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HIGH CAPACITY ADAPTIVE BASE-STATION ANTENNA SYSTEMS

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Outline

- Background
- Adaptive Antenna Systems

  GSM (Global Systems for Mobile Communications)

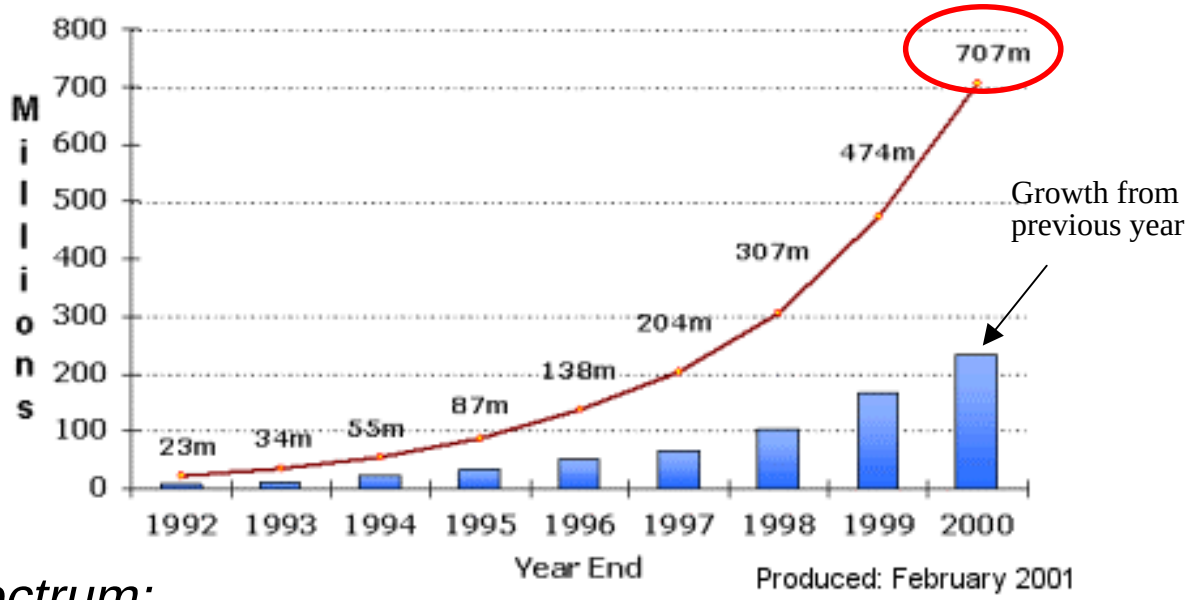
  GPRS (General Packet Radio Service)

  EDGE (Enhanced Data Rates for Global Evolution)

  WCDMA (Wideband Code Division Multiple Access)
- Hardware realization
- Conclusions

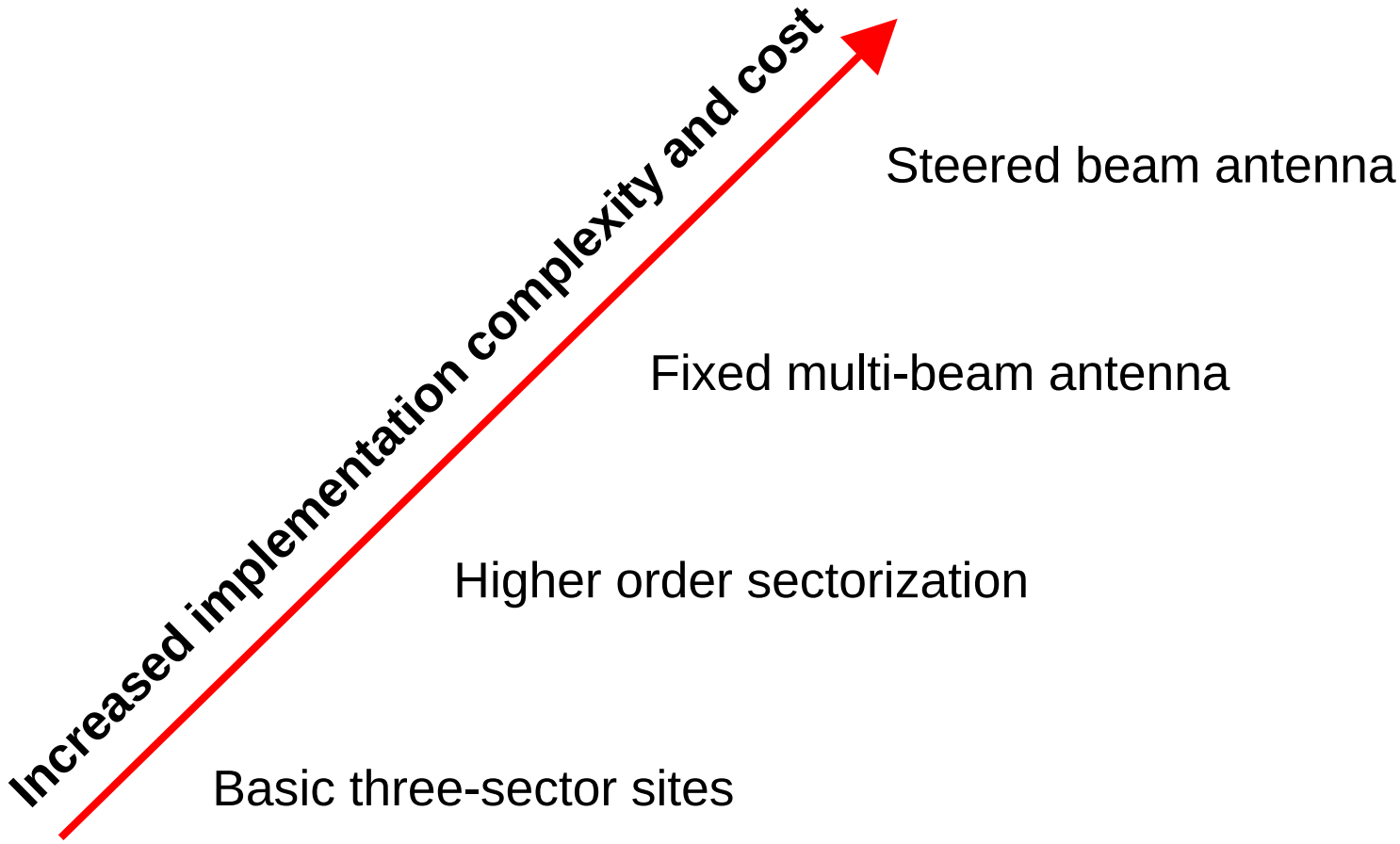
Background

- 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 acquring new sites & infastructure !
- *Higher degree of sectorization:*
  Increased number of hand-offs !

Technology for Advanced Antenna Systems



GSM Adaptive Antenna Concept

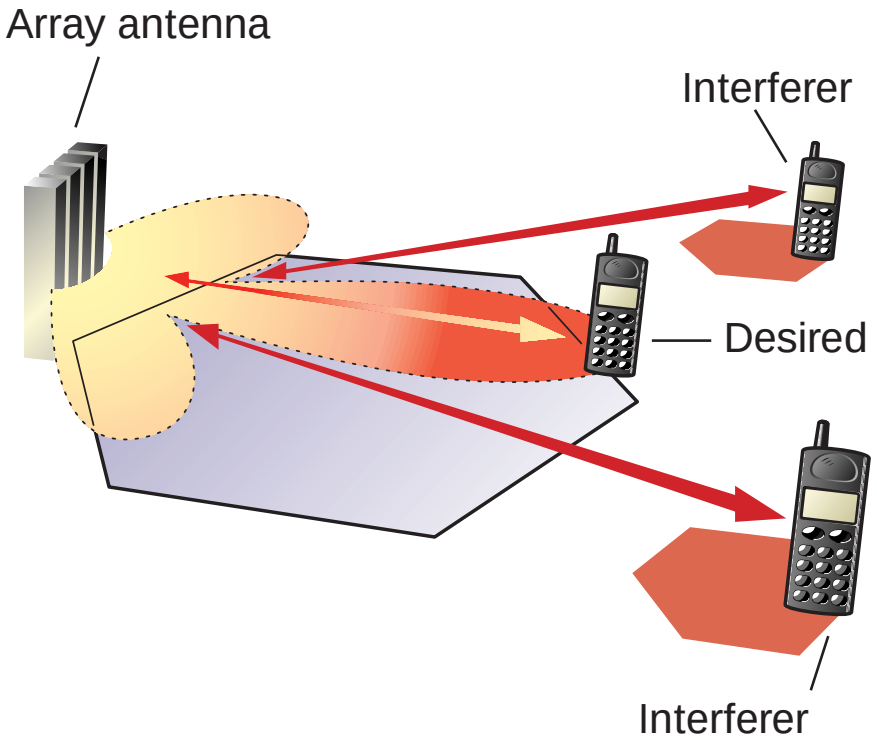


Illustration: Claes-Göran Andersson

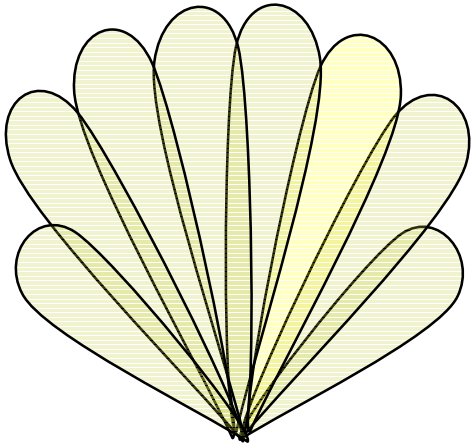
- Narrow beams are directed from the base-station towards the mobile stations
- A beam can be (steered towards the desired mobile station or) selected from a set of fixed beams
- The beam for downlink transmission is determined on information derived from the uplink, the direction of arrival (DOA)

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

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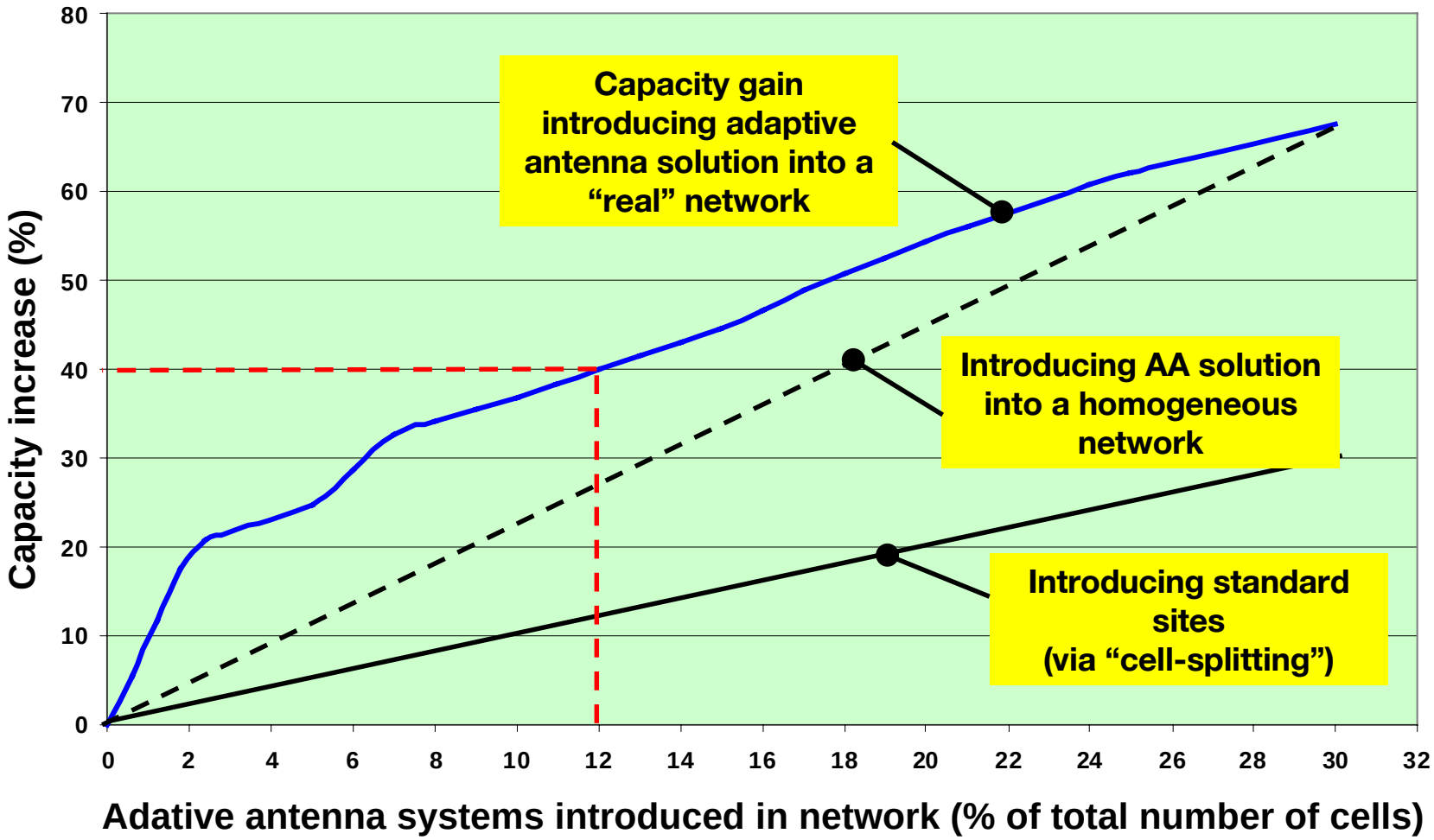
Capacity Increase with GSM Adaptive Antenna



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GSM Adaptive Antenna Characteristics

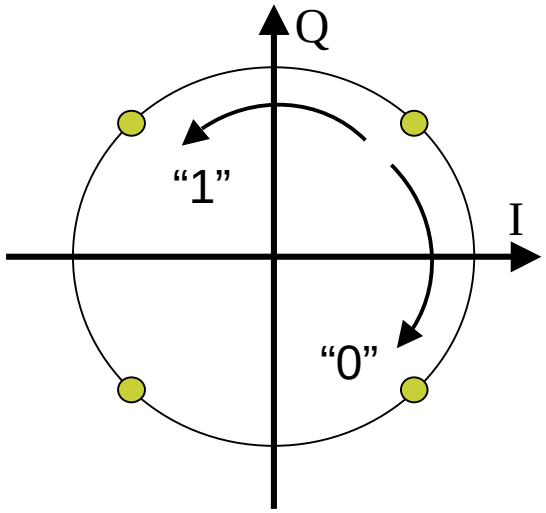
- Tailored antenna beams reduce interference levels and enable a tighter frequency reuse pattern
- Live field trials show a capacity increase of more than 100% at sites using GSM adaptive antennas
- Substantial network capacity increase can be achieved by introducing adaptive antennas in only a limited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

Goal: Reduce Operator Infrastructure Cost

EDGE Introduces a New Modulation

GPRS:

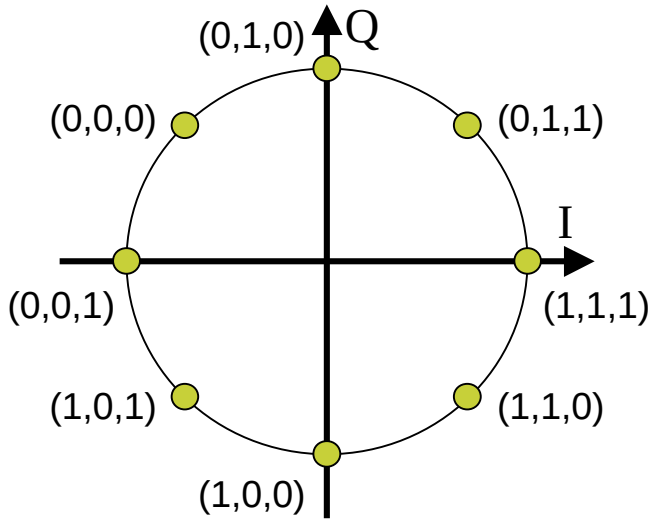
GMSK Modulation



1 bit per symbol

EDGE:

8PSK Modulation



3 bits per symbol

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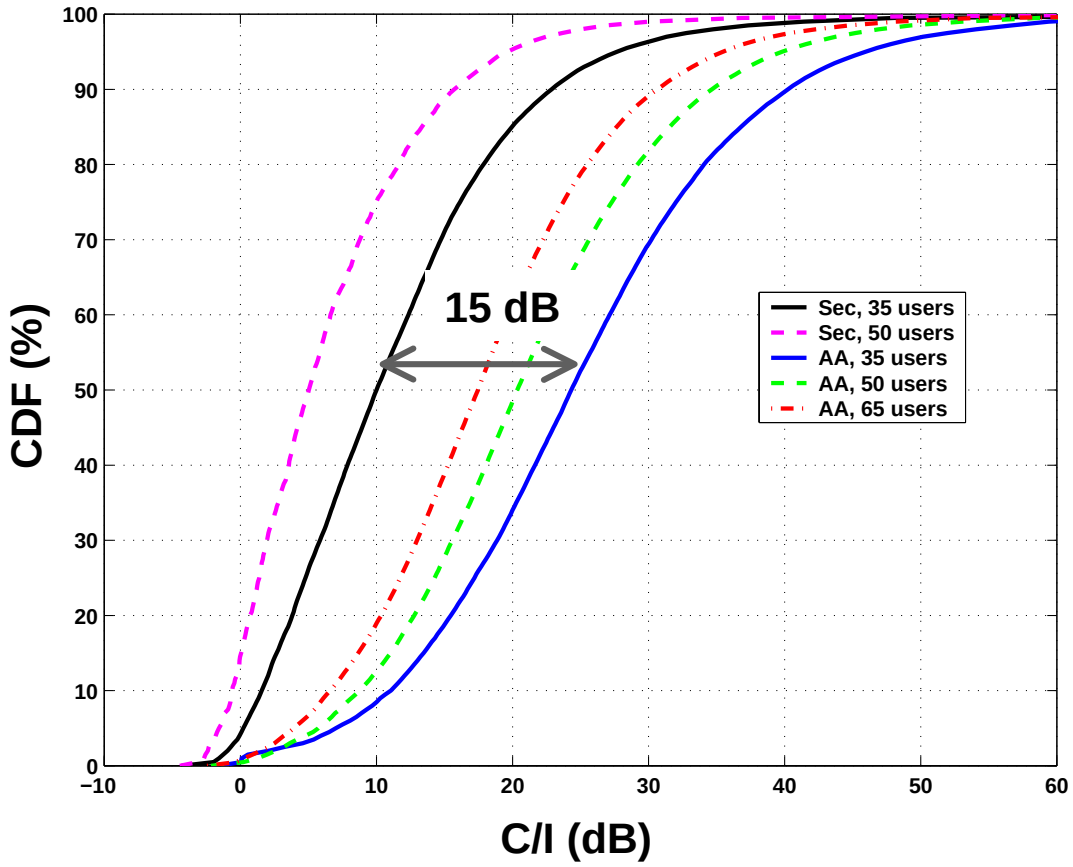
Basic Technical Parameters

	GPRS	EDGE
Modulation	GMSK	8-PSK
Symbol rate	270 ksym/s	270 ksym/s
Modulation bit rate	270 kb/s	810 kb/s
Radio data rate per time slot	22.8 kb/s	69.2 kb/s
User data rate per time slot	20 kb/s	59.2 kb/s
User data rate @ 8 time slots (including header bits)	160 kb/s (182.4 kb/s[1)])	473.6 kb/s (553.6 kb/s[1)])

1) Usually specifed at 115 kbps and 384 kbps, respectively.

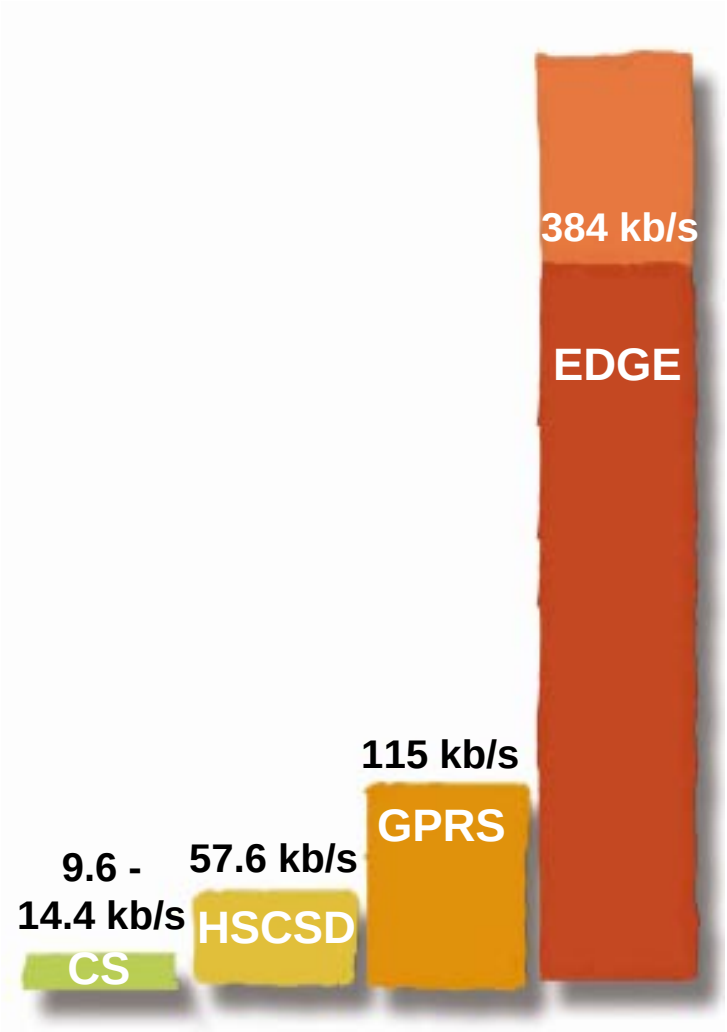
C/I Simulation Results for EDGE



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

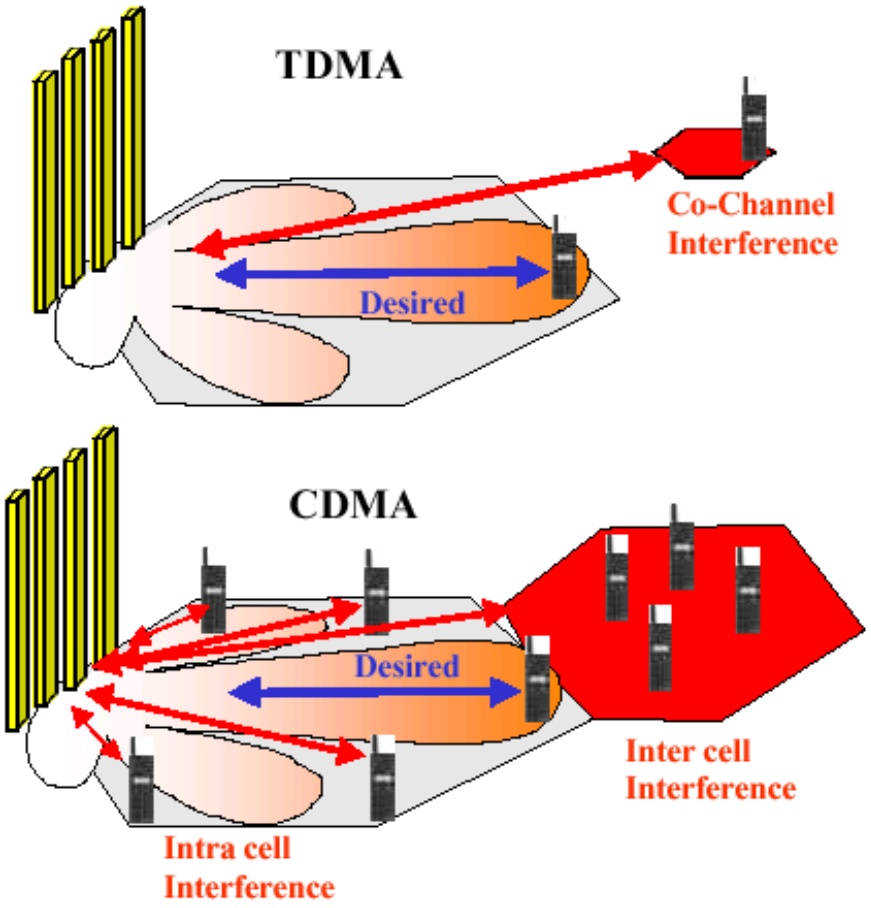
EDGE Achievements

- No new license required
- Short time to market
- Low investment costs
- Capacity tripled
- Data rates tripled

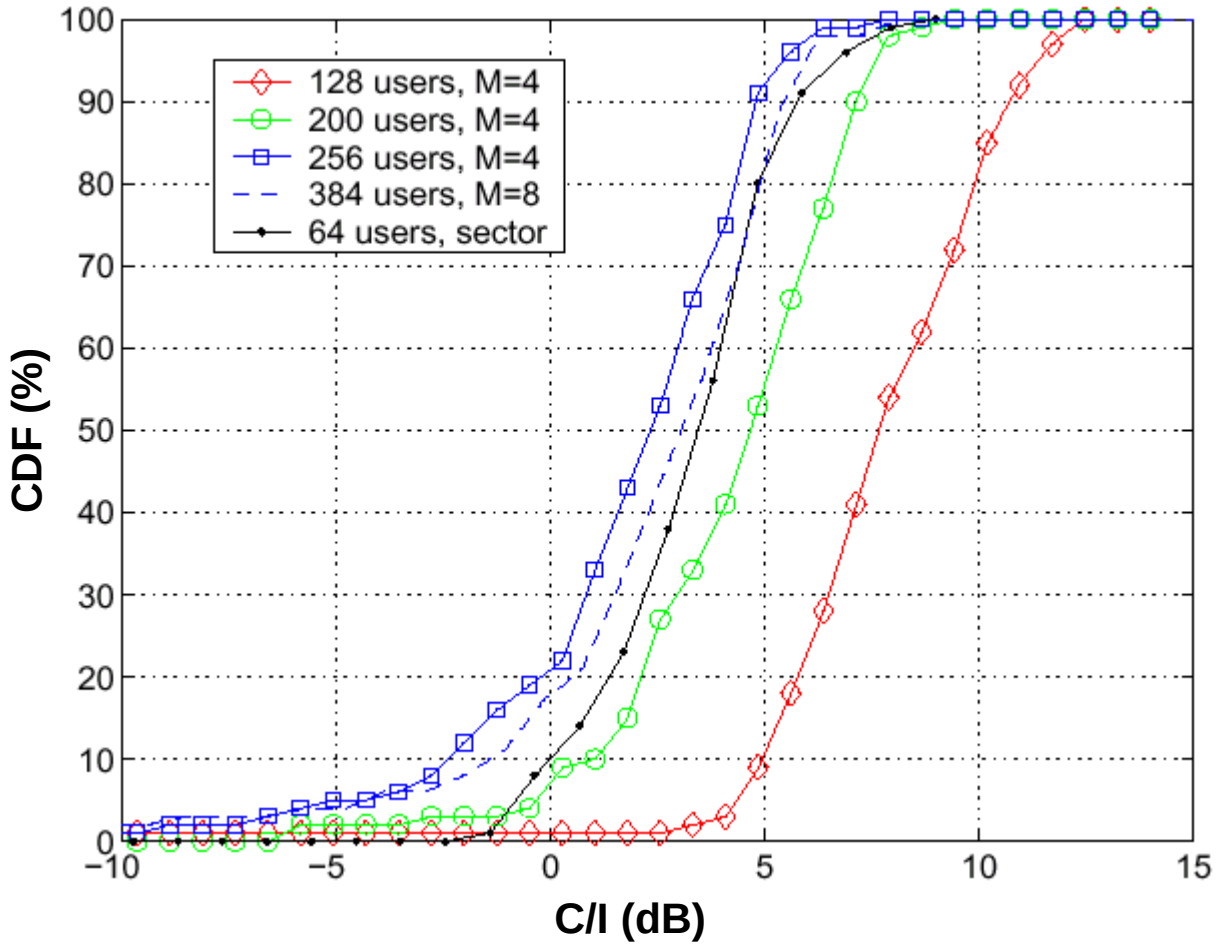


Interference Environments, TDMA vs CDMA

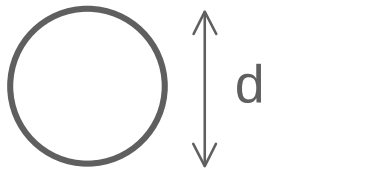
- **TDMA**
  - Inter cell interference (co-channels in distinct reuse pattern directions)
- **CDMA**
  - Intra cell interference
  - Inter cell interference

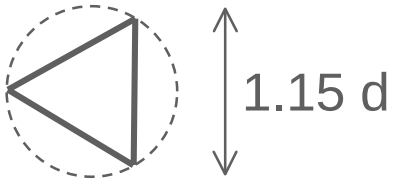


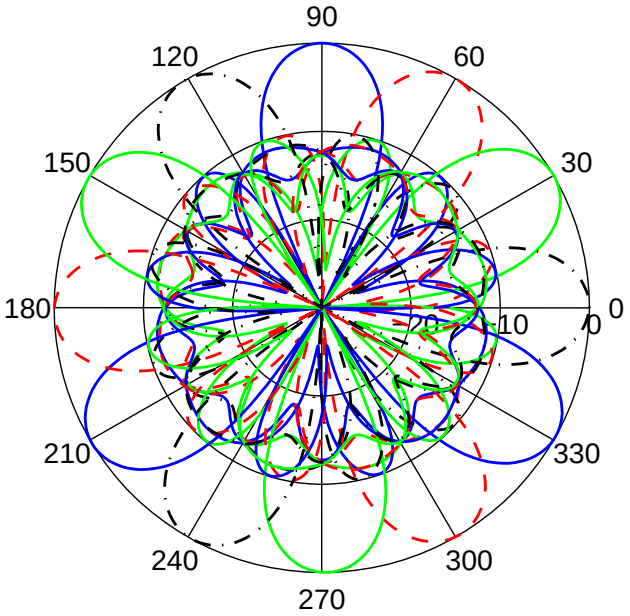
WCDMA Downlink C/I Simulation

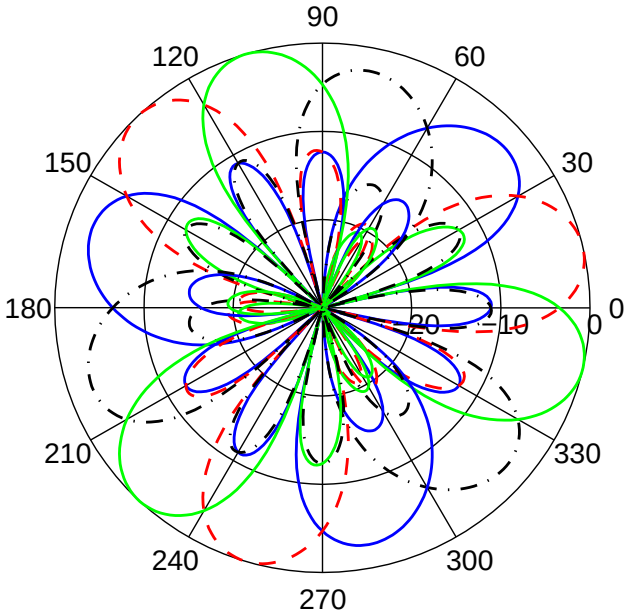


Cylindrical vs. Planar Multi-Beam Antennas









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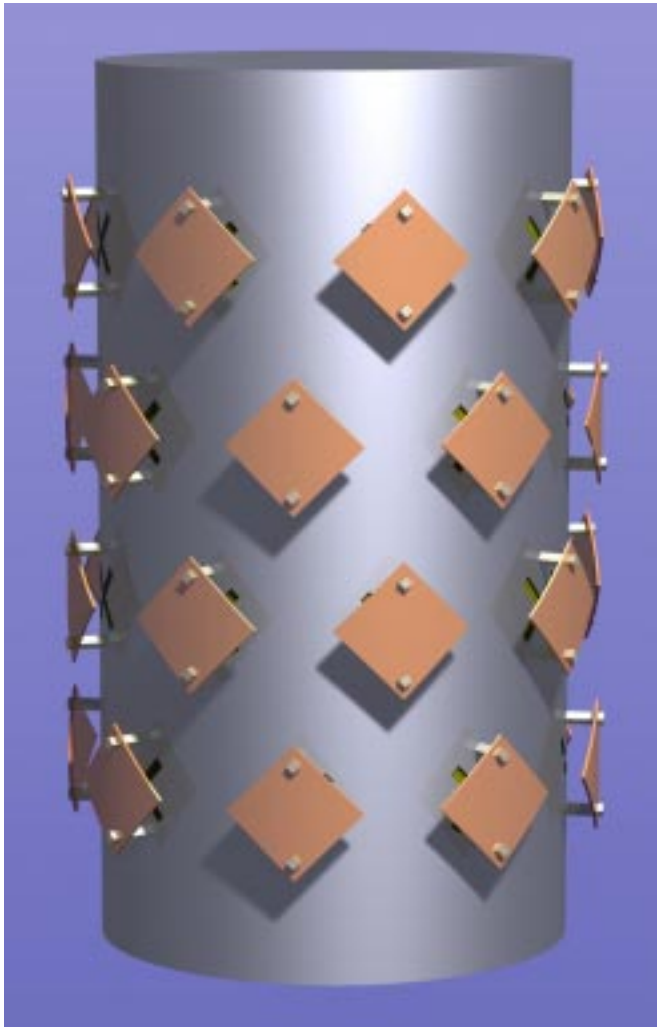
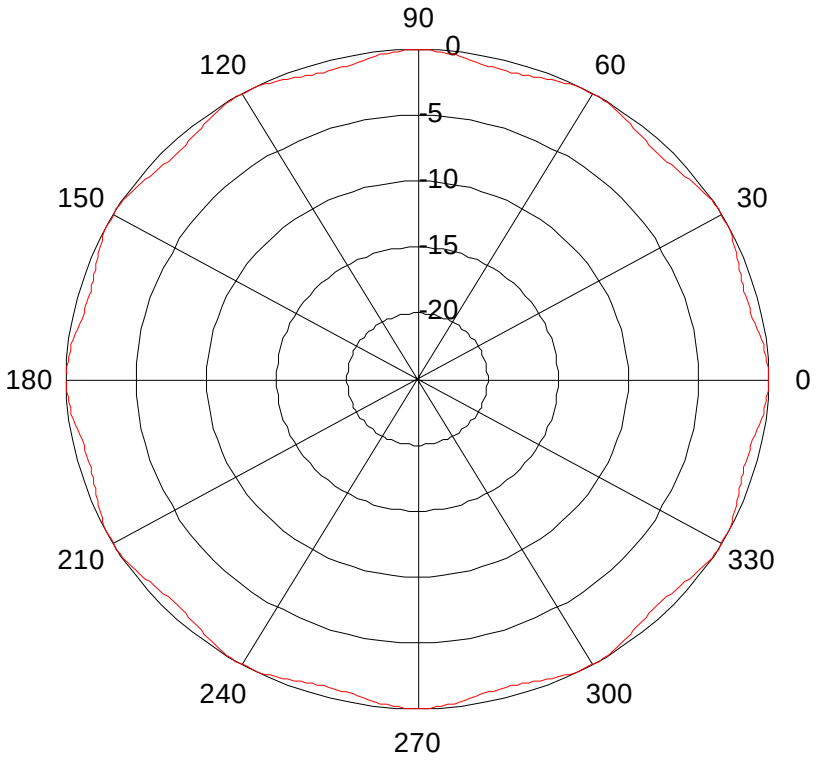
Cylindrical Array Antenna Example



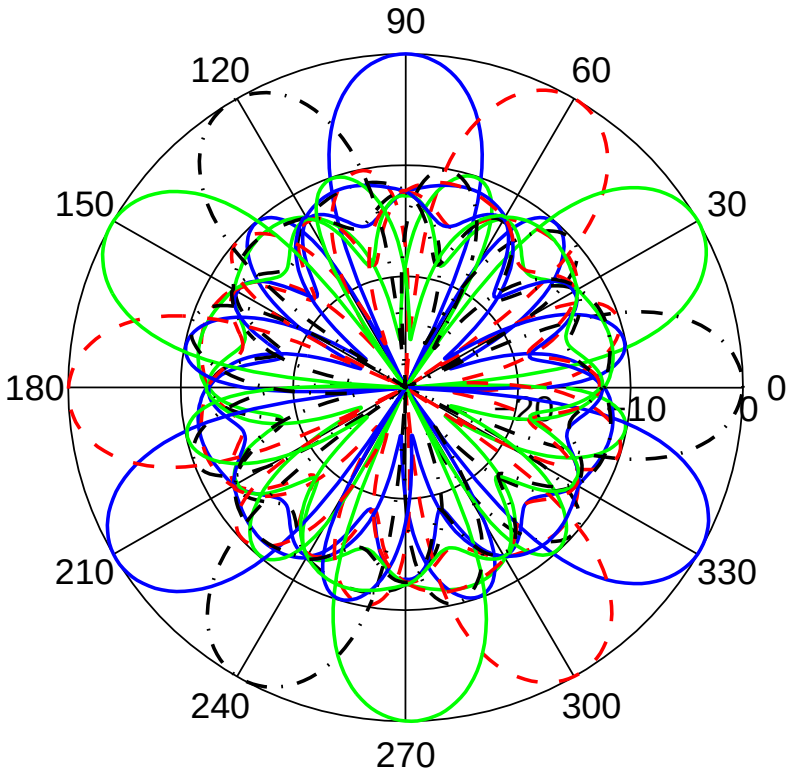
Cylindrical Omni-Directional Array Antenna

- 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



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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

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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