HIGH CAPACITY ADAPTIVE BASE-STATION ANTENNA SYSTEMS

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Outline

• Background
• Adaptive Antenna Systems
  GSM (Global Systems for Mobile Communications)
  GPRS (General Packet Radio Service)
  EDGE (Enhanced Data Rates for Global Evolution)
  WCDMA (Wideband Code Division Multiple Access)
• Hardware realization
• Conclusions
Background

• Increased mobile subscribers growth

• To satisfy capacity demand, new technology is needed

• Conventional ways to increase capacity

  ➢ More radio spectrum:
    Regulatory limitations and high costs! New terminals!

  ➢ Cell splitting:
    High costs of acquiring new sites & infrastructure!

  ➢ Higher degree of sectorization:
    Increased number of hand-offs!
Technology for Advanced Antenna Systems

- Basic three-sector sites
- Higher order sectorization
- Fixed multi-beam antenna
- Steered beam antenna

Increased implementation complexity and cost
GSM Adaptive Antenna Concept

- Narrow beams are directed from the base-station towards the mobile stations
- A beam can be (steered towards the desired mobile station or) selected from a set of fixed beams
- The beam for downlink transmission is determined on information derived from the uplink, the direction of arrival (DOA)

Illustration: Claes-Göran Andersson

Adaptive Antenna System → Reduced Interference → Tight Frequency Reuse Possible → Large Capacity Increase
GSM Multi-Beam Adaptive Antenna System

Ericsson implementation

• Low complexity adaptive antenna system solution

• Non-coherent radio chains

• 8 fixed narrow interleaved beams per 120° sector

• RF level beamforming, with no calibration requirement

• Best beams selected for uplink combining

• Best beam selected for downlink transmission
GSM Capacity Booster, RBS 2205

Radio base-station

8-beam array antenna
Capacity Increase with GSM Adaptive Antenna

Capacity gain introducing adaptive antenna solution into a “real” network

Introducing AA solution into a homogeneous network

Introducing standard sites (via “cell-splitting”)
GSM Adaptive Antenna Characteristics

- Tailored antenna beams reduce interference levels and enable a tighter frequency reuse pattern
- Live field trials show a capacity increase of more than 100% at sites using GSM adaptive antennas
- Substantial network capacity increase can be achieved by introducing adaptive antennas in only a limited number of sites

Goal: Reduce Operator Infrastructure Cost
EDGE Introduces a New Modulation

**GPRS:**
GMSK Modulation

1 bit per symbol

**EDGE:**
8PSK Modulation

3 bits per symbol
## Basic Technical Parameters

<table>
<thead>
<tr>
<th></th>
<th>GPRS</th>
<th>EDGE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modulation</strong></td>
<td>GMSK</td>
<td>8-PSK</td>
</tr>
<tr>
<td><strong>Symbol rate</strong></td>
<td>270 ksym/s</td>
<td>270 ksym/s</td>
</tr>
<tr>
<td><strong>Modulation bit rate</strong></td>
<td>270 kb/s</td>
<td>810 kb/s</td>
</tr>
<tr>
<td><strong>Radio data rate per time slot</strong></td>
<td>22.8 kb/s</td>
<td>69.2 kb/s</td>
</tr>
<tr>
<td><strong>User data rate per time slot</strong></td>
<td>20 kb/s</td>
<td>59.2 kb/s</td>
</tr>
<tr>
<td><strong>User data rate @ 8 time slots</strong> (including header bits)</td>
<td>160 kb/s (182.4 kb/s&lt;sup&gt;1)&lt;/sup&gt;)</td>
<td>473.6 kb/s (553.6 kb/s&lt;sup&gt;1)&lt;/sup&gt;)</td>
</tr>
</tbody>
</table>

1) Usually specified at 115 kbps and 384 kbps, respectively.
C/I Simulation Results for EDGE

- www-traffic model
- Link-adaptation inactive
- Same amount of traffic
- No protocol aspects considered
EDGE Achievements

- No new license required
- Short time to market
- Low investment costs
- Capacity tripled
- Data rates tripled
Interference Environments, TDMA vs CDMA

• **TDMA**
  - Inter cell interference (co-channels in distinct reuse pattern directions)

• **CDMA**
  - Intra cell interference
  - Inter cell interference
WCDMA Downlink C/I Simulation

CDF (%) vs C/I (dB)

- 128 users, M=4
- 200 users, M=4
- 256 users, M=4
- 384 users, M=8
- 64 users, sector
Cylindrical vs. Planar Multi-Beam Antennas
Cylindrical Array Antenna Example
Cylindrical Omni-Directional Array Antenna

- 12 radiating columns
- 2 wavelength diameter
- 0.5 wavelength spacing
- all columns fed
- in-phase excitation
Cylindrical Multi-Beam Array Antenna

- 12 radiating columns
- 2 wavelength diameter
- 0.5 wavelength spacing
- 5 fed columns
- co-phasal excitation
Cylindrical Array Antenna Trade-Offs

- Radiation pattern types
  - Omni-directional beam for coverage and/or broadcast
  - Narrow multi-beams for capacity

- Cylinder radius and number of radiating elements
  - Radiation pattern ripple in azimuth with omni coverage
  - Number of directional beams in azimuth for capacity
  - Sidelobe level
Adaptive Base-Station Antenna System

Conclusions

- Less interference transmitted
  - Minimize interference spread in downlink

- Enable receiver interference suppression
  - Possibility to utilize spatial separation in uplink

- Adaptive antenna systems show substantial performance improvements

- Grow-on-site capacity increase in existing networks
  - No new additional sites
  - Site-by-site migration strategy