Project	IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>
Title	Space-Time Codes for 3 Transmit antennas for the OFDMA PHY
Date Submitted	2004-06-25
Source(s)	Erik Lindskog, V. Shashidhar, B. Sundar Rajan, Djordje Tajkovic, David Garrett, K. Giridhar, Bob Lorenz, Babu Mandava, A. Paulraj, Trevor Pearman, Kamlesh Rath, Aditya Agrawal Beceem Communications, Inc. Freedom Circle, Suite 101 Santa Clara, CA 95054 Voice: +1-408-387-5014 Fax: +1-408-387-5010 elindskog@beceem.com
Re:	802.16e/D8
Abstract	We propose Space-Time codes for 3 transmit antennas with full diversity.
Purpose	To propose 3 transmit antenna Space-Time codes for 802.16e/D4.
Notice	This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.
Patent Policy and Procedures	The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures <http://ieee802.org/16/ipr/patents/policy.html>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, provided the IEEE receives assurance from the patent holder or applicant with respect to patents essential for compliance with both mandatory and optional portions of the standard." Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair <mailto:chair@wirelessman.org> as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard being developed within the IEEE 802.16 Working Group. The Chair will disclose this notification via the IEEE 802.16 web site <http://ieee802.org/16/ipr/patents/notices>.

Space-Time Codes for 3 Transmit antennas for the OFDMA PHY

Erik Lindskog, V. Shashidhar, B. Sundar Rajan, Djordje Tajkovic,
David Garrett, K. Giridhar, Bob Lorenz, Babu Mandava, A. Paulraj
Trevor Pearman, Kamlesh Rath, Aditya Agrawal

Beceem Communications, Inc.

Introduction

We propose Space-Time codes for 3 transmit antennas with full diversity. While these codes are specified as Space-Time codes, they may also be used as Space-Frequency codes or as hybrids.

Proposed Space-Time Codes

We here propose 3Tx schemes for the standard.

The 3Tx-Rate 1 code we propose, that gives full-diversity order of 3 is

$$\begin{bmatrix} s_1 & e^{0.5j}s_3 & e^{0.5j}s_2 \\ s_2 & s_1 & e^{0.5j}s_3 \\ s_3 & s_2 & s_1 \end{bmatrix}$$

The 3 Tx – Rate 2 code we propose, with full diversity order of 3 is

$$\begin{bmatrix} s_1 + s_4 w_9 & e^{0.5j}(s_3 + s_6 w_9 w_3) & e^{0.5j}(s_2 + s_5 w_9 w_3^2) \\ s_2 + s_5 w_9 & s_1 + s_4 w_9 w_3 & e^{0.5j}(s_3 + s_6 w_9 w_3^2) \\ s_3 + s_6 w_9 & s_2 + s_5 w_9 w_3 & s_1 + s_4 w_9 w_9^2 \end{bmatrix}$$

where $\omega_k = e^{\frac{2\pi}{k}j}$, $k = 3,9.$

The 3Tx-Rate 3 code we propose is

$$\begin{bmatrix} s_1 + s_4 w_9 + s_7 w_9^2 & e^{0.5j}(s_3 + s_6 w_9 w_3 + s_9 w_9^2 w_3^2) & e^{0.5j}(s_2 + s_5 w_9 w_3^2 + s_8 w_9^2 w_3) \\ s_2 + s_5 w_9 + s_8 w_9^2 & s_1 + s_4 w_9 w_3 + s_7 w_9^2 w_3^2 & e^{0.5j}(s_3 + s_6 w_9 w_3^2 + s_9 w_9^2 w_3) \\ s_3 + s_6 w_9 + s_9 w_9^2 & s_2 + s_5 w_9 w_3 + s_8 w_9^2 w_3^2 & s_1 + s_4 w_9 w_9^2 + s_7 w_9^2 w_3 \end{bmatrix}$$

where $\omega_k = e^{\frac{2\pi}{k}j}$, $k = 3,9$. This code is the counterpart of 2Tx-Rate 2 and 4Tx-Rate 4 codes discussed above and provides diversity order 3.

Specific text changes

[Add to 802.16e/D8]

Add new section '8.4.8.3.5 Transmission schemes for 3 antenna BS'

STC for 3Tx-Rate 1,2 and 3:

For three antenna BS, one of the three transmission matrices A, B or C, shall be used:

Matrix A:

$$\begin{bmatrix} s_1 & e^{0.5j} s_3 & e^{0.5j} s_2 \\ s_2 & s_1 & e^{0.5j} s_3 \\ s_3 & s_2 & s_1 \end{bmatrix}$$

Matrix B:

$$\begin{bmatrix} s_1 + s_4 w_9 & e^{0.5j}(s_3 + s_6 w_9 w_3) & e^{0.5j}(s_2 + s_5 w_9 w_3^2) \\ s_2 + s_5 w_9 & s_1 + s_4 w_9 w_3 & e^{0.5j}(s_3 + s_6 w_9 w_3^2) \\ s_3 + s_6 w_9 & s_2 + s_5 w_9 w_3 & s_1 + s_4 w_9 w_9^2 \end{bmatrix}$$

where $\omega_k = e^{\frac{2\pi}{k}j}$, $k = 3,9$.

Matrix C:

$$\begin{bmatrix} s_1 + s_4 w_9 + s_7 w_9^2 & e^{0.5j}(s_3 + s_6 w_9 w_3 + s_9 w_9^2 w_3^2) & e^{0.5j}(s_2 + s_5 w_9 w_3^2 + s_8 w_9^2 w_3) \\ s_2 + s_5 w_9 + s_8 w_9^2 & s_1 + s_4 w_9 w_3 + s_7 w_9^2 w_3^2 & e^{0.5j}(s_3 + s_6 w_9 w_3^2 + s_9 w_9^2 w_3) \\ s_3 + s_6 w_9 + s_9 w_9^2 & s_2 + s_5 w_9 w_3 + s_8 w_9^2 w_3^2 & s_1 + s_4 w_9 w_9^2 + s_7 w_9^2 w_3 \end{bmatrix}$$

where $\omega_k = e^{\frac{2\pi}{k}j}$, $k = 3,9.$

References

[1] V. Shashidhar, B. Sundar Rajan and P. Vijay Kumar, "STBCs with optimal diversity-multiplexing trade-off for 2, 3 and 4 transmit antennas," to appear Proceedings of IEEE International Symposium on Information Theory, June 27-July 3, 2004.