HIGH CAPACITY ADAPTIVE BASE-STATION ANTENNA SYSTEMS

Anders G Derneryd

Ericsson Research, Corporate Unit
Ericsson Microwave Systems AB
Antenna Research Center
SE-431 84 Molndal
Sweden
E-mail: anders.derneryd@ericsson.com

Abstract:
The deployment of cellular systems is a success and as the number of subscribers grows, service providers may experience capacity problems due to limited frequency spectrum. Consequently, service providers need to find methods to enhance the coverage and capacity of their networks. Today's systems are optimally designed for supporting speech traffic in circuit-switched services. The introduction of data packet-switched services will put increased requirements on the spectrum efficiency utilization. One approach to increase the network capacity is to condense the system by adding cell sites to decrease the site-to-site distance. However, this is both a time-consuming and expensive process. Higher order sectorisation with narrower sector beams is another method to increase capacity, but at the cost of increased hand-over rates.

Adaptive base-station antenna systems for GSM, such as the Ericsson RBS 2205, are now being deployed, as a means to achieve the higher spectral efficiency needed to cope with the higher traffic demands. Migration of adaptive antennas into an existing cellular network is used to improve the quality-of-services or to increase the capacity by implementing a tighter frequency reuse plan. The interference reduction achievements that are achievable by this type of antenna systems improve the network performance. The obtainable capacity gain depends on the percentage of cells equipped with adaptive antenna arrays. Studies of the capacity in a GSM real network shows a 50% increase by replacing only 20% of sector antennas with adaptive antenna systems.

The combination of adaptive antennas and GPRS (General Packet Radio Service) shows a greatly increased capacity potential relative to sector antenna systems. In GPRS, one or more timeslots will only be allocated when needed and are released as soon as the transmission of the data packets is finished. Users of GPRS benefit from short access time and high data rates up to 160 kbps.

EDGE (Enhanced Data rates for Global Evolution) is the next step in the mobile evolution, offering high-speed mobile Internet services in existing spectrum. It introduces a new modulation technique along with improvements in the radio protocol that allow operators to use existing GSM frequency spectrums (800, 900, 1800 and 1900 MHz) more effectively. EDGE supports data, multimedia services and applications at up to 384 kbps.

The third generation (3G) systems introduce wide-band radio communications, with access speeds of up to 2Mbit/s. Compared with today's mobile networks, 3G will significantly boost network capacity and operators will be able to support more users, as well as offer more sophisticated services. Even though WCDMA (Wideband Code Division Multiple Access) systems will have high capacity, the limits may be reached in certain heavily loaded cells. This could for example be due to a large growth in the number of subscribers that are expected to use high data-rate services. Antenna arrays at the base station is then expected to be an important feature also in cellular WCDMA networks.

A number of different advanced base station antenna concepts have been proposed. They can mainly be divided into two groups. One group consists of fixed beam solutions, i.e., an antenna system where one can choose from a number of fixed beams pointing in different directions within the cell. The other group consists of beam-formers with steerable beams and possibly with beam shaping. The two concepts require different architectures, but usually the requirements on hardware are less strict for a fixed beam antenna system.

Adaptive antennas at the base station used for both transmitting and receiving in narrow beams improve the C/I-ratio in both up- and down-link. Interference is rejected in up-link and in down-link, less interference is spread in the system. System level simulations in a scenario with uniformly distributed speech-users show that the capacity performance is basically proportional to the number of orthogonal beams used at the base station.

Reception performance is mainly the same for a fixed and a steered beam concept when all output signals from the beam-forming network are orthogonal and used in the subsequent signal processing. On transmission, both fixed beam concepts, using interleaved beams, and steered beam implementations can be designed to have similar performance. However, a major difference is that a system with an RF beam-forming network in the antenna unit can be operated without coherent radio chains. Non-coherent operation means that phase and amplitude relationships between the different radio chains from the antenna to the transceivers are not known. However, coherency is required in a steered beam implementation. In this case, the radio chains are coherent and various forms of beam shaping can be applied such as forming a main beam in one direction and a null in another one and thus further improving interference suppression.