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Resource Allocation using Dynamic Fractional Frequency Reuse:

A Technique to Reduce Inter Cell Interference at the Cells Edges

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ABSTRACT

This article describes how a multi user cellular system insists on having increase in the spectral efficiency for the number of users and base stations. As far as cellular structures are concerned, the users at the edges experience inter cellular interference (ICI) than the users at the cell center. This is due to lack of resource allocation at cell edges. To improve the throughput at the edges a technique called Fractional Frequency Reuse (FFR) is employed. This article explores the Dynamic FFR(DFFR) in OFDMA system to improve the overall throughput.

KEYWORDS

Dynamic Fractional Frequency Reuse (DFFR), Fractional Frequency Reuse (FFR), Inter Cell Interference (ICI), Orthogonal Frequency Division Multiple Access (OFDMA)

1. INTRODUCTION

The wireless systems strive for increase in spectral efficiency due to increase in the number of users. The main concern for this is the bandwidth, power, and low complexity of systems. As the number of users increase a probable rise in the interference rate is observed. This is more prominent at the cell edges. The dense population of the users demand for more resources to be allocated to minimize inter cell interference and maximize spatial reuse of the frequency.

The Fractional Frequency Reuse (FFR) techniques used with Orthogonal Frequency Division Multiple Access (OFDMA) minimizes the interference levels for the users at the center of the cell as well as at the edges of the Hexagonal cell.

There are two common FFR modes: Strict FFR and Soft Frequency Reuse (SFR).

1. **Strict FFR:** Figure 1(a) is an interpretation of Strict FFR for a cell-edge reuse factor of $\Delta = 3$ (Rahman, Wong, & Yanikomeroglu, 2009; Panicker et al., 2009). Users in each cell center are allocated a common sub-band. The users at the cell-edge bandwidth is divided across cells based on a reuse factor of Δ. Strict FFR thus requires a total of $\Delta + 1$ sub-bands. Users at the cell center do not share any spectrum with edge users, which reduces interference for both center and cell-edge users.
2. **Soft Frequency Reuse:** Figure 1(b) is an interpretation of Soft Frequency Reuse with a reuse factor of $\Delta = 3$ on the cell-edge. SFR employs the same cell-edge bandwidth dividing technique

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as Strict FFR, but the cell center users share sub-bands with edge users in other cells. Because cell center users share the bandwidth with neighboring cells, they transmit at lower power levels than the cell-edge users (Necker, 2008; Mao, Maaref, & Teo, 2008). Soft Frequency Reuse is more bandwidth efficient than Strict FFR.

FFR can be considered in the uplink or downlink. Fractional frequency reuse (FFR) has been proposed as an ICIC (Inter cell interference coordination) technique in OFDMA based wireless networks (Yu, Huang, Dutkiewicz, & Mueck, 2013). Basically, FFR is a method to partition the cell's bandwidth so that (i) cell-edge users of adjacent cells do not interfere with each other and (ii) interference received by the cell-interior users is reduced, and (iii) using more total spectrum than conventional frequency reuse. The use of FFR in cellular networks leads to improvement in coverage for cell-edge users and spectral efficiency.

2. RELATED WORK

Recent research work on FFR has focused on the optimal design of FFR systems by utilizing advanced techniques such as graph theory ("Interference avoidance concepts," n.d.) to maximize network throughput. Novlan et al. (2011), Stolyar and Viswanathan (2008), Luo and Zhang (2008) in consider scheduling and the authors determine the frequency division in a two-stage heuristic approach.

These techniques along with the other related work support the numerical findings of the proposed system model.

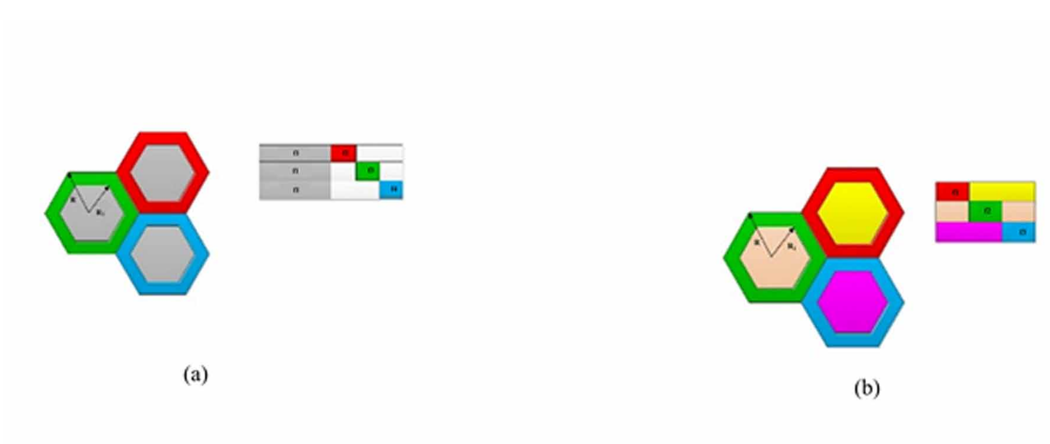
3. SYSTEM MODEL

In the OFDMA network the frequency is divided into subcarriers while the time is divided into time slots. In the LTE standards, the traffic bearer is defined as a physical resource block, is a group of subcarriers that can be coherently allocated to the users for a given time.

To realize the system model, the following assumptions need to be made:

1. A physical resource block consists of 12 consecutive subcarriers in the frequency domain.
2. One slot duration 0.5 msec in the time domain.

Figure 1. (a) Illustrates strict frequency reuse (Rahman et al., 2009; Panicker et al., 2009); (b). Illustrates soft frequency reuse (Necker, 2008; Mao et al., 2008)



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