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Re:	802.16e/D5
Abstract	We propose improved space-time codes for 4 Tx rate 2.
Purpose	To propose enhancements of the space-time codes in 802.16e/D4.
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Enhancements to 4 Transmit Antenna Rate 2 Space-Time Codes for the OFDMA PHY

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Introduction

We propose a improved space-time code for 4 Tx rate 2.

Proposed enhancement

STC for 4Tx-Rate 2:

We propose to replace the transmission matrix B with the transmission matrix B' given by

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

where, with $Re[s]$ and $Im[s]$ denoting the real and imaginary part of a complex variable s and $\theta = 0.5tan^{-1}2$,

$$\begin{aligned} \tilde{s}_1 &= Re[s_1 e^{j\theta}] + jIm[s_7 e^{j\theta}]; \quad \tilde{s}_7 = Re[s_7 e^{j\theta}] + jIm[s_1 e^{j\theta}] \\ \tilde{s}_2 &= Re[s_2 e^{j\theta}] + jIm[s_8 e^{j\theta}]; \quad \tilde{s}_8 = Re[s_8 e^{j\theta}] + jIm[s_2 e^{j\theta}] \\ \tilde{s}_3 &= Re[s_3 e^{j\theta}] + jIm[s_5 e^{j\theta}]; \quad \tilde{s}_5 = Re[s_5 e^{j\theta}] + jIm[s_3 e^{j\theta}] \\ \tilde{s}_4 &= Re[s_4 e^{j\theta}] + jIm[s_6 e^{j\theta}]; \quad \tilde{s}_6 = Re[s_6 e^{j\theta}] + jIm[s_4 e^{j\theta}]. \end{aligned}$$

This code is intended to be used as a space-time-frequency code with the two first columns on one tone and the second two columns on a second tone.

The proposed code gives more coding gain than the current transmission matrix B with MMSE detection as shown in Figure 2.

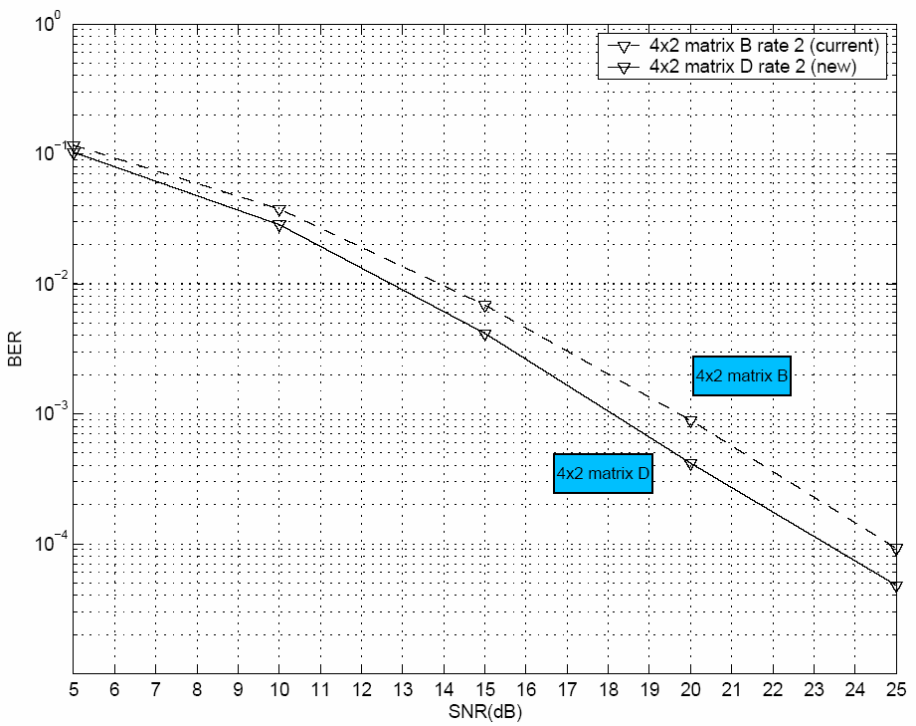

Figure 3: Performance comparison (uncoded) for the 4Tx-Rate 1 matrix B currently in the standard and the proposed matrix D for QPSK modulation in a flat Rayleigh fading channel with MMSE type receivers.

Specific text changes

[Modify the following sections of 802.16e/D3]

8.4.8.3.4 Transmission schemes for 4-antenna BS:

Replace the existing transmission matrix B with B_1 shown below:

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

$$\tilde{s}_1 = Re[s_1 e^{j\theta}] + jIm[s_7 e^{j\theta}]; \quad \tilde{s}_7 = Re[s_7 e^{j\theta}] + jIm[s_1 e^{j\theta}]$$
$$\tilde{s}_2 = Re[s_2 e^{j\theta}] + jIm[s_8 e^{j\theta}]; \quad \tilde{s}_8 = Re[s_8 e^{j\theta}] + jIm[s_2 e^{j\theta}]$$
$$\tilde{s}_3 = Re[s_3 e^{j\theta}] + jIm[s_5 e^{j\theta}]; \quad \tilde{s}_5 = Re[s_5 e^{j\theta}] + jIm[s_3 e^{j\theta}]$$
$$\tilde{s}_4 = Re[s_4 e^{j\theta}] + jIm[s_6 e^{j\theta}]; \quad \tilde{s}_6 = Re[s_6 e^{j\theta}] + jIm[s_4 e^{j\theta}].$$

.

where the complex symbols to be transmitted are $x_1, \ldots, x_8$ which take values from a square QAM constellation and $s_i = x_i e^{j\theta}$ for i=1,2,..,8, where $\theta = \frac{1}{2}\tan^{-1} 2$ and

$\tilde{s}_1 = s_{1I} + js_{3Q}$; $\tilde{s}_2 = s_{2I} + js_{4Q}$; $\tilde{s}_3 = s_{3I} + js_{1Q}$; $\tilde{s}_4 = s_{4I} + js_{2Q}$ where $s_i = s_{iI} + js_{iQ}$.

This code should be used as a space-time-frequency code with the two first columns on a first tone and the second two columns on the second tone.

References

[1] B.A.Sethuraman, B.Sundar Rajan and V.Shashidhar, "Full-diversity, High-rate Space-Time Block Codes from Division Algebras," IEEE Transactions on Information Theory, Vol.49, No.10, Oct. 2003, pp.2596-2616.

[1] Zafar Ali Khan, B. Sundar Rajan and Moon Ho Lee,"On single-symbol and double-symbol decodable STBCs," Proceedings of IEEE Intl. Symposium on Information Theory (ISIT-2003), Yokohama, Japan, June 2003, p.127.

[2] 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.

[3] IEEE P802.16e/D3 Air Interface for Fixed and Mobile Broadband Wireless Access Systems – Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands