Abstract

The focus of the work is on Orthogonal Frequency Division Multiple Access (OFDMA) based next generation (4G and beyond, e.g. Long Term Evolution) cellular networks. OFDMA is deployed using frequency reuse one in such networks to achieve very high area spectral efficiency. However, frequency reuse one causes heavy Inter-Cell Interference (ICI) which leads to poor Signal to Interference plus Noise Ratio (SINR) in cell edge regions. The aim of this work is to investigate the methods to improve cell edge performance of OFDMA cellular networks using Fractional Frequency Reuse (FFR) and Soft Frequency Reuse (SFR) schemes.

The investigation is carried out for both Best Effort (BE) and Real Time (RT) traffic. Performance is evaluated under an assumption of dense Urban Micro cell scenario (e.g. Inter Site Distance - 200 m). In FFR and SFR schemes, bandwidth is divided between center and edge bands in a ratio of α. An SINR threshold γ_{th} is used to classify users between center and edge bands. The ratio of the power spectral density between center and edge bands is defined as ρ_p. The focus of this work is to find these parameters for which the cell edge performance of FFR and SFR schemes is improved while not taking a heavy penalty on the sum cell capacity for BE traffic. Another focus area of this work is to evaluate the performance of FFR and SFR for RT traffic. A semi-analytical framework is developed and the operating range of the above mentioned design parameters is obtained. Four different bandwidth partitioning methods are proposed, namely, (a) 'Probability method', (b) 'Average method', (c) 'Static Proportional Channel Fair method' and (d) 'Grade of Service Fair method' for use in FFR.

From the results obtained, in case of BE traffic, in FFR with equal power configuration, the cell edge performance is improved by a factor of three and eight. The mean spectral efficiency is improved by 7% and 50% when compared against the reuse one and reuse three respectively. In case of SFR, the cell edge performance is improved by a factor of three and nine when compared against reuse three and reuse one respectively.

With unequal power configuration in FFR, the mean spectral efficiency is improved by 17% and 56% when compared against reuse one and reuse three respectively. The cell edge performance is improved by a factor of nine, four and one when compared against reuse one, reuse three and SFR respectively.

In RT traffic, it is found that the Erlang capacity is improved by 3% and 6.5% in the proposed GoS fair and Proportional Channel (PC) fair methods of FFR when compared against reuse one for strict Quality of Service (QoS) Voice over Internet Protocol (VoIP) traffic. However at strict QoS video rate, the capacity is improved by 30% in GoS fair and PC fair methods of FFR when compared against reuse one. With unequal power configuration in FFR, the percentage improvement in Erlang capacity is by 10% and 7% in PC fair and GoS fair methods respectively over reuse one for VoIP traffic. The coverage performance is improved by 32% in SFR over the reuse one for VoIP users, whereas it is improved by 30% and 50% in edge and total cell capacity in SFR over reuse one for video users. In this work, the values of the above mentioned parameters are found which increase the performance of FFR and SFR.

Hence it is concluded that with suitable choice of values of design parameters, FFR and SFR provide notable gain in cell edge performance over reuse three while at the same time providing better or comparable cell average performance when compared to reuse one for both BE and RT traffic. Therefore, the methods proposed in this work may be recommended for deployment in 4G and next generation OFDMA based cellular networks.

Keywords: LTE, FFR, SFR, SINR threshold, Bandwidth partitioning, Power ratio, BE traffic, RT traffic, Voice over Internet Protocol, Video.