

Project	IEEE 802.16 Broadband Wireless Access Working Group < http://ieee802.org/16 >
Title	Proposed Text Changes to DL MIMO SDD Text
Date Submitted	2008-07-14
Source(s)	<p>Mo-Han Fong, Hosein Nikopourdeilami, Jun Yuan, Sophie Vrzic, Robert Novak, Dongsheng Yu, Kathiravetpillai Sivanesan</p> <p>mhfong@nortel.com hosein@nortel.com</p> <p>*<http://standards.ieee.org/faqs/affiliationFAQ.html></p> <p>Nortel Networks</p>
Re:	Call for Comments on DL MIMO SDD text, C802.16m-08/657r2
Abstract	This contribution proposes modification to the open loop MIMO sections
Purpose	For discussion and approval by TGM for 802.16m SDD
Notice	<i>This document does not represent the agreed views of the IEEE 802.16 Working Group or any of its subgroups. It represents only the views of the participants listed in the "Source(s)" field above. It is offered as a basis for discussion. It is not binding on the contributor(s), who reserve(s) the right to add, amend or withdraw material contained herein.</i>
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	The contributor is familiar with the IEEE-SA Patent Policy and Procedures: < http://standards.ieee.org/guides/bylaws/sect6-7.html#6 > and < http://standards.ieee.org/guides/opman/sect6.html#6.3 >. Further information is located at < http://standards.ieee.org/board/pat/pat-material.html > and < http://standards.ieee.org/board/pat >.

Proposed Text Changes to DL MIMO SDD Text

Mo-Han Fong, Hosein Nikopourdeilami, Jun Yuan, Sophie Vrzic,

Robert Novak, Dongsheng Yu, Kathiravetpillai Sivanesan

Nortel Networks

Introduction

This contribution proposes text change on the OL MIMO sections. In the current text in C802.16m-08/657r2, the precoding matrix is composed of two components, i.e. a unitary matrix and a diagonal matrix. However, the details on the elements in the matrices are TBD. Comparative studies were performed in C802.16m-08/824 for different OL schemes with different unitary matrices and with and without the diagonal matrix. The results do not show the benefit of the diagonal matrix. Some discussion has been on-going in the DL MIMO Rapporteur Group reflector on 2D-POD versus CDD versus STTD/AH or SM/AH. Some simulation results have been presented and compared in the reflector. It is not clear at this point what the optimum definition of the diagonal matrix elements should be. Therefore, we suggest putting the diagonal matrix as FFS at this point until further studies is conducted.

In addition, for the 8tx case for OL MIMO, the precoder used for transforming 8 physical antennas to ‘effective antenna’ as seen by the MS does not need to be specified as long as the demodulation pilots are precoded to the desired number of ‘effective antennas’. For example, to support up to 4 effective antennas regardless of the number of physical antennas, the demodulation pilots of up to 4 effective antennas can be defined from standards specification point of view. How the BS transforms the physical antennas to the 4 effective antennas is implementation specific and does not need to be specified in the standards.

Proposed Text Change

11.x.2.1.1. Open-loop SU-MIMO

A number of antenna configurations and transmission rates are supported in open-loop SU-MIMO. Among them, 2Tx antennas with rate 1 transmission and 4Tx antennas with rate 1 transmission are defined as Transmit Diversity modes. The operation of these modes is specified in Section 11.x.2.1.1.1. The other modes, including 2Tx antennas with rate 2 transmission, 4Tx antennas with rate 2 transmission, 4Tx antennas with rate 3 transmission, and 4Tx antennas with rate 4 transmission, are defined as Spatial Multiplexing modes. The operation of these modes is specified in Section 11.x.2.1.1.2. The dimensions of the vectors and matrices for open-loop SU-MIMO are shown in the following table. For OL SU-MIMO, the number of tx antennas are defined in terms of the number of effective antennas as seen by the MS. Up to 4 effective antennas are supported. When the number of physical antennas is greater than 4, how the BS maps the physical antennas to the 4 effective antennas is implementation specific and does not need to be specified in the standards.:

Table 1. Matrix dimensions for open-loop SU-MIMO modes

N_T	Rate	M	N_F
2	1	2	2
4	1	2	2

<u>8</u>	<u>1</u>	<u>2</u>	<u>2</u>
2	2	2	1
4	2	2	1
<u>8</u>	<u>2</u>	<u>2</u>	<u>1</u>
4	3	3	1
<u>8</u>	<u>3</u>	<u>3</u>	<u>1</u>
4	4	4	1
<u>8</u>	<u>4</u>	<u>4</u>	<u>1</u>

On a given frequency resource k [size is FFS], the precoding matrix \mathbf{P} can be defined using the following equation:

$$\mathbf{P}(k) = \mathbf{D}(k)\mathbf{W}(k).$$

The precoder is composed of two matrices. The first matrix $\mathbf{W}(k)$ is an $N_T \times M$ unitary matrix, where N_T is the number of transmit antennas and M are the numbers of physical and effective layers antennas, respectively. The matrix $\mathbf{W}(k)$ is selected from a predefined unitary matrix codebook, and changes every u subcarriers. [The detailed unitary matrix codebook, and the parameter u are FFS.] The second matrix $\mathbf{D}(k)$ is an $N_T \times N_T$ diagonal matrix as follows,

$$\mathbf{D}(k) = \begin{bmatrix} e^{j\theta_0 k} & 0 & \dots & 0 \\ 0 & e^{j\theta_1 k} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & e^{j\theta_{(N_T-1)} k} \end{bmatrix}$$

where k denotes frequency resource index and $\theta_i, i=0, 1, 2, \dots, N_T-1$ denotes the phase angleshift for the i th each physical transmit antenna. [The value of the phase angleshift θ_i is FFS.]

11.x.2.1.1.1. Transmit Diversity

The following transmit diversity modes are supported for open-loop single-user MIMO:

- 2Tx rate-1: STBC/SFBC
- 4Tx rate-1: STBC/SFBC with precoder
- 8Tx rate-1: STBC/SFBC with precoder

In Transmit Diversity mode, the MIMO encoder generates 2Tx STBC/SFBC, and then multiplied by $N_T \times 2$ unitary matrix and $N_T \times N_T$ diagonal matrix as described in section 11.x.2.1.1.

For the transmit diversity modes, the input to the MIMO encoder is represented a 2×1 vector

$$\mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix}.$$

The output of the MIMO encoder is a 2×2 matrix

$$\mathbf{z} = \begin{bmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{bmatrix}.$$

For the 2Tx rate-1 mode, the output of the precoder is a 2×2 matrix

$$\mathbf{y} = \mathbf{z}.$$

For the 4Tx rate-1, the output of the precoder is a 4×2 matrix

$$\mathbf{y} = \mathbf{P} \times \mathbf{z},$$

where \mathbf{P} is a 4×2 unitary precoder and \mathbf{D} is a 4×4 diagonal delay matrix. Note that \mathbf{W} and \mathbf{D} may be frequency dependent as described in section 11.x.2.1.1.

~~For the 8Tx rate-1, the output of the precoder is a 8×2 matrix~~

~~$$\mathbf{y} = \mathbf{P} \times \mathbf{z},$$~~

~~where \mathbf{W} is a 8×2 unitary precoder and \mathbf{D} is a 8×8 diagonal delay matrix. Note that \mathbf{W} and \mathbf{D} may be frequency dependent as described in section 11.x.2.1.1.~~

11.x.2.1.1.2. Spatial Multiplexing

The following spatial multiplexing modes are supported for open-loop single-user MIMO:

- Rate-2 spatial multiplexing modes:
 - 2Tx rate-2: rate 2 SM
 - 4Tx rate-2: rate 2 SM with precoding
- Rate-3 spatial multiplexing modes:
 - 4Tx rate-3: rate 3 SM with precoding
- Rate-4 spatial multiplexing modes:
 - 4Tx rate-4: rate 4 SM

For the rate-2 spatial multiplexing modes, the input to the MIMO encoder is represented as a 2×1 vector

$$\mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix}.$$

The output of the MIMO encoder is a 2×1 vector

$$\mathbf{z} = \mathbf{x}.$$

For the 2Tx rate-2 mode, the output of the precoder is a 2×1 vector

$$\mathbf{y} = \mathbf{z}.$$

For the 4Tx rate-2 mode, the output of the precoder is a 4×1 vector

$$\mathbf{y} = \mathbf{P} \times \mathbf{z},$$

where \mathbf{P} is a 4×2 unitary precoder and \mathbf{D} is a 4×4 diagonal delay matrix. Note that \mathbf{W} and \mathbf{D} may be frequency dependent as described in section 11.x.2.1.1.

~~For the 8Tx rate-2 mode, the output of the precoder is a 8×1 vector~~

~~$$\mathbf{y} = \mathbf{P} \times \mathbf{z},$$~~

~~where \mathbf{W} is a 8×2 unitary precoder and \mathbf{D} is a 8×8 diagonal delay matrix. Note that \mathbf{W} and \mathbf{D} may be frequency dependent as described in section 11.x.2.1.1.~~

For the rate-3 spatial multiplexing modes, the input to the MIMO encoder is represented as a 3×1 vector

$$\mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \end{bmatrix}.$$

The output of the MIMO encoder is a 3×1 vector

$$\mathbf{z} = \mathbf{x}.$$

For the 4Tx rate-3 mode, the output of the precoder is a 4×1 vector

$$\mathbf{y} = \mathbf{P} \times \mathbf{z},$$

where \mathbf{PW} is a 4×3 unitary precoder and \mathbf{D} is a 4×4 diagonal delay matrix. Note that \mathbf{W} and \mathbf{D} may be frequency dependent as described in section 11.x.2.1.1.

~~For the 8Tx rate-3 mode, the output of the precoder is a 8×1 vector~~

~~$$\mathbf{y} = \mathbf{P} \times \mathbf{z}_z$$~~

~~Where \mathbf{W} is a 8×3 unitary precoder and \mathbf{D} is a 8×8 diagonal delay matrix. Note that \mathbf{W} and \mathbf{D} may be frequency dependent as described in section 11.x.2.1.1.~~

For the rate-4 spatial multiplexing modes, the input to the MIMO encoder is represented as a 4×1 vector

$$\mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \end{bmatrix}.$$

The output of the MIMO encoder is a 4×1 vector

$$\mathbf{z} = \mathbf{x}.$$

For the 4Tx rate-4 mode, the output of the precoder is a 4×1 vector

$$\mathbf{y} = \mathbf{z}.$$

~~For the 8Tx rate-4 mode, the output of the precoder is a 8×1 vector~~

~~$$\mathbf{y} = \mathbf{P} \times \mathbf{z}_z$$~~

~~where \mathbf{W} is a 8×4 unitary precoder and \mathbf{D} is a 8×8 diagonal delay matrix. Note that \mathbf{W} and \mathbf{D} may be frequency dependent as described in section 11.x.2.1.1.~~