CDMA coverage under mobile heterogeneous network load

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Abstract— **We analytically investigate coverage (determined by the uplink) under non-homogeneous and moving traffic load of third generation UMTS mobile networks. In particular, for different call assignment policies we investigate cell breathing and the movement of the coverage gap occurring between cells when a hot spot moves among the cells. These call assignment policies mainly differ in handling non feasible call configurations. To establish the maximally possible coverage, calls at the cell borders will be dropped such that the remaining carried calls establish their SIR target. By assigning calls to different base stations according to these policies, the coverage gap differs especially under moving non-homogeneous load.**

I. Introduction

The third generation UMTS network air interface is based on the flexible and efficient CDMA multiplexing technique that enables all calls to use the entire bandwidth. As a consequence, users compete for power in the allocated bandwidth and a key-factor for analysis becomes the interference level. The problem of minimization of total interference in the network (or in other words maximization of network capacity) remains one of the major research topics in the field of DS-WCDMA. This problem has mainly two complimentary parts: (1) power control, and (2) assignment of calls to base stations. In the analysis of the second part it is sometimes overlooked that optimality of some specific assignment strategies depends not only on non-homogeneity of traffic load between cells but also on distribution of this load within the cells. Knowledge of the call distribution helps to choose an optimal assignment for a specific situation and gives the opportunity to optimize the available channel space.

It is commonly agreed that (due to the asymmetrical nature of data traffic) the capacity of the CDMA system is determined by the downlink, but coverage is determined by the uplink [8]. The present study analytically investigates coverage under non-homogeneous and moving teletraffic load, and therefore focusses on the uplink. In particular, for different call assignment policies we investigate cell breathing and the movement of the coverage gap occurring between cells when a hot spot moves among the cells. The different call assignment strategies considered in this paper are characterized by the following optimization objectives: (a) minimal total received power, (b) minimal total transmitted power, (c) minimal total interference. For comparison we also consider the situation with a fixed border in the middle between base stations. Our analysis is set up for a general network configuration. For a simplified, yet representative, two cell network we provide numerous numerical results, which illustrate the performance of the different call assignment strategies under various traffic loads.

The rest of this paper is organized as follows. In the next section, we discuss some related literature. Section III provides a brief description of the modelling approach used in this paper. In Section IV-VI we give a mathematical description of the optimization problems to be solved and derive and discuss some useful properties. Section VII contains the numerical results for the simplified two cell network. Finally, in Section VIII, we summarize and conclude our study.

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II. Related literature

A substantial body of literature focusses on the CDMA uplink. However, most references consider either homogeneously loaded cells or non moving calls. An important exception is [14], where (via simulation) for non homogeneous but non moving load the capacity (number of carried calls) is considered. The coverage, however, is not taken into account.

A nice overview of distributed power control algorithms that minimize total transmitted power is provided in [8]. Recent references on optimal power control are e.g. [12] and [10]. In particular, in [10] the impact of the statistical variations of the signals due to fading are considered, and the authors show that well-known methods for allocating power (which ignore fading; often based on Perron-Frobenius eigenvalue theory) can be used to determine power allocations that are close to achieving optimal (i.e. minimal) outage.

Call assignment strategies are presented in e.g. [2], [7], [1], [3] and [6]. In particular, in [2] several call dropping strategies to be applied in case of congestion (and leading to coverage gaps) are discussed and evaluated. Their analysis is based on simulations. The authors of [1] also study and compare different dropping strategies for situations in which not all SIR targets can be attained. They provide an analytical study for homogeneous traffic loads and nicely point out the unfavorable effects that may occur for certain dropping strategies.

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