Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Interference Mitigation for 802.16m**
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Source(s)	Chang-Lan Tsai, Ren-Jr Chen, Chung-Lien Ho, Yan-Xiu Zheng, Richard Li ITRI Wern-Ho Sheen NCTU/ITRI E-mail: tsaichangl@itri.org.tw richard929@itri.org.tw
Re:	IEEE 802.16m-08/024, Call for Contributions on Project 802.16m System Description Document (SDD) Topic: Interference Mitigation
Abstract	Proposal of the interference mitigation scheme in 802.16m
Purpose	Discussion and approval by the task group.
Notice	
Release	
Patent Policy	

Interference Mitigation for 802.16m

Chang-Lan Tsai, Ren-Jr Chen, Chung-Lien Ho, Yan-Xiu Zheng, Richard Li
ITRI
Wern-Ho Sheen
NCTU/ITRI

1. Introduction

In the multi-cell OFDMA environment, user throughput would be limited by inter-cell interference, especially for the user near the cell-edge. Frequency reuse factor of 1 results in large system spectral efficiency. However, the cell-edge user throughput is extremely low. On the other hand, frequency planning considering a large frequency reuse factor effectively reduces inter-cell interference. However, the system spectral efficiency is decreased. Fractional frequency reuse (FFR) scheme is shown to trade of between overall system throughput and average/cell-edge user throughput [1]. It should be considered as an advanced frequency allocation scheme to keep balance of users' throughput in 16m system.

2. Frequency Reuse 1 and 3

There are two common used frequency allocation schemes. One is to reuse the total bandwidth in each sector. This frequency reuse factor is 1. It is illustrated in Figure 1. The other scheme is that the total bandwidth is reused every three sectors, and each sector uses disjoint frequency band. It is illustrated in Figure 2, where the transmit power is increased (in Figure 2, $\lambda \geqq 1$) as the total transmit power is now allocated into 1/3 of the total bandwidth. Interference from adjacent sectors is eliminated and hence the user throughput and the packet error rate are largely improved. However, as each sector uses only 1/3 of the bandwidth, the spectral efficiency is less than that of the scheme with frequency reuse factor of 1.

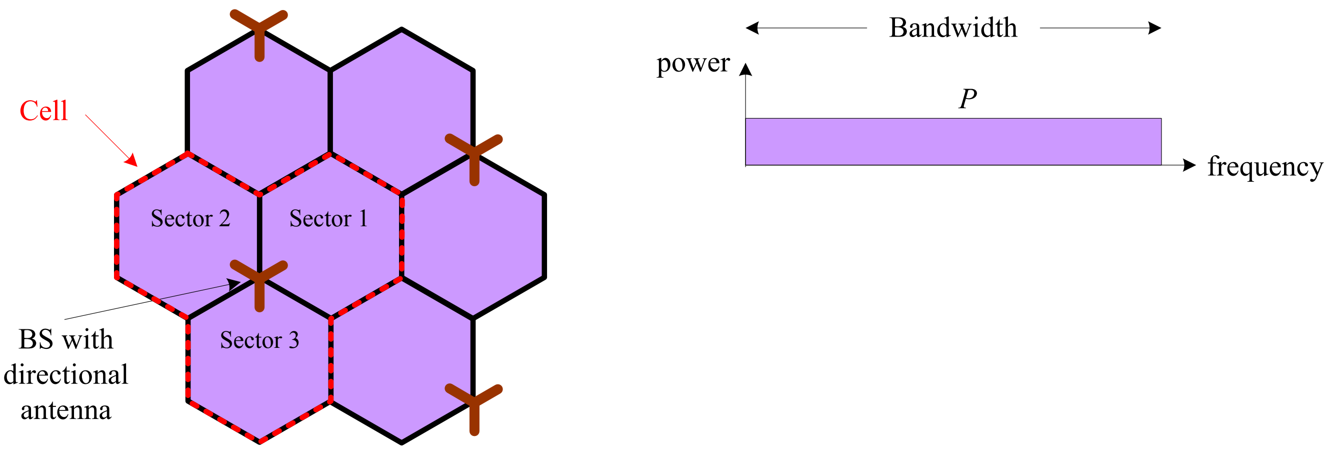

Figure 1. Frequency allocation with reuse factor of 1.

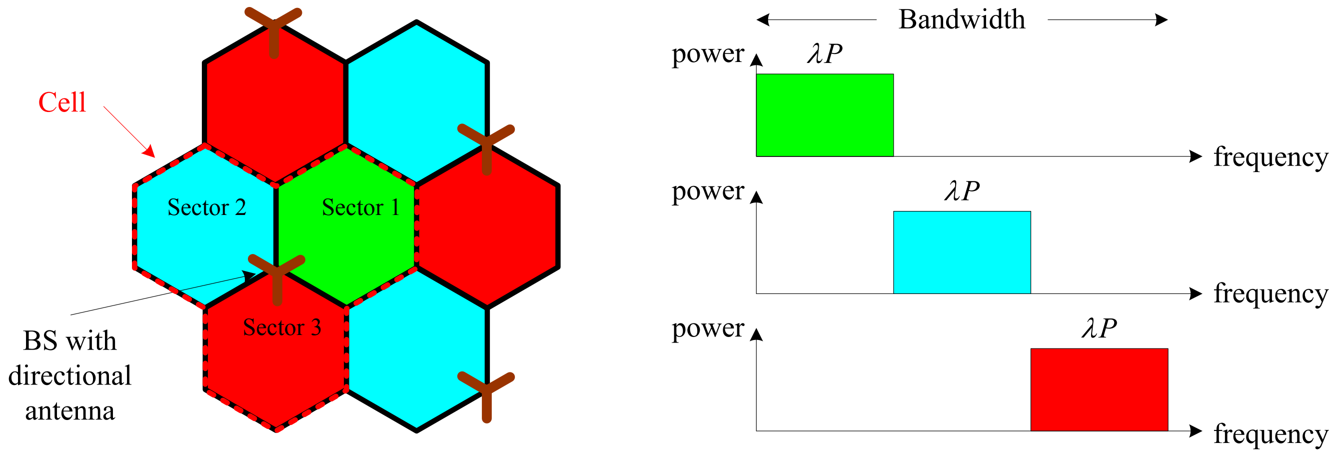

Figure 2. Frequency planning with reuse factor of 3 (with $\lambda \geqq 1$).

3. Interference Mitigation Using Fractional Frequency Reuse

3.1 Fractional Frequency Reuse

In order to improve the cell-edge user throughput and at the same time retain the spectral efficiency, the scheme of fractional reuse, which means that there are various frequency reuse factor in the frequency allocation in one sector, the total bandwidth is considered. By considering the advantages of frequency reuse 1 and 3, we divide the total bandwidth into two parts, one is sector center band and the other is sector edge band. The sector center band applies frequency reuse 1 to keep spectral efficiency. While the sector edge band applies frequency reuse 3 to enhance edge users' throughput. See Figure 3 for reference. The sector edge band is further divided into three frequency groups, which are specified by green, blue and red colors, respectively. Each group is non-overlapped to avoid interference. It is similar to the scheme of frequency reuse 3 (Figure 2). The interference-limited users (i.e., the user at the cell/sector edge) are scheduled using this band in their sector. Under the constraint of total transmit power, the power transmitted to the edge users can be increased (in Figure 3, $\alpha_1 \geqq 1$). The increased power level can further enhance the signal quality and hence the throughput of the users at the cell-edge. Comparing with frequency reuse 1 (Figure 1) and frequency reuse 3 (Figure 2), the spectral efficiency of this scheme (Figure 3) is less than that of Figure 1 because some frequency band is reserved without transmission to avoid interference. However, the throughput of sector edge users is large increased.

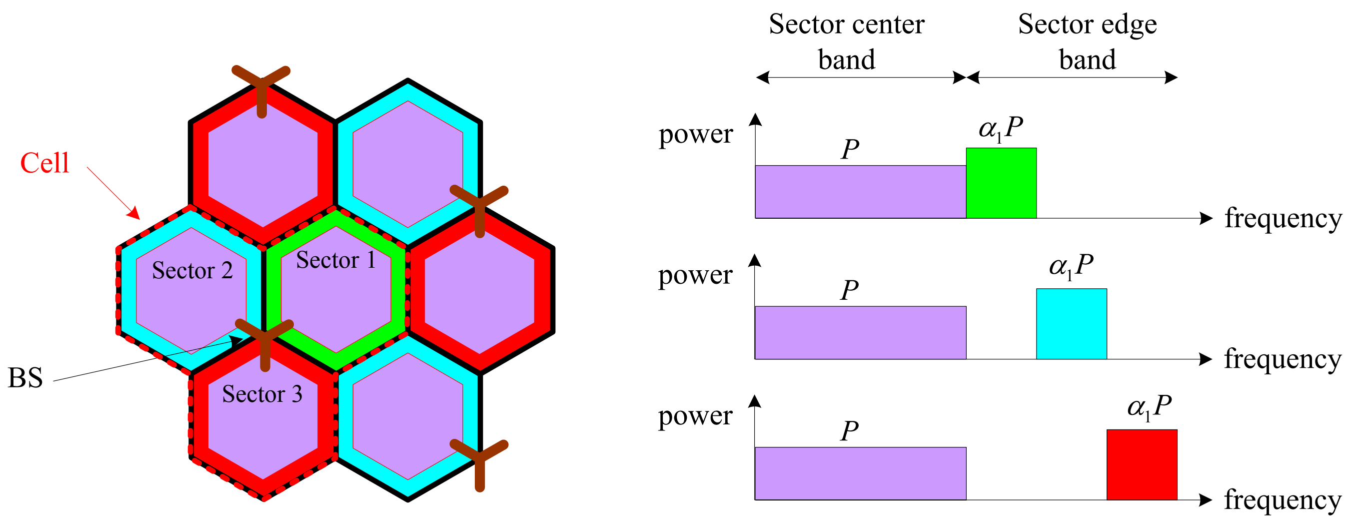

Figure 3. Frequency allocation for fractional frequency reuse (with $\alpha_1 \geqq 1$).

3.2 Soft Fractional Frequency Reuse

Soft reuse the sector edge band can compensate for the loss due to the reserved band in each sector. Instead of not transmitting signal in the reserved frequency in each sector, the BS can use the blank frequency band with reduced power resulting in less interference to the neighboring sectors. Since the transmit power is small, this frequency band is suitable for users near the BS (center users) as the path loss is small. As demonstrated in Figure 4, the power level β_2 in the soft reused band is smaller than 1. The total transmit power is constrained. Compare this scheme with Figure 3, the cell-edge user throughput may be decreased and the sector throughput may be increased. The power levels α_2 and β_2 are the designed parameter of the system to trade of between sector's (sum) throughput and average/edge users' throughput.

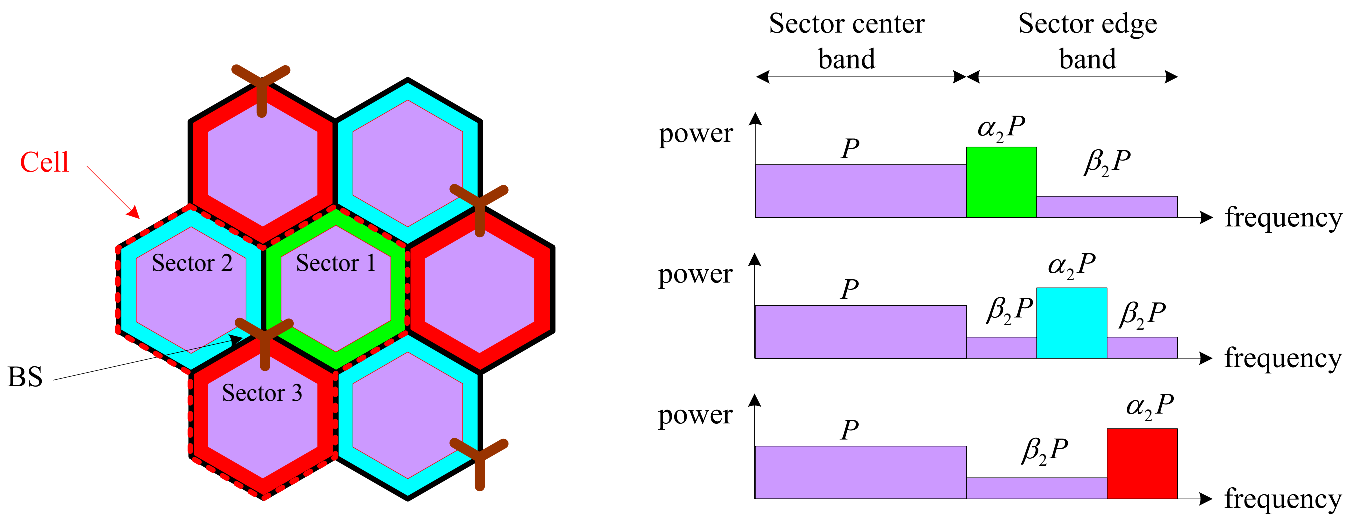

Figure 4. Frequency allocation for soft fractional frequency reuse (with $\alpha_2 \geqq 1, \beta_2 < 1$).

3.2 Flexible Fractional Frequency Reuse

The partition of sector center and edge bands depends on the traffic load the user distribution in each sector. These factors vary with time. Flexible frequency reuse partition is required to attain most efficiency usage of the frequency and power. Examples are demonstrated in Figure 5. Comparing with Figure 4, the portion of sector center band at the left scheme in Figure 5 is reduced. This is suitable to the case that many users are near the cell/sector edge. The extreme case is shown at the right scheme in Figure 5. This is similar to the frequency allocation of frequency reuse 3, excepting that the blank frequency band in each sector is now reused with reduced power. It can be classified as 'soft frequency reuse 3'.

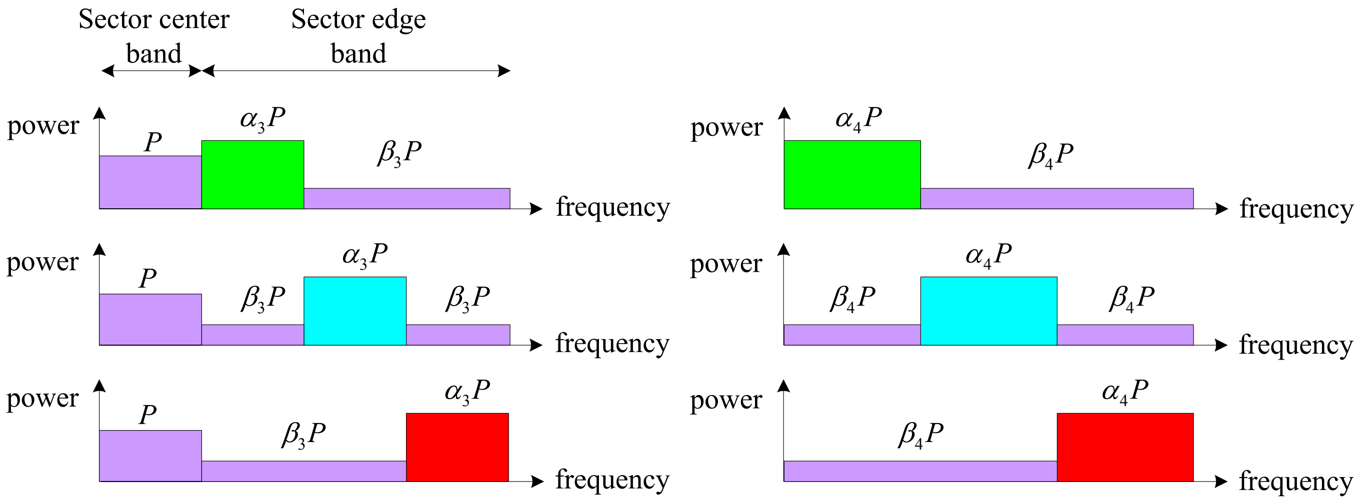

Figure 5. Flexible frequency allocation for soft fractional frequency reuse (with α_3, $\alpha_4 \geqq 1$, β_3, $\beta_4 < 1$).

4. Conclusion

Advanced frequency partitioning provides more flexible bandwidth usage and much flat distribution of users throughput. Frequency reuse factor of 1, 3 and fractional frequency reuse schemes are adjusted adaptively to accommodate to time-varying traffic load and users' distribution.

Text Proposal for the 802.16m SDD

-----------------------------------Start text proposal-----------------------------------

[*Insert a new subclause on interference mitigation in theP802.16m System Description Document (SDD)*]

11.x Interference Mitigation

11.x.y Interference suppression by fractional frequency reuse

Fractional frequency reuse (FFR) scheme should be supported to improve average and cell-edge user throughput. The ratio of different frequency reuse factor and the corresponding power level are optimized or adjusted adaptively according to the traffic load and user distribution, etc., to trade of between spectral efficiency and average/cell-edge user throughput enhancement. Coordination between BSs for frequency partition is needed to avoid/suppress inter-cell/sector interference.

-----------------------------------End text proposal-----------------------------------

Reference

[1] Y. Xiang and J. Luo, "Inter-cell interference mitigation through flexible resource reuse in OFDMA based communication networks," in Proc. European Wireless 2007, pp. 1-7, Apr. 2007.