Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Operating mode identification using preamble**
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Source(s)	Jiho Jang, Seungjoo Maeng, Panyuh Joo, Jaeho Jeon, Soonyoung Yoon Samsung Electronics Co., Ltd. Dong Suwon P.O.Box 105 416, Maetan-3dong, Yeongtong-gu, Suwon-city, Gyeonggi-do, Korea 442-600 jiho.jang@samsung.com sjmaeng@samsung.com panyuh@samsung.com jhjeon@samsung.com soon.young.yoon@samsung.com
Re:	
Abstract	Method to identify the operating mode using preamble
Purpose	Adopting of proposed method into P802.16e
Notice	
Release	
Patent Policy and Procedures	

Operating mode identification using preamble

Problem Definition and Proposed Solutions

For flexible usage of the symbol structure in IEEE 802.16e/D3, we propose a method of operating mode identification using preamble. For example, PUSC symbol structure is useful for sectored cell deployment to lower inter-cell interference. For frequency reuse one deployment, however, FUSC and optional FUSC symbol structures are beneficial in order to increase spectral efficiency. Moreover, AAS supporting BS may prefer the AMC subchannel structure. Consequently, it is crucial that the FCH is flexibly configured according to the preferred system deployment and system capability to support advanced technology. The followings are details of reasoning for the employment of operation mode identification which is proposed in this contribution.

A. In case of frequency reuse 1 deployment (see Figure 1)

1. FUSC or Optional FUSC (O-FUSC) is beneficial in terms of spectral efficiency because they use the whole bandwidth.
2. Comparing with PUSC with all subchannels, O-FUSC has the gain of spectral efficiency by about 3 percents since O-FUSC uses 1728 subcarriers while PUSC uses 1680 subcarriers.
3. Comparing with PUSC with all subchannels, O-FUSC has the gain of signal to interference ratio (SIR) since the hit property of subcarriers in a subchannel for O-FUSC is much better than that for PUSC (see Figure 2).

B. In case of frequency reuse 3 deployment using sectored cell structure (see Figure 3)

1. PUSC may have benefits in terms of SIR at cell edge since the interference from other cells or sectors is lowered.

C. In case of frequency reuse 3 deployment using omni cell structure (see Figure 4)

1. Comparing with PUSC with all subchannels, O-FUSC has the gain of spectral efficiency by about 3 percents since O-FUSC uses 1728 subcarriers while PUSC uses 1680 subcarriers.
2. Comparing with PUSC with all subchannels, O-FUSC has the gain of signal to interference ratio (SIR) since the hit property of subcarriers in a subchannel for O-FUSC is much better than that for PUSC (see figure 2).

D. In case of employing AAS systems

1. In AAS systems using beamforming, AMC subchannel structure is preferred since energy concentration into narrow frequency band is easier to implement and yields more gain than spreading out the total energy into wideband.

We propose a method of operating mode identification using preamble which requires minor modifications of ~~existing~~ current standard. The proposed method of operating mode identification does not have any impacts on the existing preamble structure. The PAPR and frame synchronization performances can be retained when comparing with the default mode (PUSC) operation. In addition, the complexity of MSS in scanning the operating mode does not increase since the operating mode may be fixed to use a specific symbol structure corresponding to the strategy of cell deployment. Also, the implementation of MSS to support all the kinds of symbol structure can be easily done by only adding a control logic which has the rules of mapping the modulated symbols into physical subcarriers according to the symbol structure.

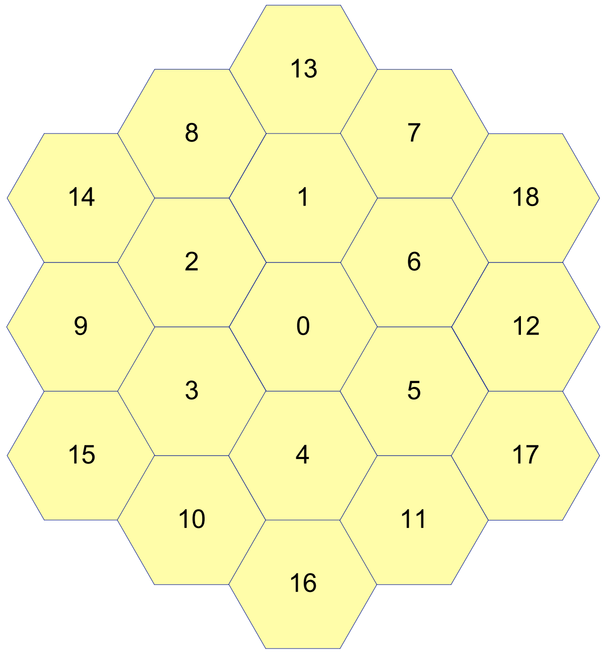
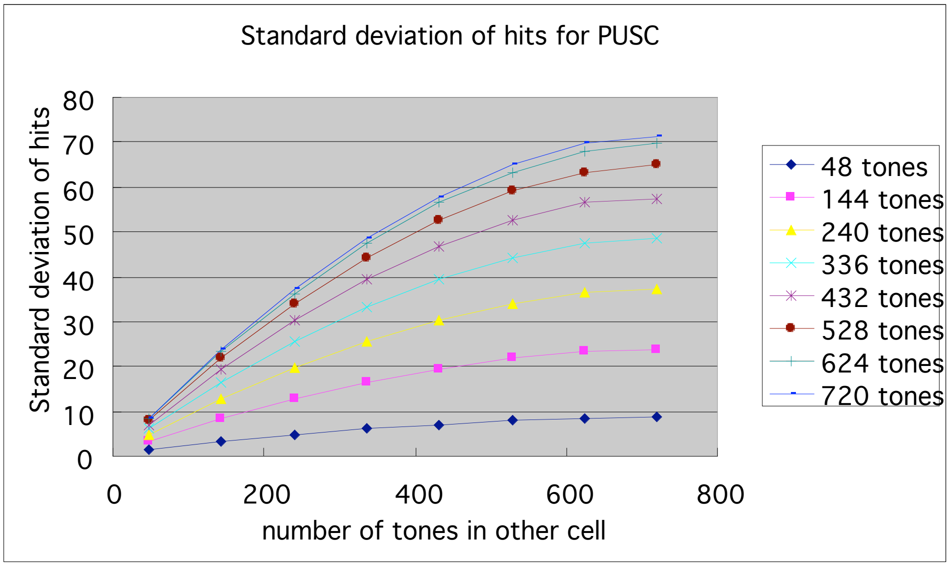
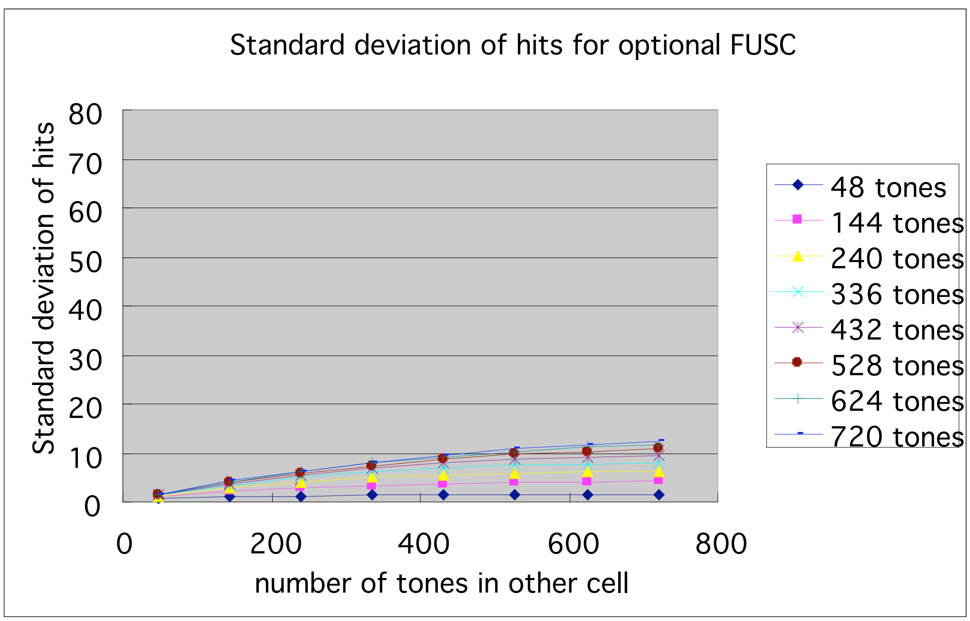


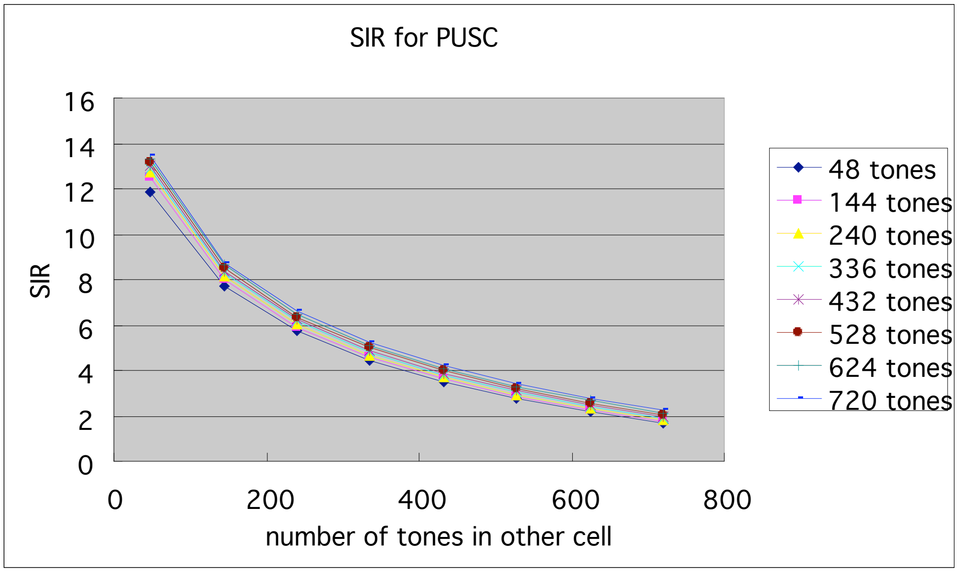
Figure 1. Example of frequency reuse 1 deployment


Standard deviation of hits for PUSC
Standard deviation of hits
0
10
20
30
40
50
60
70
80
0
200
400
600
800
number of tones in other cell
48 tones
144 tones
240 tones
336 tones
432 tones
528 tones
624 tones
720 tones

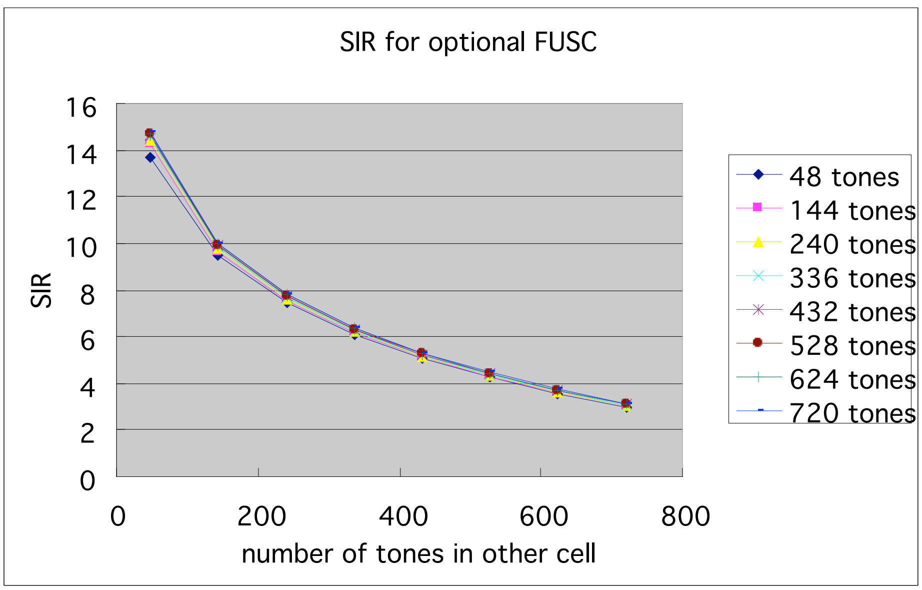
(a)


Standard deviation of hits for optional FUSC
Standard deviation of hits
0
10
20
30
40
50
60
70
80
0
200
400
600
800
number of tones in other cell
48 tones
144 tones
240 tones
336 tones
432 tones
528 tones
624 tones
720 tones

(b)



(c)



(d)

Figure 2. Standard deviation of hits and SIR for PUSC and optional FUSC

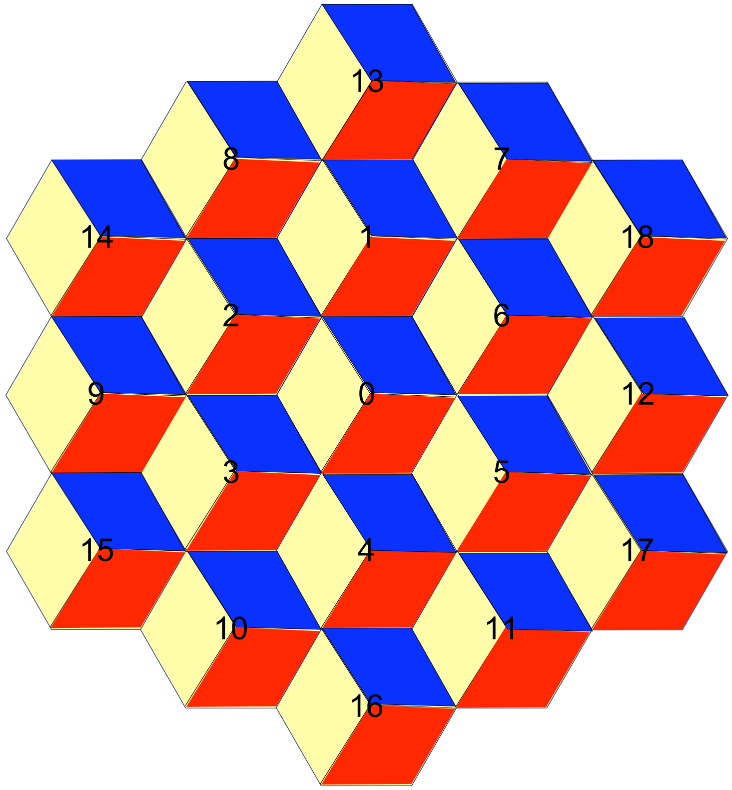


Figure 3. Example of frequency reuse 3 deployment with 3-sectored cells

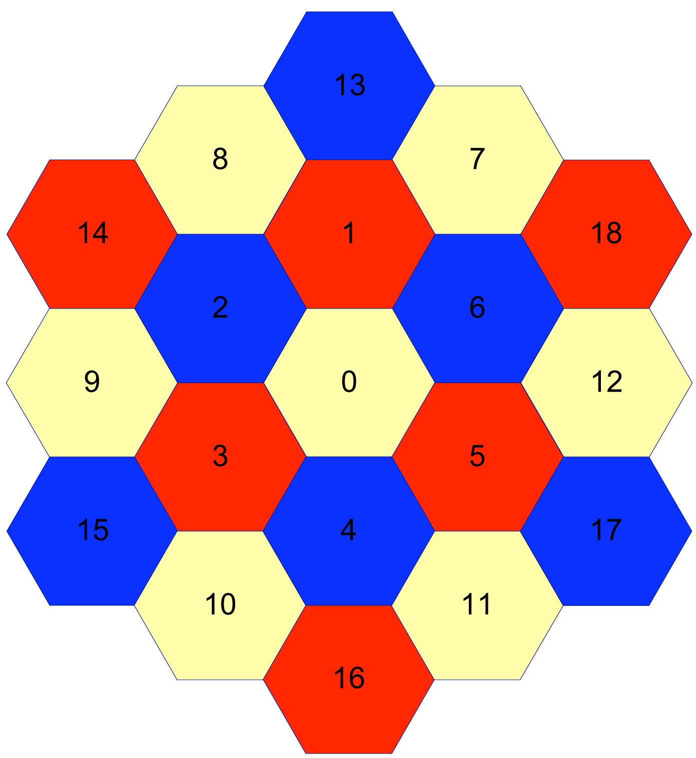


Figure 4. Example of frequency reuse 3 deployment with omni cells

Suggested change to the standard

[ADD new section '8.4.6.1.1.1 Operating mode identification using preamble' before section 8.4.6.1.2]

8.4.4.2.1 Operating mode identification using preamble

For FFT size other than 2048-FFT, the FCH shall be transmitted using QPSK rate 1/2 with four repetitions using the symbol structure (e.g. PUSC, FUSC, optional FUSC or AMC) designated in the preamble, and the mandatory coding scheme (e.g. the FCH information will be sent on four adjacent subchannels). Table aaa defines the structure of DL_Frame_Prefix for FFT size other than 2048-FFT.

Table aaa–OFDMA downlink Frame Prefix format for FFT size other than 2048-FFT

Syntax	Size	Notes
DL_Frame_Prefix_Format() {		
Used subchannel bitmap	6 bits	xxxxx1: Subchannels 0-11 used xxxx1x: Subchannels 12-19 used xxx1xx: Subchannels 20-31 used xx1xxx: Subchannels 32-39 used x1xxxx: Subchannels 40-51 used 1xxxxx: Subchannels 52-59 used When FUSC, optional FUSC or AMC symbol structure is used for FCH, all subchannels shall be used with all 1's for the 'used subchannel bitmap'
Ranging_Change_Indication	1 bit	
Repetition_Coding_Indication	2 bits	00 – No repetition coding on DL-MAP 01 – Repetition coding of 2 used on DL-MAP 10 – Repetition coding of 4 used on DL-MAP 11 – Repetition coding of 6 used on DL-MAP
Coding_Indication	3 bits	000 – CC encoding used on DL-MAP 001 – BTC encoding used on DL-MAP 010 – CTC encoding used on DL-MAP 011 to 111 – reserved
DL-MAP Length	8 bits	
Reserved	4 bits	Reserved; Shall be set to 0
}		

The information about symbol structure for FCH is transmitted using preamble by the following method.

In case when the preamble is cyclically shifted in time domain by n/4 of OFDMA symbol for n=0,1,2,3 (see Table bbb), 4 types of symbol structure can be differentiated. When the preamble is cyclically delayed in time by N samples, the transmitted waveform s(t) becomes as following:

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_c t} \cdot \left(\sum_{\substack{k=-(N_{used}-1)/2 \\ k\neq 0}}^{k=(N_{used}-1)/2} c_k \cdot e^{j2\pi Nk/N_{FFT}} \cdot e^{j2\pi k\Delta f(t-T_g)} \right) \right\} \quad \text{(xxx)}$$

where c_k are the preamble tone values, and t is the time elapsed since the beginning of the OFDMA symbol with $0 < t < T_s$. Four types of operating modes each of which defines symbol structure for FCH are listed in Table bbb.

Table bbb – Operating mode configuration

n (index for delay in time)	Operating mode
0 (default)	PUSC
1	FUSC
2	Optional FUSC
3	AMC

References

[1] IEEE P802.16-REVd/D5-2004 Draft IEEE Standards for local and metropolitan area networks part 16: Air interface for fixed broadband wireless access systems.

[2] IEEE P802.16-REVe/D3-2004 Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Band.