Chapter 14
Fractional Reuse Partitioning Schemes for Overlay Cellular Architectures

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ABSTRACT

In this paper, the authors propose three partitioning schemes for adaptive clustering with fractional frequency reuse namely maximal fractional frequency reuse partitioning (MFRP), optimal fractional reuse partitioning (OFRP), and GoS-oriented frequency reuse partitioning. The authors propose that an overlaid cellular clustering scheme, which uses adaptive fractional frequency reuse factors, would provide a better capacity by exploiting the high level of signal to interference ratio (SIR). The proposed methods are studied via simulations and the results show that the adaptive clustering with different partitioning methods provide better capacity and grade of service (GoS) comparing to the conventional cellular architectures.

INTRODUCTION

Cellular systems have been a well established solution for wireless communications over three decades. The architecture of the cellular system allows resource utilization in the power-space domain. Since the frequency spectrum is limited

and expensive resource, effectively make use of it to achieve optimum system capacity is extremely important.

The conventional method of allocating resource is called fixed channel assignment (FCA), in which fixed number of channels is assigned to each cell according to a preset cluster size in order to satisfy the desired signal quality at the cell edge. Even though FCA schemes are simple

and straightforward methods, they do not adapt to changing traffic conditions and user distributions due to fixed cluster size. Moreover, in FCA, the overall average grade of service (GoS) of the system is the same as the GoS in a cell. Since traffic in cellular systems can be non-uniform with distributed users, a fixed allocation of channels in a cell may result high blocking in some cells, while others might have a large number of spare channels (Zhang & Yum, 2002; Katzela & Naghshineh, 1999). This could result poor resource utilization. Non-uniform channel allocation and channel borrowing methods are introduced in Oh (1992) and Anderson (1973) to solve the drawbacks of the FCA schemes. However; under heavy traffic conditions, the channel borrowing methods could be inadequate as well. They may increase the blocking probability which leads a reduction in channel utilization (Tekinay & Jabbari, 1991).

In order to overcome these deficiencies of FCA schemes, dynamic channel allocation (DCA) is discussed in Zhang and Yum (2002). In DCA, all channels are placed in a pool and assigned to a new call when the signal to interference ratio (SIR) criterion is satisfied. Simulations in Kahwa and Georganas (1978), Cox and Reudink (1973) and analysis in Jordan and Khan (1993) show that under heavy traffic intensity, DCA could even perform worse.

Effective reuse of the resources as an overlaid manner can highly improve the total capacity of the system. Reuse Partitioning (RP) (Chen & Chong, 2004; Chong & Leung, 2001) is a very useful technique to achieve high spectrum efficiency in cellular systems by using different cluster sizes (e.g., frequency reuse factors (FRF)). In RP, a cell is divided into several concentric SIR regions and each region has a different cluster size. A mobile close to its BS is assigned a channel with a smaller reuse distance whereas a mobile far from its BS with low signal quality is assigned a channel with a larger reuse distance. This scheme allows less complex systems to perform efficiently without need for adaptive modulation schemes and power

rearrangements. More available resource can be offered to the end user with having a smaller FRF which leads to the ultimate goal in overlaid cellular systems is achieving the cluster size of 1 (N=1). However, with the uniform usage of N=1, the most cell edge users are suffered from inter-carrier interference and this will cause a degradation in the total system capacity and low data rate in transmission.

Restrictions caused by the uniform reuse factor can be solved by Fractional Frequency Reuse (FFR) method (Lei, Zhang, Zhang, & Yang, 2007). The FFR scheme separates the cell into two different geographical regions: the inner cell area close to the base station and outer cell area near to the cell edge. The global reuse factor is fractioned to the inner cell area therefore different cluster sizes are used in two different regions. In its simplest form, FFR implements a reuse scheme-N (N>1) system in order to prevent unacceptable levels of interference that might be ex, while i and j are being non-negative integers. Conventional approach in cellular systems consider N as a fixed number and they design the architecture on the assumption of the worst case SIR for the neighboring clusters which is given in Figure 1 is as follows (Huawei, 2005).

Figure 1. Co-channel interference for worst case cell-edge assumption
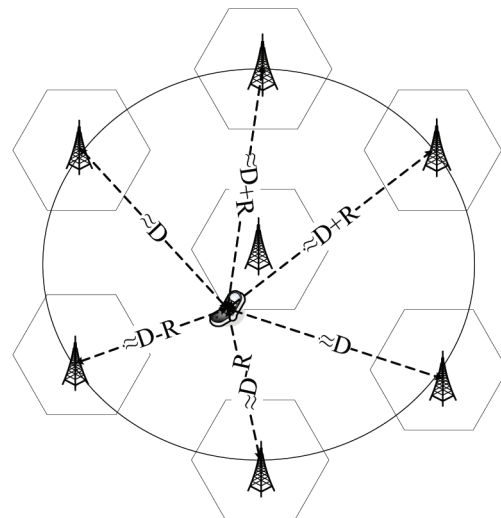
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