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Re:	This is a response to a Call for Comments on IEEE P802.16e-D5a
Abstract	The collaborative spatial multiplexing can be applied to the case in OFDMA.
Purpose	This document is submitted for review by 802.16e Working Group members. **Pink line indicates the revised text.**
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Extension of Collaborative Spatial Multiplexing in OFDMA

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1. Introduction

In OFDMA of the current 802.16e standard, collaborative spatial multiplexing mode is supported through MIMO_UL_Basic_IE(). Two single transmit antenna MSSs can perform collaborative spatial multiplexing onto the same subchannel. This mode can result in capacity increment by assigning same uplink resource to two MSSs simultaneously.

When BS has two or more receive antennas, the collaborative spatial multiplexing can be applied to the case where two MSSs have 2 transmit antennas.

In this contribution, we suggest to modify the MIMO_UL_Basic_IE( ) **or add the new MIMO_UL_Enhanced_IE()** to achieve the above case.

2. Feasible collaborative SM modes

There are various feasible collaborative SM modes according to the following combinations of # of transmit antennas in MSS and STC configuration (STTD or SM). The current collaborative SM corresponds to the first example of the followings.

- **Collaborative SM example #1**

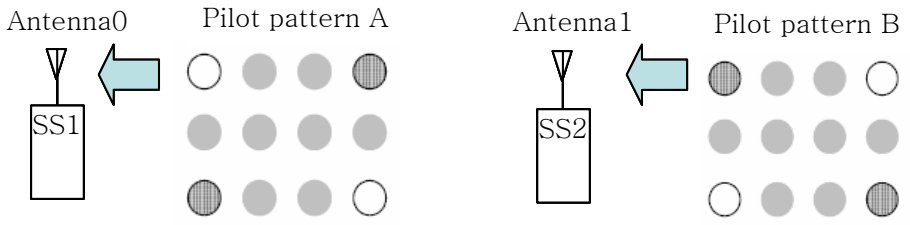

Figure 1. The case of two SSs with single transmit antenna

SS1 and SS2 share the BW resource, but a SS1 uses the uplink tile with pilot pattern A and a SS2 uses the uplink tile with pilot pattern B in PUSC mode.

- **Collaborative SM example #2**

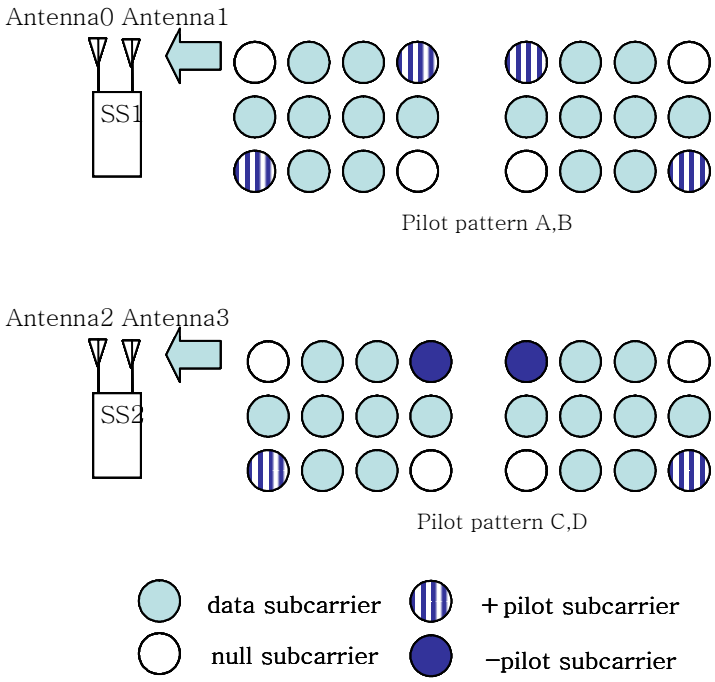

Figure 2. The case of two SSs with dual transmit antennas

A SS1 uses the uplink tile with pattern A and B, and a SS2 uses the uplink tile with pattern C and D.

3. Proposition

The second example of the aforementioned collaborative SM examples requires four pilot patterns to distinguish the channels from each antenna of MSSs. For the purpose of realizing the above configurations, more pilot patterns are needed to support the various collaborative SM modes. Therefore, we propose to add new pilot pattern C, D to current pilot pattern A, B as shown in Figure 2.

In addition, we suggest to modify the MIMO_UL_Basic_IE() **or to add the MIMO_UL_Enhanced_IE()** to indicate the various collaborative SM modes and to support that MSS has two transmit antennas.

4. Simulation result

The figures below show the performance results of the collaborative SM. We assume that there are two MSSs with dual antennas and a BS with 4 antennas, and a MSS uses pilot pattern A and B in each antenna and another MSS uses pilot pattern C and D for STTD structure.

Figure 3 and 4 are BER and FER for CC 1/2 rate, UL PUSC mode and Pedestrian B channel with 10km/h. The Eb/No of the proposed pilot pattern are about -2.8dB in QPSK, 2.6dB in 16QAM, and 7.7dB in 64QAM at 10% FER. And figure 5 and 6, which are simulated in Vehicular A channel with 60km/h, show a little worse performance than figure 3 and 4.

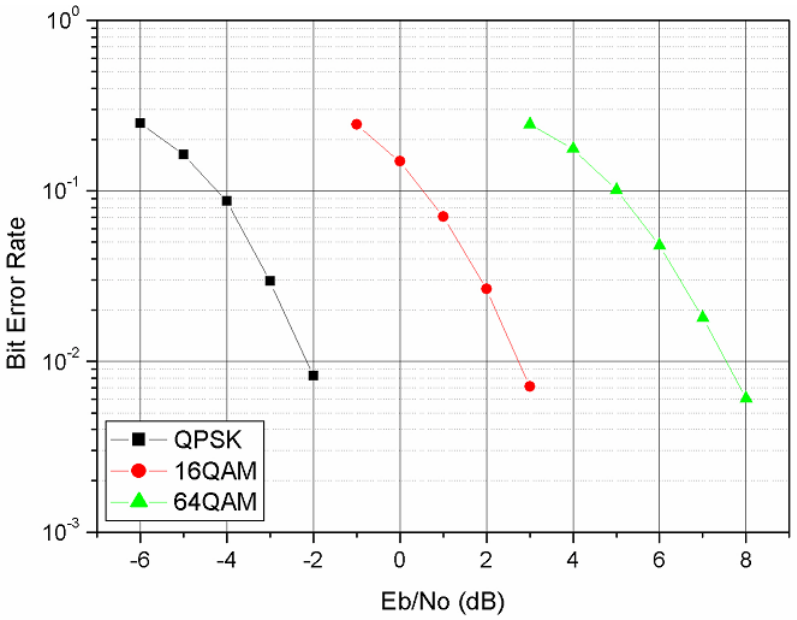

Figure 3. BER of two MSSs with dual antennas and BS with 4 antennas (Pedestrian B with 10km/h)

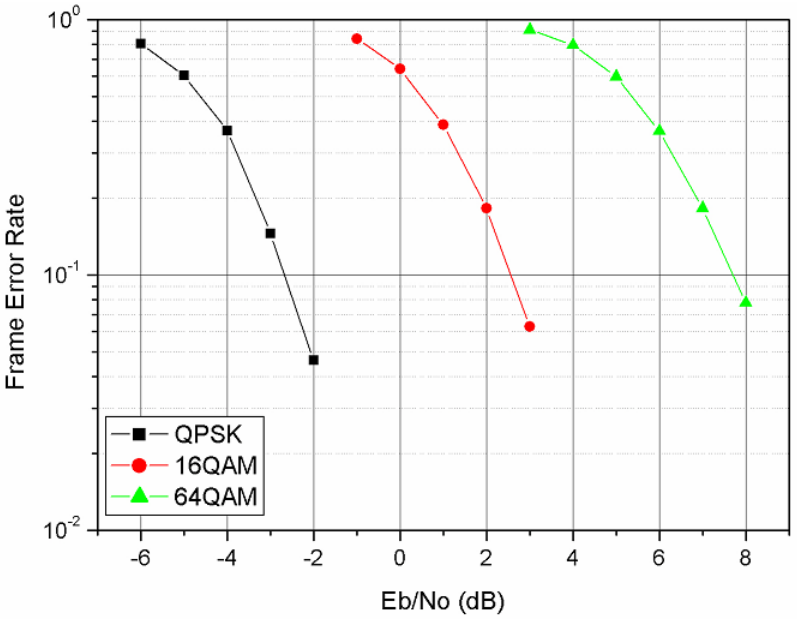

Figure 4. FER of two MSSs with dual antennas and BS with 4 antennas (Pedestrian B with 10km/h)

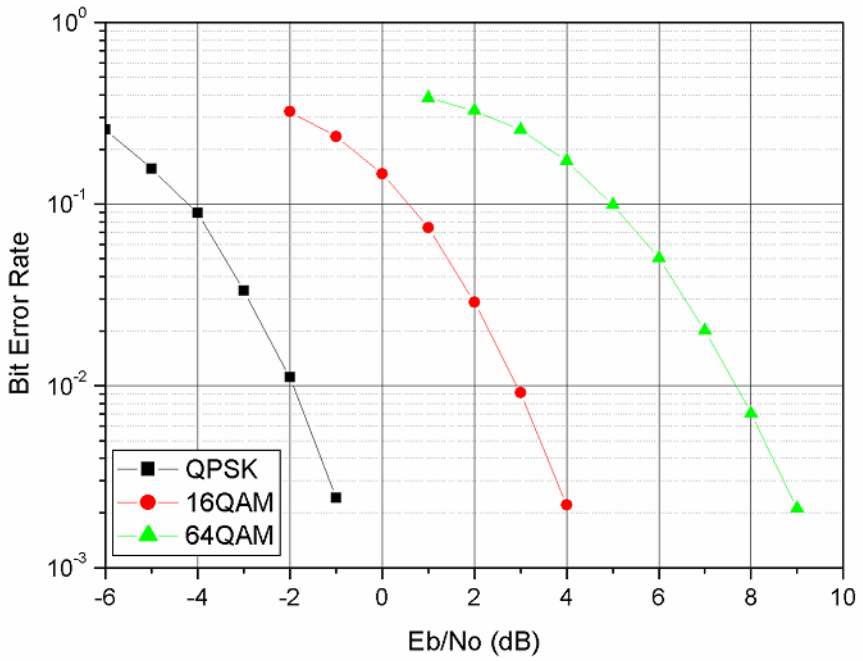

Figure 5. BER of two MSSs with dual antennas and BS with 4 antennas (Vehicular A with 60km/h)

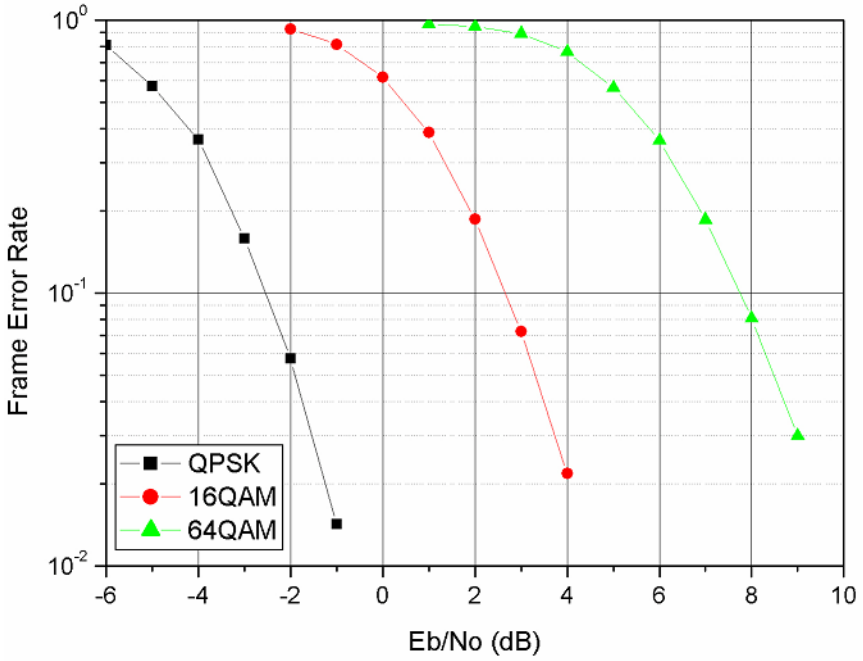

Figure 6. FER of two MSSs with dual antennas and BS with 4 antennas (Vehicular A with 60km/h)

5. Proposed Text Change

---------- Start of Option 1 and Option 2 ----------

[Option 1]

We propose to change the reserved field to Pilot pattern field in the MIMO UL basic IE and we refer to the IEEE std 802.16-2004.

8.4.5.4.11 MIMO UL basic IE format

[Change Table 297 as follows:]

Table 297 – MIMO UL basic IE () format

Syntax	Size	Notes
MIMO_UL_basic_IE () {		
Extended UIUC	4bits	MIMO=0x02
Length	4bits	Length of the message in bytes (variable)
Num_Assign	4bits	Number of burst assignment
For (j=0; j< Num_assign; j++){		
CID	16bits	SS basic CID
UIUC	4bits	
MIMO_Control	1bit	For dual transmission capable SS 0: STTD 1: SM For Collaborative SM capable SS 0 : pilot pattern A 1 : pilot pattern B
Duration	10bits	In OFDMA slots (see 8.4.3.1)
~~Reserved~~ Pilot pattern / *Reserved*	1bit	If SS has dual transmission, BS indicates pilot pattern. 0 : pilot pattern A/~~,~~ B 1 : pilot pattern C/~~,~~ D Otherwise :~~ *reserved*~~ **Shall be set to zero**
}		
Padding	variable	Number of bits required to align to byte length, shall be set to zero.
}		

Num_assign

This field specifies the number of assignments in this IE.

MIMO_Control

MIMO_Control field specifies the MIMO mode of UL burst. For a dual transmission capable SS, the value of 0 indicates STTD mode, the value of 1 indicates SM mode; For a collaborative SM capable SS, the value of 0 indicates pilot pattern A, the value of 1 indicates pilot pattern B.

Pilot pattern

This field specifies the Collaborative SM mode for a dual transmission capable MSS. The value of 0 indicates pilot pattern A, B and the value of 1 indicates pilot pattern C, D.

[Option 2]

[Add a new Section 8.4.5.4.19]

8.4.5.4.19 MIMO UL Enhanced IE format

In the UL-MAP, a MIMO-enabled BS may transmit UIUC=15 with the MIMO_UL_Enhanced_IE() to indicate the MIMO configuration and pilot patterns of the subsequent uplink allocation to a specific MIMO-enabled MSS CID. The MIMO mode indicated in the MIMO_UL_Enhanced_IE() shall only apply to the subsequent uplink allocation until the end of frame.

Table xxx – MIMO UL Enhanced IE () format

Syntax	Size	Notes
MIMO_UL_Enhanced_IE () {		
Extended UIUC	4bits	Enhanced MIMO=0x??
Length	4bits	Length of the message in bytes (variable)
Num_Assign	4bits	Number of burst assignment
For (j=0; j< Num_assign; j++){		
Num_CID	2bits	
For (i=0; i <Num_CID; i++){		
CID	16bits	MSS basic CID
UIUC	4bits	
Matrix_Indicator	1 bit	For MSS with dual antenna 0: Matrix A (STTD, see 8.4.8.4.3) 1: Matrix B (SM, see 8.4.8.4.3) For MSS with single antenna Skip this field
Pilot Pattern Indicator	1 bit	For MSS with single antenna 0: pilot pattern A 1: pilot pattern B For MSS with dual antenna 0 : pilot pattern A/B 1 : pilot pattern C/D
}		
Duration	10bits	In OFDMA slots (see 8.4.3.1)
}		
Padding	Variable	
}		

Num_Assign

This field specifies the number of assignments in this IE.

Matrix_Indicator

This field specifies the MIMO mode of UL burst. For MSS with dual antenna it indicates STC Matrix and for MSS with single antenna it is skipped.

Pilot Pattern Indicator

This field indicates pilot patterns to MSS with single antenna or to MSS with dual antenna (see 8.4.8.1.5).

---------- End of Option 1 and Option 2 ----------

8.4.8.1.5 Uplink using STC

[Insert Figure 249a after Figure 249 as follows:]

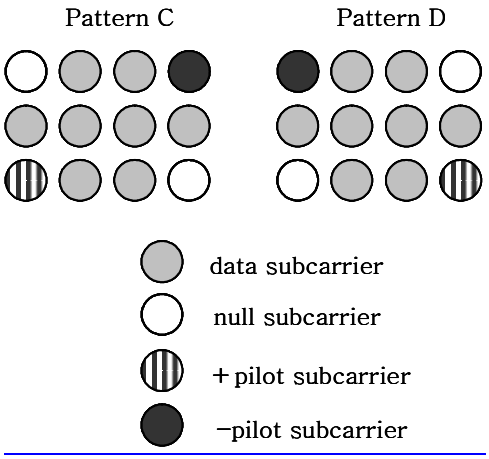

Figure 249a – Pilot Patterns in UL PUSC tile

[Add text in section 8.4.8.1.5.1 as follows:]

Two single transmit antenna SS's can perform collaborative spatial multiplexing onto the same subchannel. In this case, the one SS should use the uplink tile with pattern-A and the other SS should use the uplink tile with pattern-B. Also, two dual transmit antenna SS's can perform collaborative spatial multiplexing onto the same subchannel. In this case, the one SS should use the uplink tile with the pilot pattern A, B and the other SS should use the uplink tile with the pilot pattern-C, D through ~~MIMO_UL_Basic_IE~~ **MIMO_UL_Enhanced_IE**. Pilot patterns are illustrated in the Figure 249 and 249a.

6. References

[1] IEEE P802.16-2004