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Title	Uplink Power Control Enhancement for 802.16e OFDMA PHY	
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Re:	For consideration in Working Group Recirculation Ballot #14b, on P802.16d/D3.	
Abstract	By adapting tile-based power control, the uplink performance in OFDMA system is enhanced in the NLOS environment.	
Purpose	Adoption	
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Uplink Power Control Enhancement for 802.16e OFDMA PHY

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1. Introduction

In IEEE P802.16e/D2-2004, the fast uplink power control is supported by using Fast tracking indication in the UL-MAP (as shown in Table 263b). The average received power from all Subscriber Stations (SS) at the Base Station (BS) are kept at the same level through this mechanism. The uplink power control mechanism based on the SS average power works fine in LOS case.

However, in the NLOS environment,

1. the received power in different subcarriers may vary vastly due to the multipath effect.
2. the Inter-Carrier Interference (ICI) occurs due to frequency offset and the non-orthogonal nature on uplink.

Due to the difference of local oscillator and existence of Doppler shift, the frequency offsets of the received signals from different SSs are not coordinated. ICI occurs between two neighboring subcarriers that belong to different SSs.

As specified in the current standard, the Subscriber Stations (SS) shall be synchronized to the BS with a tolerance of maximum 2% of the subcarrier spacing. The adjacent subcarriers, which belong to two different SSs, may have the opposite-direction frequency shift, thus the ICI is caused by the summation of the frequency shifts of the signals from two SSs.

Therefore, strong power in a subcarrier may generate an ICI that destroys the reception of the weak signal in its adjacent subcarrier. This symptom is similar to that caused by near-far effect.

The ICI in NLOS case can be illustrated in a simple OFDMA system as shown in Figure 1. There are three SSs in this system, representing by green, red, blue colors, respectively. Each SS transmit in a tile that consists of 4 consecutive subcarriers by 3 OFDM symbols. Due to multipath effect, red signals are much stronger than their neighbors. The accumulated ICIs represented in black lines may hamper the reception of the blue signal at subcarrier 2 and green signal at subcarrier -3.

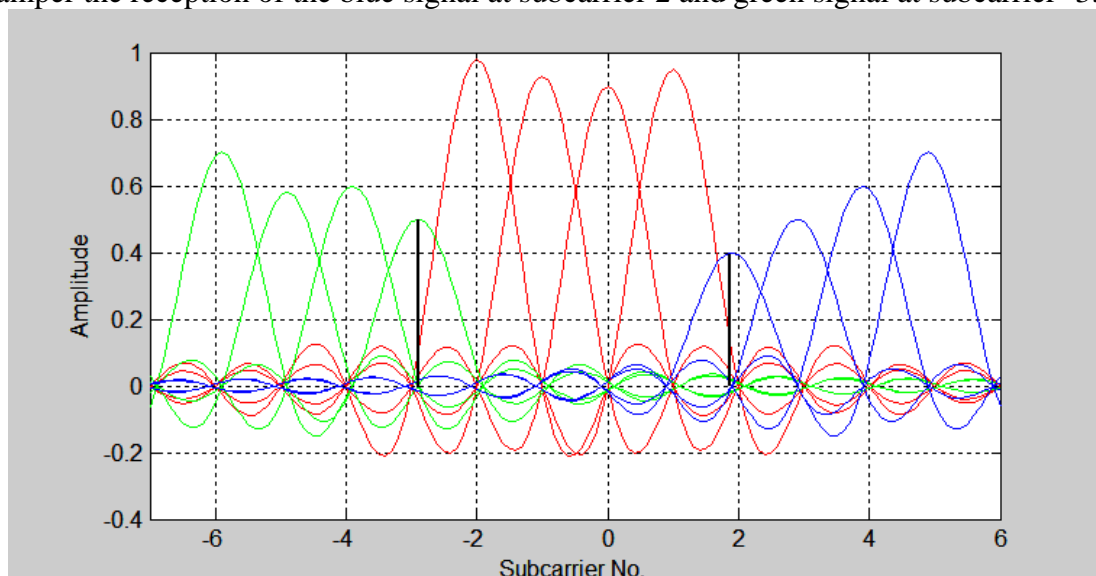


Fig.1 Received frequency-domain signal in Base Station

2. The Solution

Based on the analysis above, we propose the tile-based power control. The Base Station (BS) measures the average power of the tile, and then feeds back the adjustment command to the SS. The SS performs the power adjustment in digital domain. This accurate uplink power control eliminates the near-far effect in OFDMA system.

3. Performance

The performance is evaluated by simulation. The simulation parameters follow the OFDMA uplink PHY in 802.16 D5. Assume that the 70 users communicate with BS simultaneously, and each user occupies one subchannel with $\frac{1}{2}$ convolutional coded 16QAM. The two static multipath channel models are randomly assigned to the 69 users except the user 1, and the frequency offset of all the users are supposed to be the same (2% and 6% of subcarrier spacing). The user 1 is chosen as the target uplink user, whose channel model is SUI5. The uplink performance of user 1 is shown in Fig. 2. The tile-based power control brings about 1.5dB gain at frequency offset 2%, and 2.5dB gain at frequency offset 6%, compared to the user-based power control only.

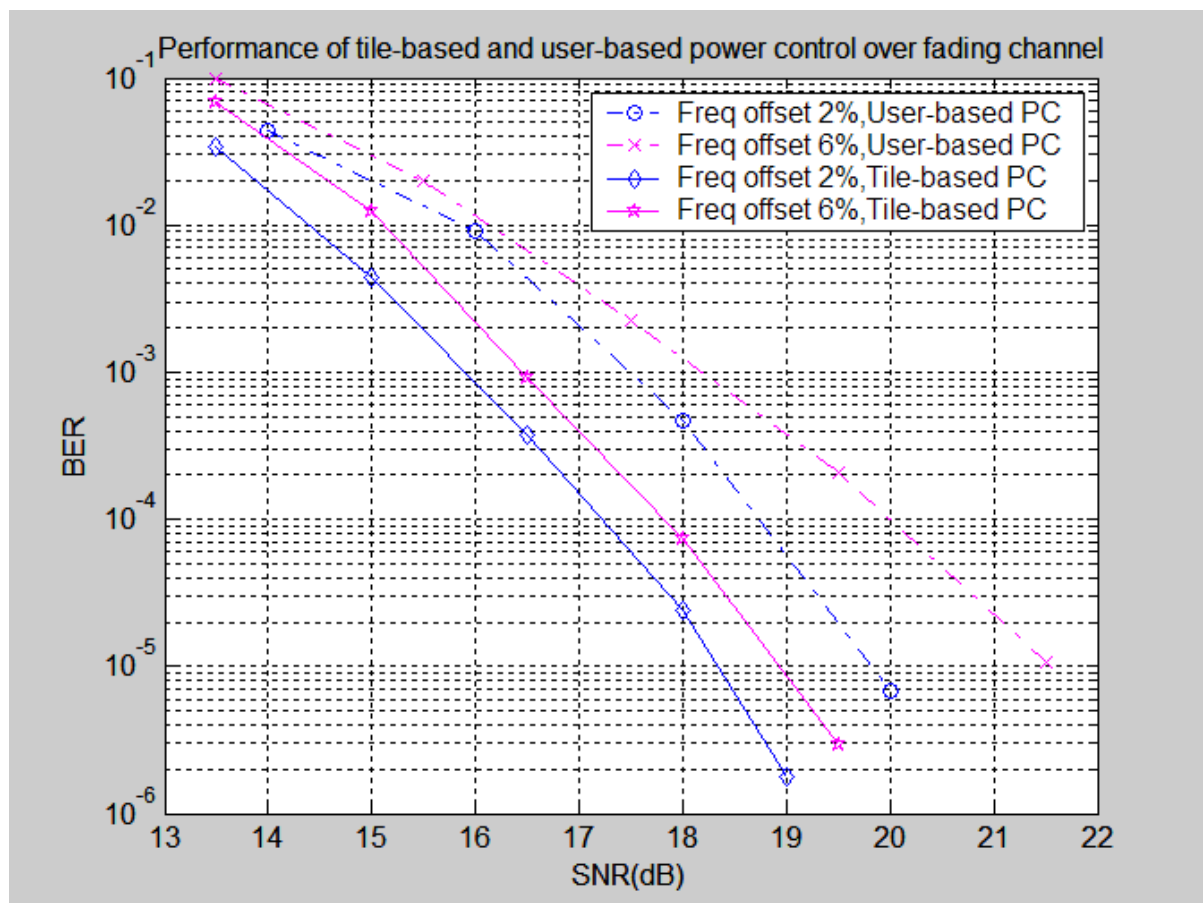


Fig.2 Performance comparison of user-based and tile-based power control

4. Proposed Text

8.4.5.4.3 Enhanced Power Control

When the UL enhance power control is used, an Enhanced Power Control IE is sent using the extended UIUC=15 with subcode 0x01. An UL enhanced power control IE is used to keep the power balance between tiles within one SS when some tiles reside in the deep fading. The power control value is expressed in 1 bit and defined according to Table xxx.

The IE is unicasted to each SS. When used, the CID in the UL_MAP_IE() should be set to Basic CID of the SS .

Table xxx. Enhanced power control IE

Syntax	Size	Notes
Enhanced_Power_Control_IE(){		
Extended UIUC	4 bits	Enhanced Fast Power Control = 0x01
Bitmap length	6 bits	The number of bytes in Power Control Bitmap, it equals to Ceil(Number_of_tiles assigned to the SS/8)
Power Adjustment Bitmap	variable	Each bit indicates if a power adjustment is necessary for a tile. "1"- the specific tile need to adjust power;"0"- the specific tile keep unchanged. The LSB of the first byte is the indicator for the tile with the lowest index.
for (i=1; i<=n; i++) {		n=Number of 1 in the Power Adjustment Bitmap
Power correction	1 bits	Power correction indication, 0: -3dB, 1: +3dB
}		
}		