Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**STP Enhancements for optional FUSC and AMC zones for OFDMA PHY Layer**
Date Submitted	**2004-05-10**
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Re:	Sponsor re-circulation Ballot
Abstract	STP enhancements for the optional AMC and FUSC with all subchannels for the downlink
Purpose	Adoption of proposed changes into P802.16e
Notice	
Release	
Patent Policy and Procedures	

1 Introduction

This document describes the PHY enhancements to enable the space-time processing (STP) functionalities in the optional FUSC [1] and the optional adjacent subcarrier permutation (or AMC) [2] zones for OFDMA. The following features are proposed:

- Pilot and data allocation for 2 and 4-antenna BS in the optional FUSC and the optional AMC modes for the downlink (DL)
- Transmission schemes for open- and closed-loop STP with 2 and 4-antenna BS

2 Specific Text Changes

[Add a new section 8.4.8.3]

[After implementing all the relevant comments and reply comments, the renumbering of the following sections and the page numbers will be coherent.]

8.4.8.3 STP using the optional FUSC and the optional adjacent-subcarrier permutation zones for DL

Two optional zones, the optional FUSC and the optional AMC zones, are described in 8.4.6.1.4 and 8.4.6.3, respectively. In both zones, pilot subcarriers are allocated first according to Table zzz in 8.4.6.1.4. The remaining subcarriers are used for data transmission.

8.4.8.3.1 Allocation of pilot subcarriers

For an STP-enabled BS with 2 or 4 antennas, pilot subcarriers are allocated to each antenna in one of the following two methods. The selection among two methods shall be based on channel condition and indicated by the Pilot_tone_set bit in MIMO_DL_Basic/Enhanced_IE() in 8.4.5.3.8(9).

Method 1: use of disjoint pilot sets
Pilots are split into 2 or 4 disjoint sets. For 2-antenna BS, all pilots in the even symbols allocated for Ant 0 whereas all pilots in the odd symbols used for Ant 1. For 4-antenna BS, pilots in the even symbols are further split for Ant 0 and 1, while those in the odd symbols split for Ant 2 and 3. See Figure yyy-1.

Method 2: use of orthogonal sequence on pilots
Pilots are shared with 2 or 4 antennas to increase the granularity and their orthogonality is maintained by the simple block code as shown in Figure yyy-2.

8.4.8.3.2 Allocation of data subchannels

In the optional FUSC mode for STP capable BS, transmit diversity (TD) users shall be allocated for two or four consecutive symbols in a row and the rest of subchannels shall be assigned for non-TD or other STP users such as spatial multiplexing (SM) users.

In the optional AMC mode, each data subchannel consists of 6 contiguous bins in the same band, thereby having one of four combinations as defined in 8.4.6.3. For STP capable BS with two antennas, however, each TD user shall have one of two formats, 3x2 or 1x6. For BS with four antennas, depending on the transmission encoding scheme, bin structure can be any of four combinations.

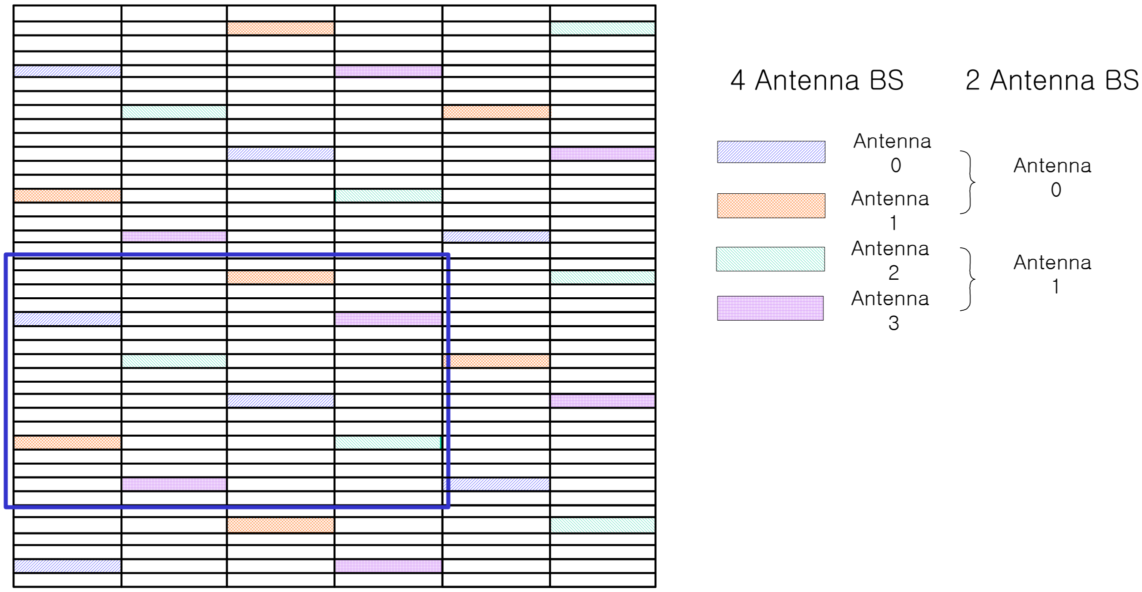

Figure yyy-1 Pilot allocation method #1

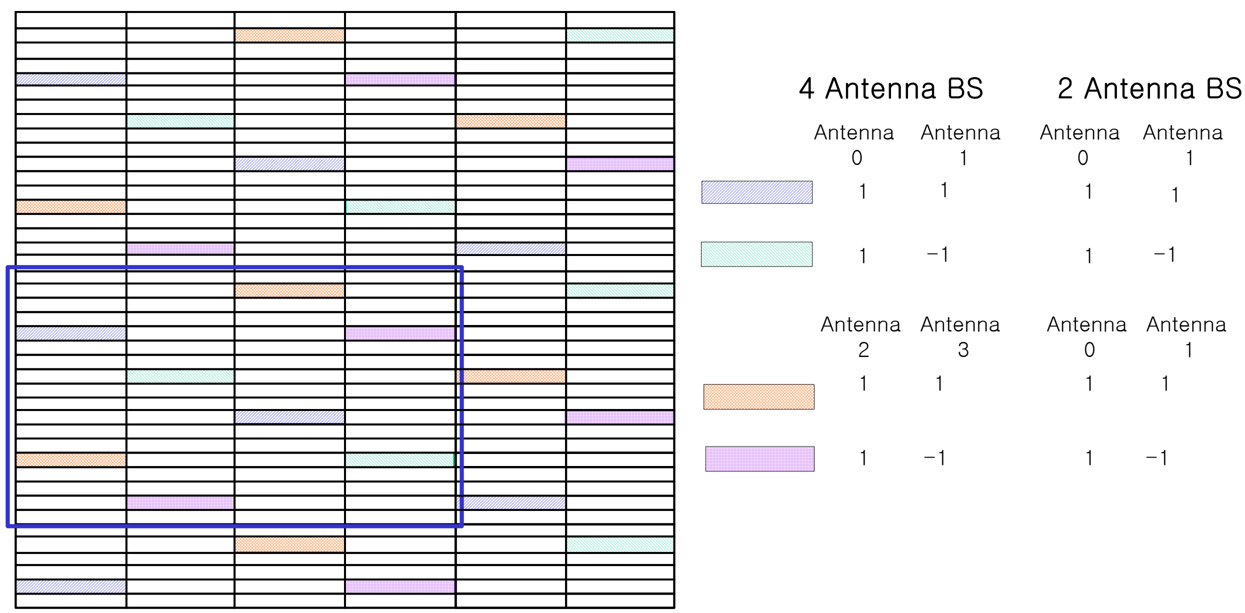

Figure yyy-2 Pilot allocation method #2

8.4.8.3.3 Transmission schemes for 2-antenna BS

8.4.8.3.3.1 Open loop encoding schemes for 2-antenna BS

Open-loop transmission encoding schemes for 2-antenna BS shall take one of the following two matrices:

$A = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix}$ for TD users, $B = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix}$ for SM users.

8.4.8.3.3.2 Closed-loop encoding schemes for 2-antenna BS

Closed-loop STP shall be enabled with Fast CQI Feedback. The information contained in CQI can be the measured channel vector or matrix itself, or its covariance matrix $\mathbf{R}_{\mathbf{H}}$, or beamforming weight vector **w**, or the suggested combination of MIMO mode and permutation by SS. On receiving CQI from SS, BS shall decide the most appropriate transmission scheme, which can be either singular value decomposition (SVD) method, transmit antenna array (TxAA) or any per-antenna rate control (PARC) variant. This is tabularized in Table xxx.

Downlink	2-antenna BS			4-antenna BS		
	Open-loop	Closed-loop scheme and its feedback		Open-loop	Closed-loop scheme and its feedback	
1-antenna SS	STTD	TxAA	Channel vector **h** or BF weight **w**	O-STTD/ QO-STTD	TxAA	Channel vector **h** or BF weight **w**
2-antenna SS	STTD/ SM	TxAA/ SVD/ PARC variants	Channel matrix **H**/ Channel matrix **H** or $\mathbf{R}_{\mathbf{H}}$/	O-STTD/ QO-STTD/ D-STTD/ SM	TxAA/ SVD/ PARC variants	Channel matrix **H**/ Channel matrix **H** or $\mathbf{R}_{\mathbf{H}}$/

Table xxx - Downlink MISO/MIMO transmission scheme

8.4.8.3.4 Transmission schemes for 4-antenna BS

8.4.8.3.4.1 Open-loop encoding schemes for 4-antenna BS

Open-loop STP with 4 BS antennas shall take one from the following four transmission matrices:

Orthgonal-STTD (O-STTD) with full (4th) diversity and 3/4 rate [3]

$$A = \begin{bmatrix} s_1 & -s_2^* & s_3^*/\sqrt{2} & s_3^*/\sqrt{2} \\ s_2 & s_1^* & s_3^*/\sqrt{2} & -s_3^*/\sqrt{2} \\ s_3/\sqrt{2} & s_3/\sqrt{2} & (-s_1 - s_1^* + s_2 - s_2^*)/2 & (s_2 + s_2^* + s_1 - s_1^*)/2 \\ s_3/\sqrt{2} & -s_3/\sqrt{2} & (-s_2 - s_2^* + s_1 - s_1^*)/2 & (-s_1 - s_1^* - s_2 + s_2^*)/2 \end{bmatrix};$$

Quasi-orthogonal STTD (QO-STTD) for 2nd order diversity and rate 1 [4]

$$B = \begin{bmatrix} s_1 & -s_2^* & s_3 & -s_4^* \\ s_2 & s_1^* & s_4 & s_3^* \\ s_3 & -s_4^* & s_1 & -s_2^* \\ s_4 & s_3^* & s_2 & s_1^* \end{bmatrix};$$

Double-STTD (D-STTD) for 2nd order diversity and rate 1

$$C = \begin{bmatrix} s_1 & -s_2^* & s_5 & -s_7^* \\ s_2 & s_1^* & s_6 & -s_8^* \\ s_3 & -s_4^* & s_7 & s_5^* \\ s_4 & s_3^* & s_8 & s_6^* \end{bmatrix};$$

Spatial multiplexing (SM) with rate 4

$$D = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \end{bmatrix};$$

8.4.8.3.4.2 Closed-loop encoding schemes for 4-antenna BS

Closed-loop STP shall be enabled with Fast CQI Feedback. The information contained in CQI can be the measured channel vector or matrix itself, or its covariance matrix $\mathbf{R_H}$, or beamforming weight vector $\mathbf{w}$, or the suggested combination of MIMO mode and permutation by SS. On receiving CQI from SS, BS shall decide the most appropriate transmission scheme, which can be either singular value decomposition (SVD) method, transmit antenna array (TxAA) or any per-antenna rate control (PARC) variant [5]. This is tabularized in Table xxx.

References:

[1] IEEE C802.16d-04/72 Panyuh Joo et al, “Additional optional symbol structure”

[2] IEEE P802.16-REVe/D2-2004 Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Band

[3] Tarokh et al, “Space-time block coding for wireless communications: Performance results”, IEEE JSAC, vol. 17, No. 3, Mar 1999, pp.451--460

[4] Jafarkhani, “A quasi-orthogonal space-time block code”, IEEE Trans. Commun. Vol. 49, no. 1, Jan. 2001, pp. 1--4

[5] Lucent, “Increasing MIMO throughput with per-antenna rate control.” 3GPP TSG_R WG1 documen, TSGR1(01)087