Mitigating Cross-tier Cross-boundary Interference in Fractional Frequency Reuse Scheme for Multi-tier Networks

Oluwadamilare Adeyemo*, Mqhele Dlodlo† and Henry Ohize‡
Department of Electrical Engineering,
University of Cape Town
Cape Town, South Africa
Email: *adyolu007@myuct.ac.za, †mqhele.dlodlo@uct.ac.za
‡ohzhen001@myuct.ac.za

***Abstract*—Fractional frequency reuse scheme is an interference mitigation scheme suitable for multi-tier networks. However, critical examination of existing fractional frequency reuse schemes based on the orthogonal frequency division multiple access technique for a multi-tier network consisting of Macro-cells and Femto-cells reveals a cross-tier, cross-boundary interference for the Femto-cell users located at the boundary region of the cell centre and edge region. In this paper, we addressed this interference issue by introducing a modified resource allocation scheme that adds a buffer zone between the centre and edge region. In addition, the hybrid spectrum usage concept was incorporated into the proposed design to determine the extent of the buffer zone. System level simulation results showed our technique significantly improved signal to interference plus noise ratio (SINR) and throughput performance for the Femto-users located at the boundary region when compared to the traditionally existing scheme.**

Keywords—FFR; Femto-cell; OFDMA; Interference

I. Introduction

The continual push for increased data rates to meet stringent quality of service (QoS) demands by network subscribers' applications has been driving the evolution of mobile communication technologies. Femto-cells provide an effective means of provisioning quality indoor radio signal coverage. This has become paramount for communication services providers (CSPs) because of the increasing rate at which network services such as video on demand (VOD), online gaming and other data-centric applications are requested by subscribers from indoor areas [1]. Femto-cells exploit base-station proximity to the user equipment (UE) which leads to reduced mean path loss when compared to Macro-cell infrastructure to deliver high signal power. This is beneficial for users at the cell edge. In Long Term Evolution (LTE) networks, multiple users are granted access to the physical channels using the orthogonal frequency division multiple access (OFDMA) which is a multicarrier technique. OFDMA, due to its multicarrier characteristic is more robust to multipath propagation; also, transmission over frequency selective channels can be effectively managed by assigning subcarriers on which a UE senses the best channel gain to that particular user giving rise to Multi-User Diversity (MUD).

Femto-cells operate on the same licensed frequency band used by the pre-existing Macro-cells in the same geographical area. The increased possibility of interference as a result of this arrangement is a major drawback for the widespread deployment of Femto-cells by CSPs. Research efforts have led to the development of schemes such as Beam-forming, collaborative scheduling, power control techniques, cognitive techniques and fractional frequency reuse (FFR) schemes in its various forms such as strict FFR, soft-FFR and FFR-3/6 [2]. Performance analyses of these schemes in terms of complexity, signalling overhead and the peculiarity of Femto-cells circuitry shows that FFR gives an optimal performance [2]. In this paper we examined the cross-boundary, cross-tier interference scenario that is inherently present in the existing schemes as evident in literature. We then propose a scheme that mitigates this challenge.

The rest of this paper is organized as follows; Section II gives the related works to the proposed scheme existing in literature. In Section III, the system model is given, Section IV explained the proposed scheme in details. The simulation model, parameters and results discussion are presented in Section V while Section VI gives the concluding remarks.

II. Related Works

Due to its simplicity and established compatibility to multi-tier networks comprising of Macro-cells and Femto-cells, substantial efforts have been directed at investigating network performance using different implementations of FFR [3][4][5]. In [4], an FFR-3 scheme that implements three sectors in a single cell was investigated. Each Macro-cell was divided into cell centre region (CCR) and cell edge region (CER). The total available spectrum (W) was divided into two. The first portion of the spectrum was allocated to the CCR with a reuse factor of unity. The second portion was further divided into three sub-bands with each sector allocated a single sub-band for the Macro-cell user equipment (MUE). Orthogonalization of resource usage for the Macro-cell and Femto-cell equipment units in each sector and region was done. The authors adopted the result presented in [6] as optimal values for the dimensioning of the cell in terms of the CCR and frequency allocation to the regions.

Saquib et al. in [5] proposed a multi-tier resource allocation scheme that incorporates six sectors in a single cell for the FFR

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