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Project: IEEE 802.16 Broadband Wireless Access Working Group

Title: Self-organizing Dynamic Fractional Frequency Reuse Through Distributed Inter-cell Coordination

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Source:

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Abstract:
Soft fractional frequency reuse (FFR) offers significant edge-cell throughput benefits at the expense of some additional PHY (over the air) and backhaul signaling. In this contribution we outline the mobile to base station and inter base station signaling requirements for self-organizing, automatic FFR where no a priori frequency planning is required. The PHY signaling involves mobile sending back periodic signal-to-interference-and-noise (SINR) ratio on a per sub-band or resource set basis and also the ratio of path gains from a given number of strongest interferers to the serving base station. The backhaul signaling involves the periodic exchange of parameters that capture the sensitivities of the change in neighboring sector power levels in the different sub-bands/resource sets.

Purpose: To include in the SDD, the signaling methods for enabling self-organizing FFR.

Automatic FFR

- In OFDM systems frequency resources can be divided into sub-bands or time-frequency resources into *resource sets* and the transmit power level in each sub-band/resource set can be set independently.
- The transmit power levels can be combined with appropriate scheduling of users within each sector to achieve out-of-cell interference mitigation (soft FFR)
- It is desirable that the transmit power levels can be set automatically without any frequency planning. Such a feature will result in power settings that adapts to non-uniform traffic distribution and/or irregular base station placement.
- In order to achieve self-organizing dynamic FFR it is necessary exchange information between base stations and some additional information between mobiles and base stations.

FFR Requirements

- Time-frequency resources should be divided into well defined resource sets that are time-invariant for relatively long periods
- It should be possible to set different data transmit power levels in the different resource sets. If dedicated pilots are not used then the traffic-to-pilot will be dependent on the resource set. This should be taken into account in demodulation, i.e., signaled to the mobiles. Alternately dedicated pilots could be used for demodulation.
- The definition of the resource sets should be broadcast to the mobiles

Text for SDD: Mobile-to-base signaling Requirements

- Mobile should feedback **a measure of the interference power levels experienced in each sub-band or resource set**. Average pilot SINR in each sub-band could be used as the measure. If pilot SINR is used then it should be ensured that pilot tones hit data tones of neighboring sectors to capture the proper interference levels.
- For the base station to know which of the surrounding sectors is causing how much interference, the mobile should feedback **the ratio of path gains from each of the interfering neighbor sectors to the serving sector**. Average path gains are sufficient and hence this does not have to be on a per sub-band basis.
- Since we do not expect the transmit power levels to change frequently it is sufficient if the mobile feeds back the above information relatively infrequently, for example, once every 500 ms.
- The above signaling is in addition to the frequent signaling required for channel aware scheduling (i.e. sub-band CQI).

Text for SDD: Inter Base Station Signaling

- The extent of interference caused by a given sector's transmit power levels upon users' in the neighboring sectors is available only to the neighboring base stations themselves through feedback from their own mobiles. However, this information is required for properly adjusting the transmit power levels of the given sector. Thus some signaling is required to send information between sectors.
- Each neighboring sector of a given sector can compute the effect, upon its users, of an increase in transmit power level in each of the sub-bands in the given sector based on the SINRs and gain ratios reported back. The sensitivity computation can thus take into account the effect of the users scheduled in each of the sub-bands and their quality of service requirements etc.
- The **computed sensitivities can then be exchanged between the base stations periodically**. Exchange of information can be relatively infrequent such as once every 500 ms. The exact quantity exchanged can be specified later.

Simulation

- We present the performance of a couple of SO-FFR algorithms. Although the exact implementation of the algorithm is outside of the 802.16m specs, we provide these results to show the benefit of standardizing the suggested information elements detailed in the previous slides.

Parameter	**Assumption**
Cell Layout	Hexagonal 57 sector
Inter-site distance	2.5 Km
Path Loss Model	$L = 133.6 + 35 \log_{10}(d)$
Shadowing	Log Normal with 8.9 dB Std. Dev.
Penetration Loss	10 dB
Noise Bandwidth	1.25 Mhz
BS Power	40 dBm
BS Antenna Gain	15 dB
Rx Antenna Gain	0 dB
Rx Noise Figure	7 dB
Channel Model	No fading, Frequency-selective fading

Table: Propagation parameter values used in the simulation results

Simulation Results-I

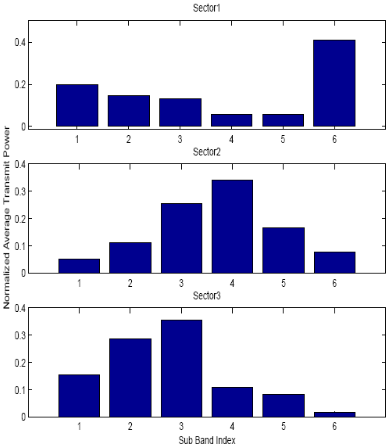

Figure: Power Allocation Resulting from the SO-FFR algorithm

Simulation Results-II

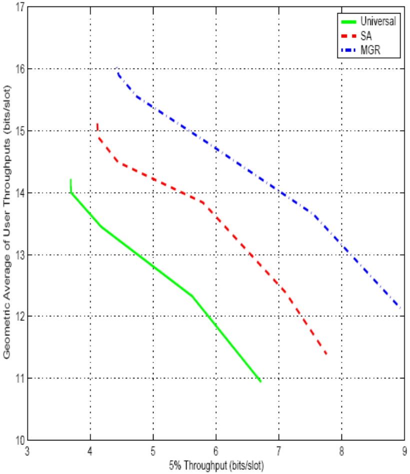

Figure: Average User vs Edge Throughput Resulting from the SO-FFR algorithm