Sensitivity of optimum downtilt angle for geographical traffic load distribution in WCDMA

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***Abstract*—The target of this paper is to evaluate the impact of geographical traffic load distribution of a cell on the optimum downtilt angle of macrocellular WCDMA network. Moreover, the target is to solve possible capacity gain from CAEDT concepts, and to provide ideas for parameter selection for CAEDT algorithm. Initial results reveal how optimum downtilt angle changes from 6° to 10° depending on whether traffic is concentrated closer to cell edge or closer to base station. Under different traffic load distributions, the network capacity changes with aforementioned tilt angles, which indicates of a possible capacity gain from a fast rate CAEDT.**

Keywords-antenna downtilt; CAEDT; optimum downtilt angle; geographical traffic load distribution; WCDMA

I. INTRODUCTION

The concept of antenna downtilt has been widely studied, and it is known to increase the system capacity in WCDMA [1–2]. Due to more efficient bearing of the vertical radiation pattern, a reduction of inter-cell interference allows capacity enhancements. However, electrical downtilt (EDT) has been observed to provide slightly better results in terms of capacity and mitigation of pilot pollution [3]. Moreover, utilization of EDT antennas might become more attractive due to better capability to change the tilt angle remotely. This is actually the fundamental idea in CAEDT (continuously adjustable electrical downtilt) concept. The need of a common interface for base station equipment to support CAEDT concept has been also recognized within the 3GPP specification body, which is currently specifying CAEDT concept for the Release 6 [4].

The latest research results have indicated the potential capacity gains that could be achieved by utilizing CAEDT. In [5], an optimum downtilt angle (based on minimum uplink transmit power) was observed to change even with a homogenous traffic distribution according to load. In [6], the idea was extended to include the impact of inhomogeneous traffic distribution. Moreover, with CAEDT and pilot power adjustment capacity gain was achieved – mainly through load balancing. In [7], a method for load balancing with tilt angle control was presented. Moreover, the tilt angle optimization criterion was based on the uplink (UL) load. Achieved capacity gains were approximately 20-30% respect to constant, network-wide tilt angle. The scope of this paper is 1) to find out the changes in optimum downtilt angle with respect to geographical traffic load distribution, 2) to observe possible capacity gains of CAEDT, 3) and to provide an analysis of the applicability of different parameters for fast rate CAEDT algorithms.

II. CAEDT

CAEDT concept can be divided into slow, medium, and fast rate modes depending on the target of usage. With a *slow rate* CAEDT, the adaptation of tilt angle can be accelerated during network evolution, i.e., to fasten the network optimization according to new dominance areas. Moreover, possible errors in initial tilt angles can be more easily corrected. Pilot pollution problem can be also more easily mitigated using CAEDT [8]. With deployment of *medium rate* CAEDT, an operator can update tilt angles separately according to day time (morning, day, evening). Adaptation to changes in long-term traffic load variation would involve at most couple of changes of tilt angle during a day. Thus, the algorithm for medium rate CAEDT could be based on a look-up table of statistical or historical data of user locations [6].

However, geographical traffic load distribution of a cell might change considerably between of tilt adjustments of medium rate CAEDT. For example, if most of the users were near the base station, a larger tilt angle would be required in order to still achieve maximum system capacity. For this purpose, an algorithm for *fast rate* CAEDT should be implemented. This algorithm would be able to adjust tilt angles based on changes in short-term traffic load distribution. Naturally, the algorithm could not be based on any statistical data, but on real-time parameter values. In a fast rate CAEDT algorithm, the updating rate would be naturally higher. Moreover, the algorithm could be based on minimization of certain parameter (such as UL load [8] or DL TX power). On the contrary, one possible parameter could be also UL TX power, which would roughly indicate user locations. The idea would be in using a reference distribution of UL TX powers during an optimum downtilt angle setting, and consequently adjust the tilt angle based on the changes in the estimated traffic load distribution. The most sophisticated method would be to use location information of the mobiles. Consequently, tilt angles in this approach would be adjusted according to a pre-defined geometrical model. This provides an example of location-based radio resource management.

III. SIMULATION APPROACH

Monte Carlo simulations were used to evaluate the impact of different geographical traffic load distributions in a 19 base

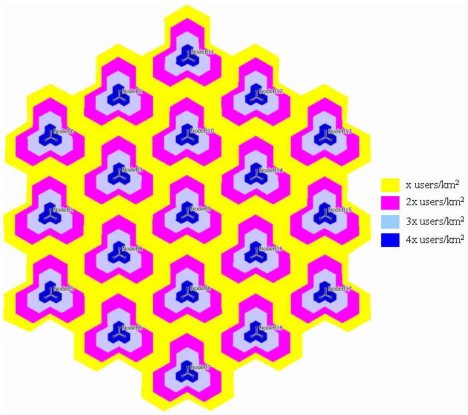

Figure 1. Network layout illustrating the user distribution areas, and an example of a hexagonal user distribution, in which, user density (*x*) increases towards the base station.

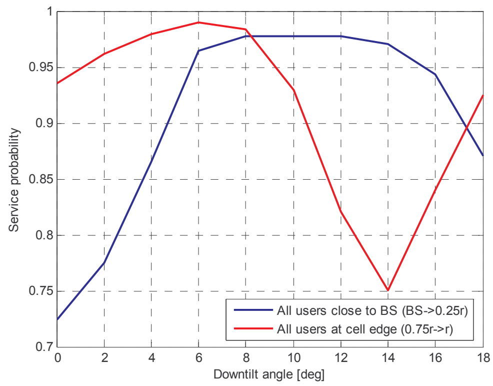

Figure 2. The impact of user distribution on the average service probability of all sites with different network-wide downtilt angles.

station hexagonal grid. The description of the static WCDMA simulator can be found from [9]. Network configuration was formed of 3-sectored sites with 65° horizontally and 6° vertically wide beamwidth [10] together with 1.5 km site spacing, and 25 m antenna height. For all sectors, hexagonal user zones of different radius are formed (Fig. 1). The radii of hexagonal area decrease in steps of 0.25r, where *r* is 2/3 of the site spacing (i.e., the length of dominance area). The length of the smallest hexagon is 0.25r. In the initial simulation results, user density increases either towards the cell edge or the base station using different user distribution zones.

IV. Initial Simulation Results

Fig. 2 shows the attained average service probabilities[1] for simulated downtilt angles. The solid line and the dashed line correspond to simulations results from traffic distributions in which the users occupy only the area close to cell edge (0.75r→r) or only the smallest hexagon near the base station (BS→0.25r), respectively. While having users at cell edge, the optimum downtilt angle based on service probability is 6°. On the other hand, having users close to base station, optimum downtilt angle is 10°. If scenarios of 6° and 10° tilt are compared, the degradation in service probability is comparatively small (Fig. 2). For example, using 10° tilt angle while users are at cell edge, the degradation of service probability is 7%. However, the applicable range of the downtilt angle is totally different with abovementioned traffic distributions. With users close to cell edge, the range is roughly from 2°-8°, while for users closer to the base station, angles of 6°-14° provide optimum performance. However, service probability provides information simultaneously from UL and downlink (DL) performances. Considering the DL and the UL maximum capacities separately reveals that, e.g., 10° tilt (1440 kbps) provides 20% better DL capacity compared to 6° (1200 kbps) if users are close to the base station. In opposite situation, the capacity gain in DL is 5%. In the UL, the gain of CAEDT as well as the gain of downtilt in general is smaller due to minor sensitivity of capacity to other-cell interference. Also, the importance of antenna vertical radiation pattern is illustrated in Fig. 2. With higher tilt angles (from 14° to 18°), the service probability increases (solid line) because of coverage enhancement due to the first vertical 'side lobe'. This indicates the importance of antenna vertical radiation pattern utilized in CAEDT.

Nevertheless, the presented results in this extended abstract should be analyzed in detail of the impact of geographical traffic load distribution on optimum downtilt angle. Clearly, the capacity and performance analysis should be targeted on both directions individually. Moreover, the focus should be on a cell level rather than network level due to possible filtering on cell-based variations.

[1] Service probability is defined as a ratio of successfully connected mobiles and all attempted mobiles. A connection establishment is successful if DL TX power/code limitation or UL noise rise target are not exceeded while having required E_b/N_0 in both directions.

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