Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Proposal for Double Uplink Scheme in OFDMA**
Date Submitted	***2004-07-07***
Source(s)	*Bin-chul Ihm, Kyuhyuk Chung, Jin-young Chun, Yongseok Jin* LG Electronics, Inc. 533,Hogye-1dong, Dongan-gu, Anyang-shi, Kyongki-do, Korea Voice: 82-31-450-7903 Fax: 82-31-450-7912 [mailto:jychun03@lge.com]
Re:	*This is a response to a Call for Comments IEEE802.16e-04/xx on IEEE P802.16e-D2*
Abstract	*Proposal for Double Uplink Scheme in OFDMA*
Purpose	This document is submitted for review by 802.16e Working Group members
Notice	
Release	
Patent Policy and Procedures	

Proposal for Double Uplink Scheme in OFDMA

Bin-chul Ihm, Kyuhyuk Chung, Jin-young Chun, Yongseok Jin
LG Electronics

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 under assumption BS has two or more receive antennas. However, this scheme can be applied to the case where BS has one receive antenna. The collaborative spatial multiplexing extends to that case and this mode is supported through the MIMO_UL_Enhanced_IE() that we propose. In addition, the collaborative spatial multiplexing can include the case of two dual transmit antenna SS's when BS has two or more receive antennas.

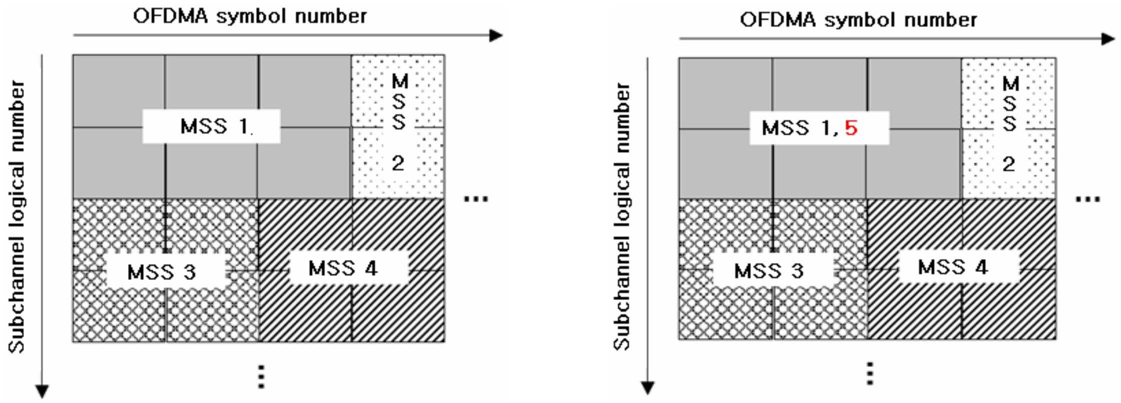

Figure 1 Example of collaborative spatial multiplexing

2. Feasible collaborative SM modes

There are various feasible collaborative SM modes according to the following combinations of # of receive antennas in BS, # 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

  Given two single transmit antenna SS's and two or more receive antenna BS, the received signals at BS are given by

$$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_N \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \\ \vdots & \vdots \\ h_{N1} & h_{N2} \end{bmatrix} \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} + v$$

where x_i, h_{ji}, s_i and v are the received signal at i^{th} antenna of BS, channel from i^{th} SS to j^{th} antenna of BS, data of i^{th} SS and AWGN vector, respectively. This example is supported in the current 802.16REVd/d5.

- Collaborative SM example 1

Given two single transmit antenna SS's and single receive antenna BS, the received signal at BS is given by

$$x = h_1 s_1 + h_2 s_2 + v$$

where x, h_i, s_i and v are received signal, channel from i^{th} SS to BS, data of i^{th} SS and AWGN, respectively.

- Collaborative SM example 2

Given two dual transmit antenna SS's, two receive antenna BS and STTD configuration, the received signals at BS are given by

$$\begin{bmatrix} x_1(k) \\ x_1^*(k+1) \\ x_2(k) \\ x_2^*(k+1) \end{bmatrix} = \begin{bmatrix} h_{1,11} & h_{1,12} & h_{2,11} & h_{2,12} \\ h_{1,12}^* & -h_{1,11}^* & h_{2,12}^* & -h_{2,11}^* \\ h_{1,21} & h_{1,22} & h_{2,21} & h_{2,22} \\ h_{1,22}^* & -h_{1,21}^* & h_{2,22}^* & -h_{2,21}^* \end{bmatrix} \begin{bmatrix} s_{1,1} \\ s_{1,2} \\ s_{2,1} \\ s_{2,2} \end{bmatrix} + v$$

where $x_i, h_{i,jk}, s_{i,j}$ and v are the received signal at i^{th} antenna of BS, channel from k^{th} antenna of i^{th} SS to j^{th} antenna of BS, j^{th} data of i^{th} SS and AWGN vector, respectively.

- Collaborative SM example 3

Given two dual transmit antenna SS's, four receive antenna BS and SM configuration, the received signals at BS are given by

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} = \begin{bmatrix} h_{1,11} & h_{1,12} & h_{2,11} & h_{2,12} \\ h_{1,21} & h_{1,22} & h_{2,21} & h_{2,22} \\ h_{1,31} & h_{1,32} & h_{2,31} & h_{2,32} \\ h_{1,41} & h_{1,42} & h_{2,41} & h_{2,42} \end{bmatrix} \begin{bmatrix} s_{1,1} \\ s_{1,2} \\ s_{2,1} \\ s_{2,2} \end{bmatrix} + v$$

where $x_i, h_{i,jk}, s_{i,j}$ and v are the received signal at i^{th} antenna of BS, channel from k^{th} antenna of i^{th} SS to j^{th} antenna of BS, data transmitted from j^{th} antenna of i^{th} SS and AWGN vector, respectively.

3. Proposition

The collaborative spatial multiplexing scheme has the merits as following:

1. Increased uplink channel capacity without additional frequency bands or hardware.
2. Increased downlink channel capacity by allocating resources of uplink subframe into downlink subframe

For the purpose of realizing the above merits, we propose more pilot patterns to support the various collaborative SM modes. The third and fourth examples in the aforementioned collaborative SM examples require four pilot patterns to distinguish the channels from each antenna of SS's. In addition, we propose the MIMO_UL_Enhanced_IE() to support the various collaborative SM modes.

4. Simulation result

The channel model is AWGN and data modulation is QPSK. Figure 2 represents the BER performance of uplink subframe when two single transmit antenna SS's and one receive antenna BS consist of collaborative SM mode. The black line expresses BER performance in single user case (case 1) and the red line expresses that of SS1 and SS2 in collaborative SM mode (case 2).

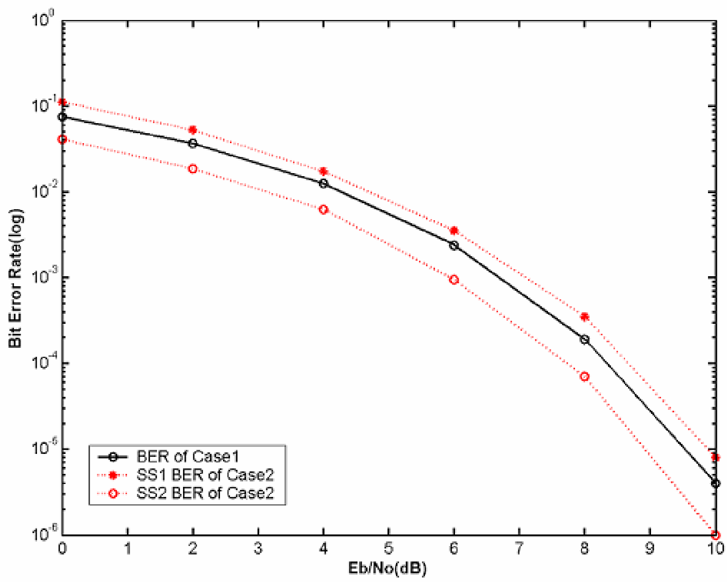

Figure 2. The BER performance of uplink subframe using collaborative SM with single receive antenna BS

Figure 3 shows the PER (packet error rate) comparison between disjoint pilot pattern and orthogonal pilot pattern (see **5. Proposed text**) in the above collaborative SM mode. A packet consists of uncoded 96 bits. In this result, the case using orthogonal pilot pattern gives around 1.5dB better performance than that using disjoint pilot pattern.

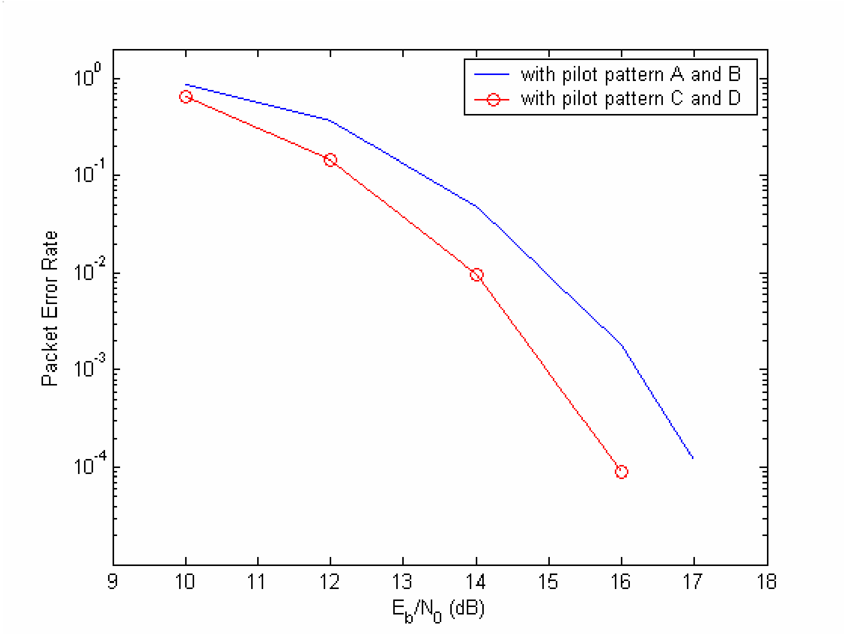

Figure 3. PER curves under two kinds of pilot patterns

5. Proposed text

[Add a new section 8.4.5.4.17]

8.4.5.4.17 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 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	
Enhanced_MIMO_Control	4bits	For dual transmission capable SS 0bxxx0: STTD mode 0bxxx1: SM mode 0bx00x: pattern A, pattern B 0bx01x: pattern C, pattern D 0bx10x: pattern E, pattern F 0bx11x-0bx11x: reserved For single transmission capable SS 0b0000 : pilot pattern A 0b0001 : pilot pattern B 0b0010 : pilot pattern C 0b0011 : pilot pattern D 0b0100 : pilot pattern E 0b0101 : pilot pattern F 0b0110 – 0b1111 : 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 dual transmission capable SS, the value of 0 of LSB indicates STTD mode, the value of 1 of LSB indicates SM mode, and the value of 00 of two middle bits indicates pilot pair (pattern A, pattern B), the value of 01 of two middle bits indicates pilot pair (pattern C, pattern D) and the value of 10 of two middle bits indicates pilot pair (pattern E, pattern F); For a collaborative SM capable SS, the value of 0 indicates pilot pattern A, the value of 1 indicates pilot pattern B, the value of 2 indicates pilot pattern C, the value of 3 indicates pilot pattern D, the value of 4 indicates pilot pattern E and the value of 5 indicates pilot pattern 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.

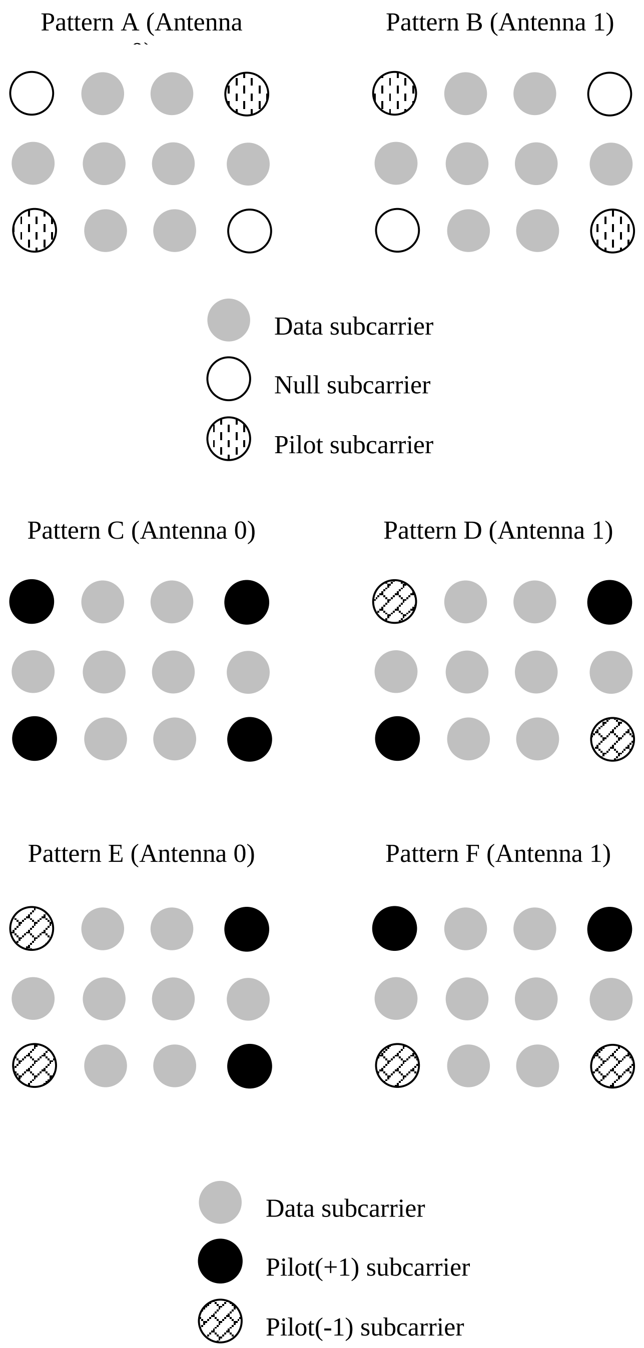

Figure yyy – MIMO tile in UL PUSC mode

Two single transmit antenna SS's 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 dual transmit antenna SS. Each 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.