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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
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# Extension of Collaborative Spatial Multiplexing in OFDMA

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## 1. Introduction

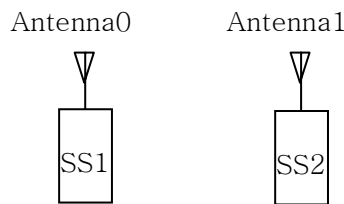
In OFDMA of the current 802.16 standard, collaborative spatial multiplexing mode is supported through MIMO\_UL\_BASIC\_IE(). Two single transmit antenna SS's can perform collaborative spatial multiplexing onto the same subchannel. This mode can result capacity increment by assigning same uplink resource to two SS's simultaneously.

And the collaborative spatial multiplexing can be applied to the case where two SS's have 2 transmit antennas when BS has two or more receive antennas. So, we propose the MIMO\_UL\_Enhanced\_IE() for applying 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 SS and STC configuration (STTD or SM). The current collaborative SM corresponds to the first example of the followings.

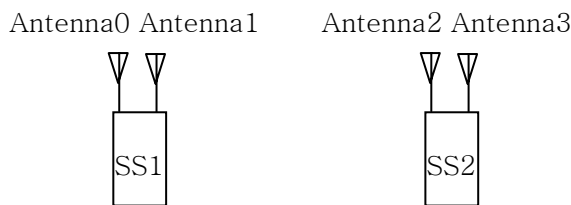
- Collaborative SM example #1



Transmission format uses matrix  $B = \begin{bmatrix} S_i \\ S_{i+1} \end{bmatrix}$

(See 8.4.8.3.3 Transmission schemes for 2-antenna BS in DL)

- Collaborative SM example #2



Transmission format uses matrices

$$A = \begin{bmatrix} S_i & -S_{i+1}^* & 0 & 0 \\ S_{i+1} & S_i^* & 0 & 0 \\ 0 & 0 & S_{i+2} & -S_{i+3}^* \\ 0 & 0 & S_{i+3} & S_{i+2}^* \end{bmatrix}$$

$$B = \begin{bmatrix} s_i & -s_{i+1}^* & s_{i+4} & -s_{i+6}^* \\ s_{i+1} & s_i^* & s_{i+5} & s_{i+7}^* \\ s_{i+2} & -s_{i+3}^* & s_{i+6} & -s_{i+4}^* \\ s_{i+3} & s_{i+2}^* & s_{i+7} & s_{i+5}^* \end{bmatrix}$$

$$C = \begin{bmatrix} s_i \\ s_{i+1} \\ s_{i+2} \\ s_{i+3} \end{bmatrix}$$

(See 8.4.8.3.5 Transmission schemes for 4-antenna BS)

### 3. Proposition

For the purpose of realizing the above configurations, we propose more pilot patterns to support the various collaborative SM modes. The second examples in the aforementioned collaborative SM examples require four pilot patterns to distinguish the channels from each antenna of SS's.

In addition, we suggest the MIMO\_UL\_Enhanced\_IE() to indicate the various collaborative SM modes and to support that SS has two transmit antennas.

### 4. Simulation result

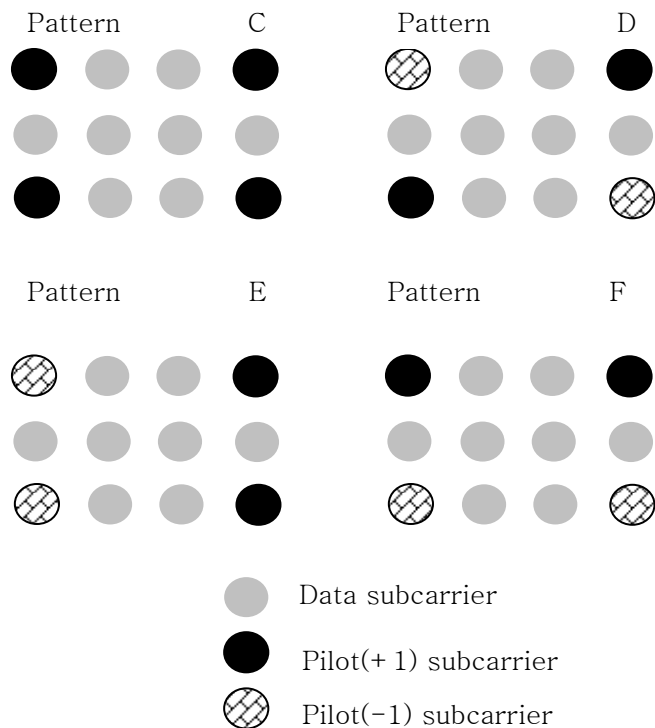


Figure 1. Proposed patterns C/D/E/F in UL PUSC mode

We compare the channel estimation errors in two fading channels using the conventional pattern A/B with the proposed patterns C/D/E/F in PUSC mode. The estimation results based on the proposed patterns are better up to SINR 15dB.

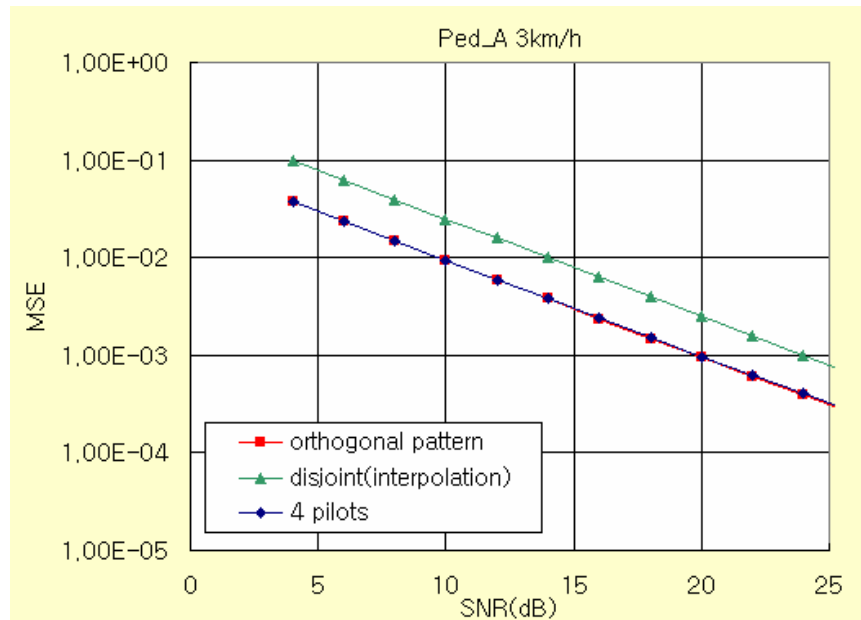


Figure 2. Channel Estimation Error in Ped\_A 3km/h

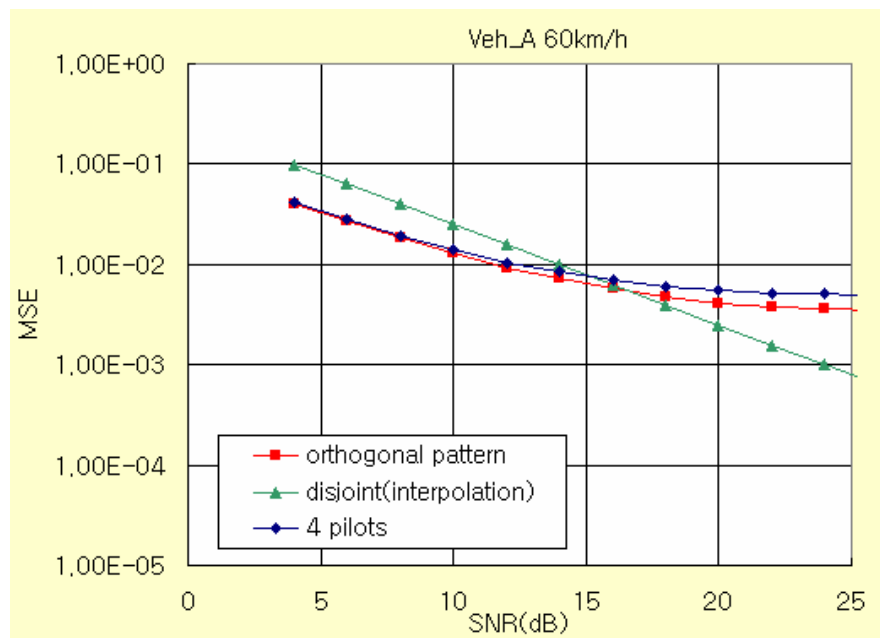


Figure 3. Channel Estimation Error in Veh\_A 60km/h

The performance results of the proposed pilot patterns are shown in Fig 4, 5, 6, and 7.

Fig 4 and 5 are shown performances in case of single MSS with dual antennas and a BS with dual antennas. And figure 6 and 7 are in case of two MSSs with dual antennas and a BS with 4 antennas.

In the case single MSS with dual antennas and a BS with dual antennas (Fig4~Fig5), the proposed pilot patterns outperform the current pilot patterns A/B more than 1dB (Using the CC 1/2 rate QPSK, Pedestrian B channel with 10km/h, the PUSC mode and the transmission matrix A for 2-antenna MSS in UL).

And, in the case two MSSs with dual antennas and a BS with 4 antennas (Fig6~Fig7), the proposed pilot patterns cannot compare. Since current spec has not any pilot pattern for 4 antennas. The proposed pilot pattern has the FER about 1.7E-3 in 0dB (Using the CC 1/2 rate QPSK, Pedestrian B channel with 10km/h, the PUSC mode and the proposed transmission matrix B for dual 2-antenna MSS in UL (same to matrix B in 8.4.8.3.5)).

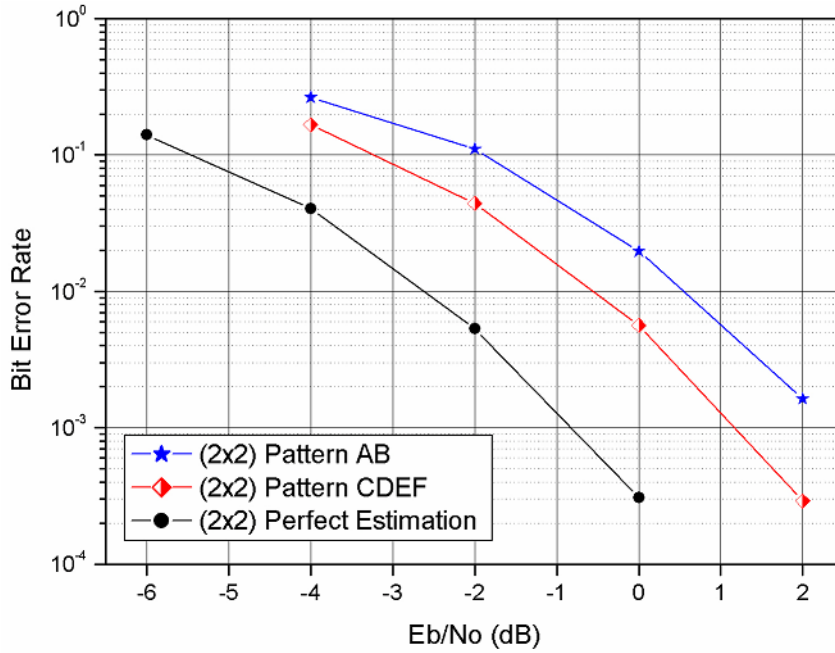


Figure 4. BER for single MSS with dual antennas and BS with dual antennas

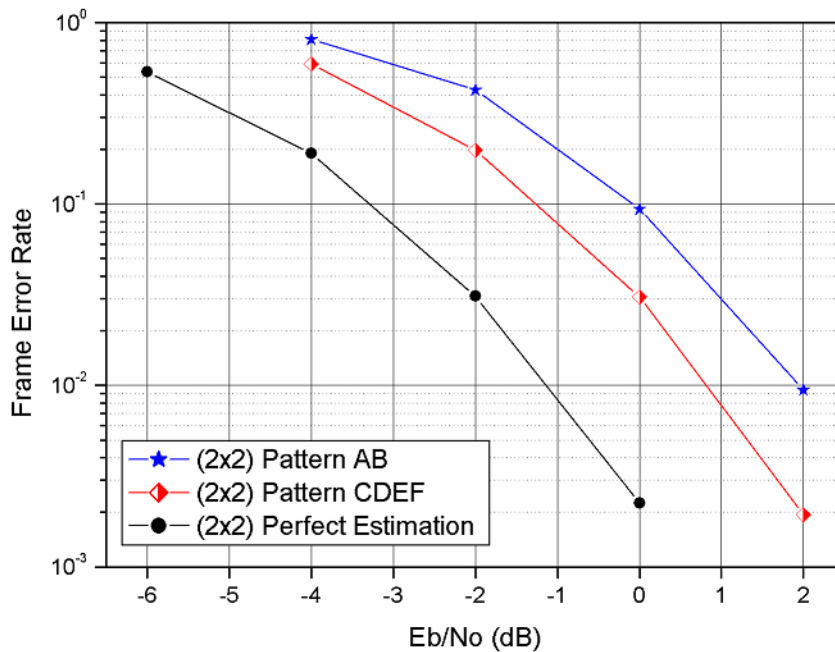


Figure 5. FER for single MSS with dual antennas and BS with dual antennas

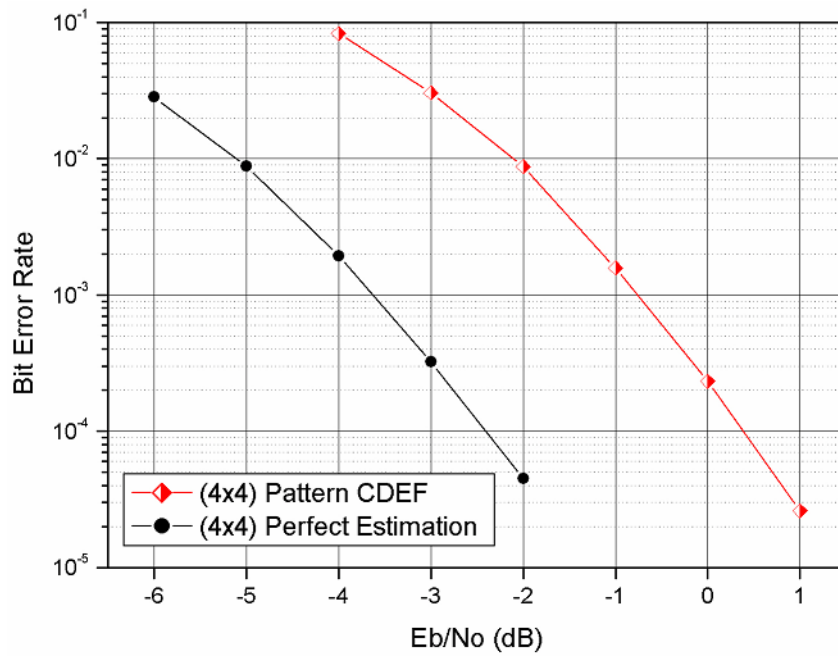


Figure 6. BER for dual MSSs with dual antennas and BS with 4 antennas

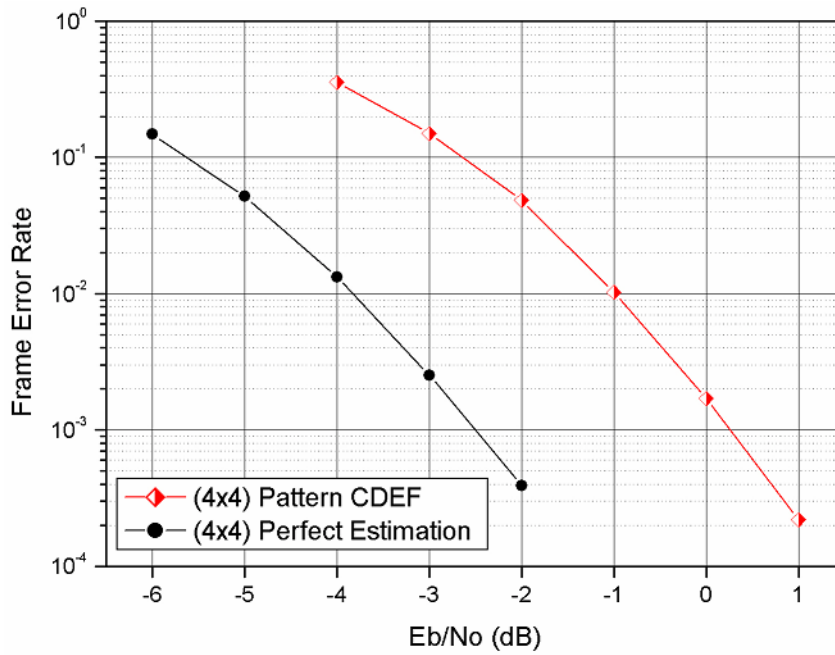


Figure 7. FER for dual MSSs with dual antennas and BS with 4 antennas

## 5. Proposed Text Change

### [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 mode and configuration of the subsequent uplink allocation to a specific MIMO-enabled MSS CID and to define various pilot patterns in order to estimate channel of SS's. The 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

<u>Syntax</u>	<u>Size</u>	<u>Notes</u>
<u>MIMO UL Enhanced IE () {</u>		
<u>Extended UIUC</u>	<u>4bits</u>	<u>Enhanced MIMO=0x0f</u>
<u>Length</u>	<u>4bits</u>	<u>Length of the message in bytes (variable)</u>
<u>Num Assign</u>	<u>4bits</u>	<u>Number of burst assignment</u>
<u>For (j=0; j&lt; Num_assign; j++){</u>		
<u>Num CID</u>	<u>2bits</u>	
<u>For ( i=0; i &lt;Num_CID; i++){</u>		
<u>CID</u>	<u>16bits</u>	<u>SS basic CID</u>
<u>UIUC</u>	<u>4bits</u>	
<u>Matrix Indicator</u>	<u>2 bits</u>	<u>For dual transmission capable MSS</u> <u>00 : STTD</u> <u>01 : SM</u>  <u>For Collaborative SM capable MSS with 2-antenna</u> <u>00: Matrix A</u> <u>01: Matrix B</u> <u>10: Matrix C</u> <u>11: Reserved</u>
<u>MIMO SM Control</u>	<u>2 bits</u>	<u>For Collaborative SM capable MSS</u> <u>00: pilot pattern A</u> <u>01: pilot pattern B</u>  <u>For Collaborative SM capable MSS with 2-antenna</u> <u>00 : pilot pattern C/D</u> <u>01 : pilot pattern E/F</u>  <u>10~11: Reserved</u>
<u>}</u>		
<u>Duration</u>	<u>10bits</u>	<u>In OFDMA slots (see 8.4.3.1)</u>
<u>}</u>		
<u>}</u>		

#### Num\_assign

This field specifies the number of assignments in this IE.

#### MIMO SM Control

This field specifies the MIMO mode of UL burst. For a dual transmission capable MSS the value of 00 indicates STTD mode, the value of 01 indicates SM mode; For a collaborative SM capable MSS, the value of 00 indicates pilot pattern A, the value of 01 indicates pilot pattern B; For a collaborative SM capable MSS with 2-antenna, the value of 00 indicates pilot pattern C/D, the value of 01 indicates pilot pattern E/F.

[Add a new section 8.4.8.1.5.1]

8.4.8.1.5.1 Uplink using enhanced STC

A user supporting transmission using STC configuration in the uplink, shall use a modified uplink tile, 2-transmit diversity data or 2-transmit spatial multiplexing data can be mapped onto each subcarrier, the mandatory tile shall be modified to accommodate those configurations. Figure yyy depicts the UL tiles for enhanced STC transmission in PUSC mode.

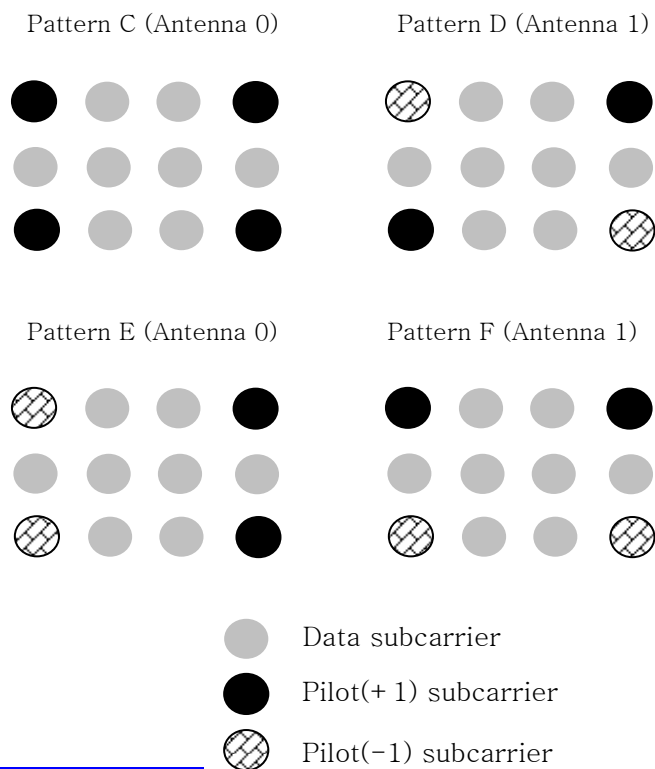


Figure yyy – MIMO tile in UL PUSC mode

Two SS's of one or two transmission antenna can perform collaborative spatial multiplexing onto the same subchannel. In this case, each SS should use the uplink tile with the pilot pattern indicated in MIMO\_UL\_Enhanced\_IE. A dual transmit antenna SS can use the allocation in STTD, SM or collaborative SM mode with other SS. SS in collaborative SM mode with dual transmit antenna sends data in ordinary STC configurations as in section 8.4.8.1.4 using the pilot pattern pair indicated in MIMO\_UL\_Enhanced\_IE. The first pilot pattern in each pair is for antenna 0 and the second is for antenna 1.

[Add the following sentence at the end of section 8.4.8.4.3 Transmission schemes for 2-antenna MSS in UL. Line 65, page244]

For two dual antenna MSSs to share the same subchannel, the matrix A, B and C for 4-antenna BS in section 8.4.8.3.5 may be used.