- Forced selection of idle and dedicated mode
- Filtering msg streams
- Rxqual in idle mode
- Sending SMS
- SIM card information

**COMARCO WIRELESS**
- Test 4 networks simultaneously
- GSM 900/1800, ETACS, AMPS
- Partial Layer 2 & 3 decoding
- Fast scanning receiver, GSM RF Spectrum
- Ability to display adjacent channel interference screen
- Noise measurements

**SAFECO WALKABOUT**
- In-building coverage
# Drive Test Equipment

## AGILENT TECHNOLOGIES(HP)
- Test 4 networks simultaneously
- Fast scanning receiver, UL & DL
- Frequency Hopping Table
- Spectrum Analysis
- Channel Power
- CW Measurement
- Interference Measurement
- GSM Broadcast Channel Analysis

## QVOICE98
- Test 4 networks simultaneously
- Evaluate measurement both way
- Good Presentation
- Capable on measuring MOS, Speech Quality, Rxquality, Rxlevel