Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Enhancement for MIMO Transmission with 3 Antennas**
Date Submitted	**2004-08-17**
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Re:	Response to Recirculation Ballot #14c
Abstract	The enhancement of the 3-antenna MIMO transmission
Purpose	To incorporate the changes here proposed into the 802.16e D5 draft.
Notice	
Release	
Patent Policy and Procedures	

Enhancement for MIMO Transmission with 3 Antennas

1 Introduction

The current Rate-1 and Rate-2 space time coding matrices for 3 transmit antennas configuration consist the following open issues for the performance optimization (1) transmit power balancing among the 3 transmit antennas (2) the inter antenna codes aggregation to maximize the antenna diversity.

1.1 Rate-1 Matrix A

The current rate-1 matrix-A in the current specification is as follows:

$$A = \begin{bmatrix} \tilde{s}_1 & \tilde{s}_2^* & 0 & 0 \\ \tilde{s}_2 & -\tilde{s}_1^* & \tilde{s}_3 & \tilde{s}_4^* \\ 0 & 0 & \tilde{s}_4 & -\tilde{s}_3^* \end{bmatrix}$$

where the row of the matrix represents the antenna index. The merit of Matrix-A structure is that it allows the simple Alamouti decoder to decode Matrix-A, therefore minimizes the receiver complexity and supports the single antenna MSS reception of signals from 3 transmit antennas. As we can see the second antenna is required to transmit two times more power than the first and third antennas, this will cause the diversity performance loss or the PA inefficiency. To resolve this issue while keeping the same matrix structure, the matrix A can be modified into the following format:

$$A = \begin{bmatrix} \tilde{s}_1 & \tilde{s}_2^* & 0 & 0 & \tilde{s}_6 & \tilde{s}_5^* \\ \tilde{s}_2 & -\tilde{s}_1^* & \tilde{s}_3 & \tilde{s}_4^* & 0 & 0 \\ 0 & 0 & \tilde{s}_4 & -\tilde{s}_3^* & \tilde{s}_5 & -\tilde{s}_6^* \end{bmatrix}$$

1.2 Rate-2 Matrix B

The current rate-2 matrix-B in the current specification is as follows:

$$B = \begin{bmatrix} \tilde{s}_1 & \tilde{s}_2^* & \tilde{s}_5 & \tilde{s}_6^* \\ \tilde{s}_2 & -\tilde{s}_1^* & \tilde{s}_6 & -\tilde{s}_5^* \\ \tilde{s}_7 & \tilde{s}_8 & \tilde{s}_3 & \tilde{s}_4 \end{bmatrix}$$

where the row of the matrix represents the antenna index, the existing code construction consists of orthogonal STTD and non-orthogonal parts, within an STTD structure, no inter-symbol interference is eliminated thanks to the orthogonality. Interference arises between the STTD structure and the non-orthogonal symbol. On the other hand, due to the practical three branch diversity antenna design (x-polar, and/or spatial). It is desirable to aggregate the STTD among the antennas, (1) to achieve additional diversity gain (2) and to combat the channel matrix ill.

$$B = \begin{bmatrix} \tilde{s}_1 & \tilde{s}_2^* & \tilde{s}_7 & \tilde{s}_8^* & \tilde{s}_{10} & -\tilde{s}_9^* \\ \tilde{s}_2 & -\tilde{s}_1^* & \tilde{s}_5 & \tilde{s}_6^* & \tilde{s}_{11} & \tilde{s}_{12}^* \\ \tilde{s}_3 & \tilde{s}_4^* & \tilde{s}_6 & -\tilde{s}_5^* & \tilde{s}_9 & \tilde{s}_{10}^* \end{bmatrix}$$

The additional advantage is to allow the drastically reduction of the MSS decoding complexity, e.g. for the first 3x2 sub-matrix, the receiver can be represented as:

$$\begin{bmatrix} r_{1,1} \\ r_{1,2} \\ r_{2,1}^* \\ r_{2,2}^* \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & h_{13} & 0 \\ h_{21} & h_{22} & h_{23} & 0 \\ h_{12}^* & -h_{11}^* & 0 & h_{13}^* \\ h_{22}^* & -h_{21}^* & 0 & h_{23}^* \end{bmatrix} \begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \\ n_3^* \\ n_4^* \end{bmatrix}$$

The zero-forcing receiver is:

$$\begin{bmatrix} \tilde{s}_1 \\ \tilde{s}_2 \\ \tilde{s}_3 \\ \tilde{s}_4 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & h_{13} & 0 \\ h_{21} & h_{22} & h_{23} & 0 \\ h_{12}^* & -h_{11}^* & 0 & h_{13}^* \\ h_{22}^* & -h_{21}^* & 0 & h_{23}^* \end{bmatrix}^{-1} \begin{bmatrix} r_{1,1} \\ r_{1,2} \\ r_{2,1}^* \\ r_{2,2}^* \end{bmatrix}$$

1.3 Mapping of the Matrix-A/B

Since the matrix A and matrix B share the same dimension, i.e. $Matrix-A/B = [M_1 \quad M_2 \quad M_2]$
The sub-carrier mapping can be designed as shown in Figure 1.

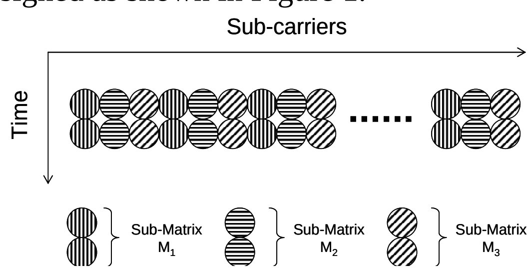

Figure 1 sub-carrier mapping

2 Text Proposal

Change Section 8.4.8.3.5

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8.4.8.3.5 Space Time Transmission Configurations for 3 Antennas

Three transmission formats are allowed for this configuration for different throughput/diversity trade-offs. The following matrices define the transmission format with row index representing the antenna number and the column index representing the sub-carrier number. The space time code is mapped over two OFDM symbols and three sub-carriers (the same mapping is repeated for the sub-channels for each format till all sub-carriers are used).

Transmission format A uses Matrix A (space time coding rate = 1)

$$A = \begin{bmatrix} \tilde{s}_1 & \tilde{s}_2^* & 0 & 0 & \tilde{s}_6 & \tilde{s}_5^* \\ \tilde{s}_2 & -\tilde{s}_1^* & \tilde{s}_3 & \tilde{s}_4^* & 0 & 0 \\ 0 & 0 & \tilde{s}_4 & -\tilde{s}_3^* & \tilde{s}_5 & -\tilde{s}_6^* \end{bmatrix}$$

Transmission format B uses Matrix B (space time coding rate = 2)

$$B = \begin{bmatrix} \tilde{s}_1 & \tilde{s}_2{}^* & \tilde{s}_7 & \tilde{s}_8{}^* & \tilde{s}_{10} & -\tilde{s}_9{}^* \\ \tilde{s}_2 & -\tilde{s}_1{}^* & \tilde{s}_5 & \tilde{s}_6{}^* & \tilde{s}_{11} & \tilde{s}_{12}{}^* \\ \tilde{s}_3 & \tilde{s}_4{}^* & \tilde{s}_6 & -\tilde{s}_5{}^* & \tilde{s}_9 & \tilde{s}_{10}{}^* \end{bmatrix}$$

Transmission format C uses Matrix C (space time coding rate = 3)

$$C = \begin{bmatrix} \tilde{s}_1 \\ \tilde{s}_2 \\ \tilde{s}_3 \end{bmatrix}$$

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