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Re:	This is a response to a Call for Comments on IEEE P802.16e-D4
Abstract	The collaborative spatial multiplexing can be applied to the case in OFDMA Blue line indicates new text change part. Green line indicates harmonized part.
Purpose	This document is submitted for review by 802.16e Working Group members
Notice	
Release	
Patent Policy and Procedures	

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 subcarrier. This mode can result in the uplink capacity increment by assigning same uplink resource to two SS's simultaneously.

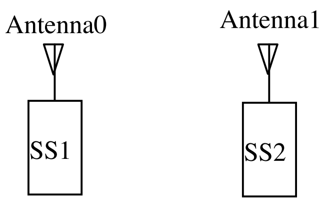
In addition, the collaborative spatial multiplexing can be applied to the case where two SS's have more than one transmit antenna when BS has two or more receive antennas.

Also, in current standard, it is considered up to 2-antenna MSS in UL. We propose to support more than 2 antennas MSS in UL.

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.

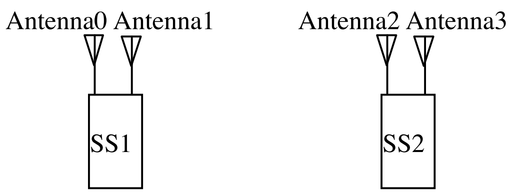
- **Collaborative SM example 0**



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 1**



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 8.4.8.3.4 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 to the SS's and to support that SS has more than two transmit antennas.

4. Simulation result

We compare the channel estimation errors in two fading channels using the conventional pattern A/B and the proposed patterns in PUSC mode. The estimation results based on the proposed patterns are better upto SINR 15dB.

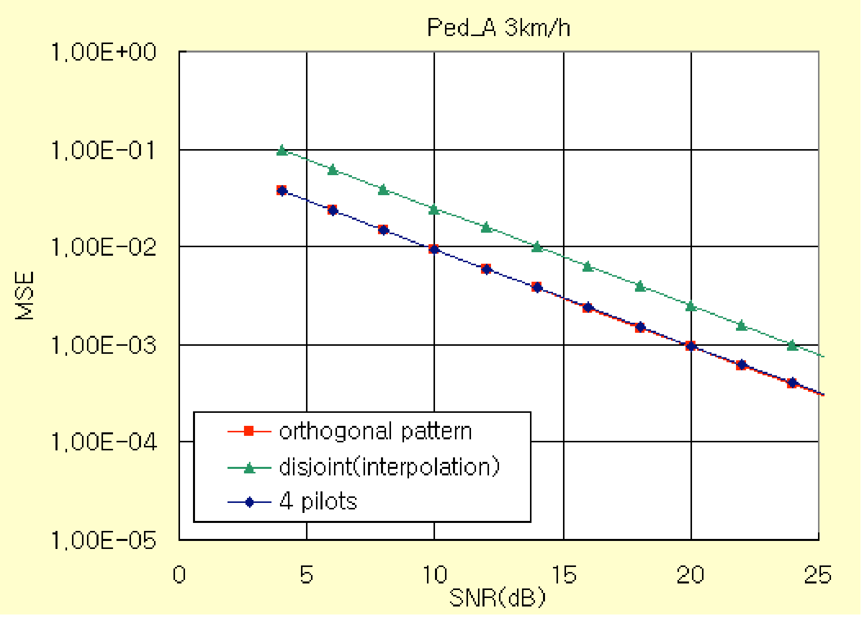


Figure – Channel Estimation Error in Ped_A 3km/h

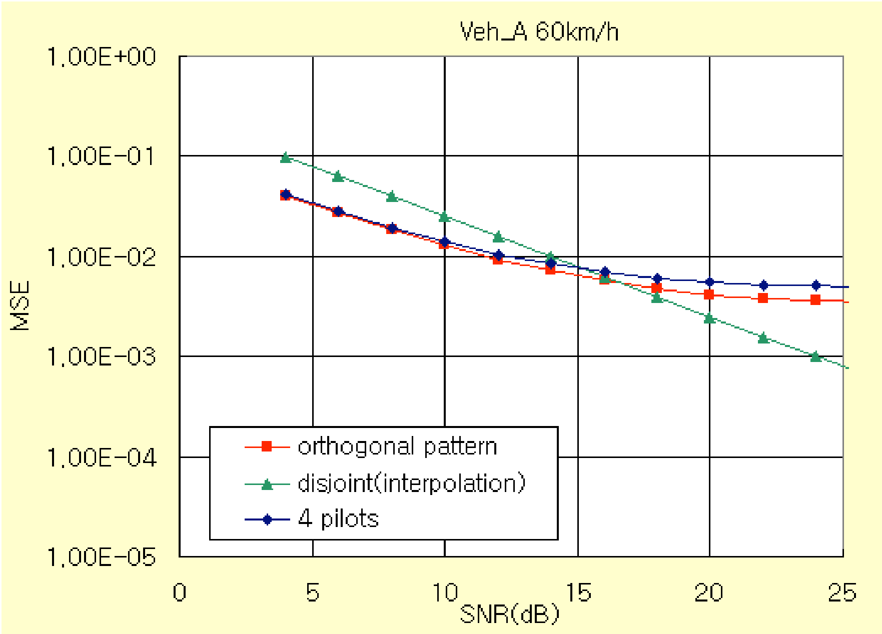


Figure – Channel Estimation Error in Veh_A 60km/h

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 SS 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

Syntax	Size	Notes
MIMO_UL_Enhanced_IE () {		
Extended UIUC	4bits	Enhanced MIMO
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	SS basic CID
UIUC	4bits	
STC	2bits	0b00 = 1 antenna 0b01 = 2 antennas 0b10 = 4 antennas 0b11 = reserved

Matrix_indicator	2bit	If (STC==0b01)
		{
		00 = Matrix A
		01 = Matrix B
		0-11 = Reserved
		}
		else if (STC ==0b10)
		{
		00 = Matrix A

		01 = Matrix B 10 = Matrix C 11 = Reserved }

Enhanced_MIMO_Control	2bit	If (STC==0b00 & Num_CID ==2)
		{
		0b00 : pilot pattern A
		0b01 : pilot pattern B
		0b10 – 0b11 : reserved
		}
		else if (STC==0bo1 & Num_CID ==2)
		{
		0b00: pattern C, pattern D
		0b01: pattern E, pattern F
		0b10 – 0b11: reserved
		}

}		
Duration	10bits	In OFDMA slots (see 8.4.3.1)
}		
}		

Num_assign

This field specifies the number of assignments in this IE.

Enhanced_MIMO_Control

This field specifies the MIMO mode of UL burst. For a single and collaborative capable SS, the value of 0 indicates pilot pattern A, the value of 1 indicates pilot pattern B, For a dual and collaborative SM capable SS, the value of 0 indicates pilot pattern C and pattern D, the value of 1 indicates pilot pattern E and pilot pattern F.

[Insert following sentence and figure after line 58, page 167 in P802.16e/D4]

For 4-antenna SS and the AMC, pilots for each antenna shall be allocated as shown in Figure 252b

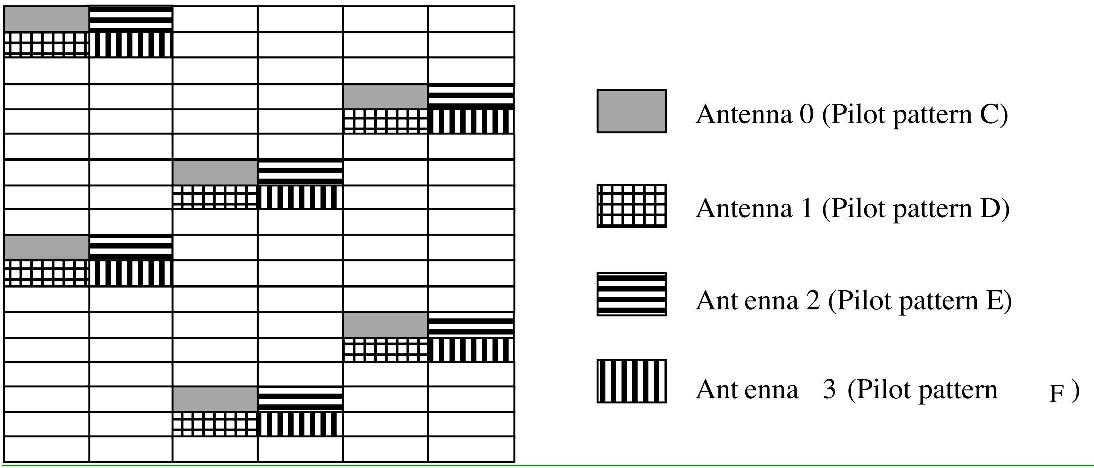


Figure -252b Uplink pilot allocation for 4-antenna SS for AMC zones

Two dual transmit antenna MSSs can perform collaborative spatial multiplexing onto the same subcarrier. In this case, one MSS should use uplink pilot allocation with pattern-C and pattern-D, and the other MSS should use the uplink pilot allocation with pattern-E and pattern-F.

[Insert 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.

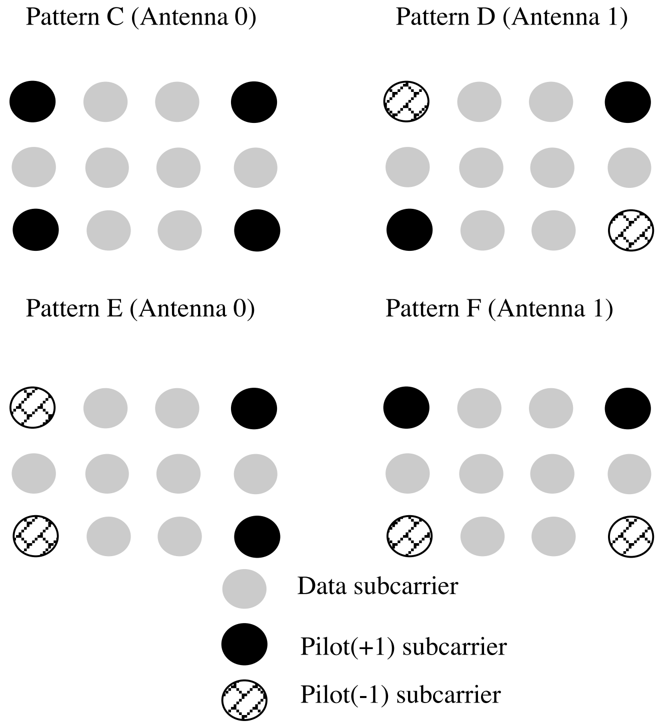


Figure yyy – MIMO tile in UL PUSC mode

Two SS's of one or two transmission antenna can perform collaborative spatial multiplexing onto the same subcarrier. 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 table after line 49, page 192 in P802.16e/D4]

OFDMA MSS antenna for MIMO support

Type	Length	Value	Scope
xxx	1	Bit #0: 2 SS Tx Bit #1: 4 SS Tx Bit #2: Collaborative SM Bit #3~7: reserved	SBC-REQ (see 6.3.2.3.23) SBC-RSP (see 6.3.2.3.24)