Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Proposed SDD Text for DL OL SU-MIMO**
Date Submitted	**2009-01-05**
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Re:	TGm SDD section 11.8.2.1.1 In response to IEEE 802.16m-08/052 "Call for Contributions and Comments on Project 802.16m System Description Document (SDD)" for Session 59
Abstract	This contribution proposes SDD text for DL OL SU-MIMO schemes
Purpose	For discussion and approval into TGm SDD text
Notice	
Release	
Patent Policy	

Proposed SDD Text for DL OL SU-MIMO

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Nortel Networks

1. Introduction

This contribution is to propose DL OL SU-MIMO schemes.

2. Text Proposal modification to SDD

(*L5, P100 of C802.16m-08/003r6*)

11.8.2.1.1 Open-loop SU-MIMO

N_T	Rate	M	N_S	N_F
~~2~~	~~1~~	~~1~~	~~1~~	~~1~~
2	1	2	2	2
~~4~~	~~1~~	~~1~~	~~1~~	~~1~~
4	1	2	2	2
~~8~~	~~1~~	~~1~~	~~1~~	~~1~~
8	1	2	2	2
2	2	2	2	1
4	2	2	2	1
~~[4]~~	~~[2]~~	~~[4]~~	~~[4]~~	~~[2]~~
4	2	4	4	2
8	2	2	2	1
~~[8]~~	~~[2]~~	~~[4]~~	~~[4]~~	~~[2]~~
8	2	4	4	2
4	3	3	3	1
~~[4]~~	~~[3]~~	~~[6]~~	~~[4]~~	~~[2]~~
8	3	3	3	1
~~[8]~~	~~[3]~~	~~[6]~~	~~[4]~~	~~[2]~~
4	4	4	4	1
8	4	4	4	1

Table 14 Matrix dimensions for open-loop SU-MIMO modes

~~[Note : This table will be updated according to the decision of OL-SU-MIMO]~~

[*modify section 11.8.2.1.1.1 and 11.8.2.1.1.2 of C802.16m-08/003r6 as follows*]

11.8.2.1.1.1 Transmit Diversity

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

- 2Tx rate-1: ~~For $M = 2$,~~SFBC~~, and for $M = 1$, a rank-1 precoder~~
- 4Tx rate-1: ~~For $M = 2$,~~SFBC with precoder~~, and for $M = 1$, a rank-1 precoder~~
- 8Tx rate-1: ~~For $M = 2$,~~SFBC with precoder~~, and for $M = 1$, a rank-1 precoder~~

~~For the transmit diversity modes with M=1, the input to MIMO encoder is x=s_1, and the output of the MIMO encoder is a scalar, z=x. Then the output of MIMO encoder is multiplied by $N_T \times 1$ matrix W, where W is described in section 11.8.2.1.1~~

For the transmit diversity mode~~s with M=2~~, the input to the MIMO encoder is represented a 2 × 1 vector.

$$\mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix}, \quad \text{(Equation 11.8.2.1.1.1-1)}$$

The MIMO encoder generates the SFBC matrix.

$$\mathbf{z} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix}, \quad \text{(Equation 11.8.2.1.1.1-2)}$$

Then the output of the MIMO encoder is multiplied by $N_T \times 2$ precoder matrix W, where W is described in section 0~~11.8.2.1.1~~.

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

$$\mathbf{y} = \mathbf{z}, \quad \text{(Equation 11.8.2.1.1.1-3)}$$

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

$$\mathbf{y} = \mathbf{W} \times \mathbf{z}, \quad \text{(Equation 11.8.2.1.1.1-4)}$$

where **W** is a 4 × 2 unitary precoder. Note that **W** may be frequency and/or time dependent as described in section 11.8.2.1.1. W is a set of N_p=6 antenna circulation matrices.

$$\mathbf{W} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix}, \begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 0 \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix}, \quad \text{(Equation 11.8.2.1.1.1-5)}$$

$\mathbf{W}$ can be changed every pair of tones or every symbol.

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

$$\mathbf{y} = \mathbf{W} \times \mathbf{z}, \quad \text{(Equation 11.8.2.1.1.1-6)}$$

where **W** is a 8 × 2 unitary precoder. Note that **W** may be frequency and/ or time dependent as described in section 11.8.2.1.1. **W** is defined as follows:

$$\mathbf{W} = \mathbf{W}_1 \times \mathbf{W}_2 , \quad \text{(Equation 11.8.2.1.1.1-7)}$$

$\mathbf{W}_1$ is a 8x4 matrix which is implementation specific, $\mathbf{W}_2$ is a 4 × 2 unitary precoder which consists of a set of N_p =6 antenna circulation matrices.

$$\mathbf{W}_2 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix}, \begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 0 \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix}, \quad \text{(Equation 11.8.2.1.1.1-8)}$$

$\mathbf{W}_2$ can be changed every pair of tones or every symbol.

The permutation rule of the antenna hopping (AH) precoders for transmit diversity mode is defined as follows:

- Let f is the index of the subcarrier starting from 0 (0 <= f <= N_{fft}-1). Note that f denotes the index of a physical tone not a logical tone. N_{fft} is the FFT size according to the bandwidth.
- Let t denote the OFDM symbol index starting form 0 (0<= t <= 5)
- The AH precoder set contains N_p (=6 for diversity mode) precoders
- n = floor(N_p / 2)
- p denotes the precoder index used for a specific tone (0<= p <= N_p-1)

$$p = \{ \text{floor}(t / n) + t * \text{floor}(N_p / n) + \text{floor}(f / 2) \} \bmod N_p \quad \text{(Equation 11.8.2.1.1.1-9)}$$

11.8.2.1.1.2 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 ~~with precoding~~
    - 4Tx rate-2: rate 2 DSFBC with precoding and rate 2 SM with precoding
    - 8Tx rate-2: rate 2 DSFBC with precoding and rate 2 SM with precoding
- Rate-3 spatial multiplexing modes:
    - 4Tx rate-3: rate 3 SM with precoding
    - 8Tx rate-3: rate 3 SM with precoding
- Rate-4 spatial multiplexing modes:
    - 4Tx rate-4: rate 4 SM
    - 8Tx rate-4: rate 4 SM with precoding

~~For the rate-R spatial multiplexing modes, the input and the output of MIMO encoder is represented by an $R \times 1$ vector~~

~~$$\mathbf{x} = \mathbf{z} = \begin{bmatrix} s_1 \\ s_1 \\ \vdots \\ s_R \end{bmatrix}$$, Equation 7~~

~~Then the output of the MIMO encoder is multiplied by $N_T \times R$ matrix W, where W is described in section 11.8.2.1.1.~~

For 2Tx antennas rate-2 mode, the input and output of the MIMO encoder and the output of the precoder are represented as a 2 × 1 vector.

$$y = z = \mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} \qquad \text{(Equation 11.8.2.1.1.2-1)}$$

For 4Tx antennas rate-2 mode, the input to the MIMO encoder is represented as a 4 × 1 vector (DSFBC case) or a 2 x 1 vector (SM case).

$$\mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \end{bmatrix} \text{ for DSFBC, } \mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} \text{ for SM,} \qquad \text{(Equation 11.8.2.1.1.2-2)}$$

The output of the MIMO encoder is a 4 × 2 matrix (DSFBC case) or a 4 × 1 vector (SM case).

$$\mathbf{z} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \\ s_3 & -s_4^* \\ s_4 & s_3^* \end{bmatrix} \text{ for DSFBC, } \mathbf{z} = \mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} \text{ for SM,} \qquad \text{(Equation 11.8.2.1.1.2-3)}$$

the output of the precoder is a 4 × 2 matrix (DSFBC case) or a 4 × 1 vector (SM case).

$$\mathbf{y} = \mathbf{W} \times \mathbf{z}, \qquad \text{(Equation 11.8.2.1.1.2-4)}$$

where $\mathbf{W}$ is a 4 × 4 unitary precoder (DSFBC case) or a 4 × 2 unitary precoder (SM case).

When using DSFBC with precoding, $\mathbf{W}$ is a set of N_p=3 antenna circulation matrices.

$$\mathbf{W} = \begin{bmatrix} 1&0&0&0 \\ 0&1&0&0 \\ 0&0&1&0 \\ 0&0&0&1 \end{bmatrix}, \begin{bmatrix} 1&0&0&0 \\ 0&0&1&0 \\ 0&1&0&0 \\ 0&0&0&1 \end{bmatrix}, \begin{bmatrix} 1&0&0&0 \\ 0&0&1&0 \\ 0&0&0&1 \\ 0&1&0&0 \end{bmatrix}, \qquad \text{(Equation 11.8.2.1.1.2-5)}$$

When using SM with precoding, $\mathbf{W}$ is a set of N_p =6 antenna circulation matrices.

$$\mathbf{W} = \begin{bmatrix} 1&0 \\ 0&1 \\ 0&0 \\ 0&0 \end{bmatrix}, \begin{bmatrix} 0&0 \\ 0&0 \\ 1&0 \\ 0&1 \end{bmatrix}, \begin{bmatrix} 1&0 \\ 0&0 \\ 0&1 \\ 0&0 \end{bmatrix}, \begin{bmatrix} 0&0 \\ 1&0 \\ 0&0 \\ 0&1 \end{bmatrix}, \begin{bmatrix} 1&0 \\ 0&0 \\ 0&0 \\ 0&1 \end{bmatrix}, \begin{bmatrix} 0&0 \\ 1&0 \\ 0&1 \\ 0&0 \end{bmatrix}, \qquad \text{(Equation 11.8.2.1.1.2-6)}$$

In DSFBC case, $\mathbf{W}$ can be changed every pair of tones or every symbol. In SM case, $\mathbf{W}$ can be changed every tone or symbol.

For 8Tx antennas rate-2 mode, the input to the MIMO encoder is represented as a 4 × 1 vector (DSFBC case) or a 2 x 1 vector (SM case).

$$\mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \end{bmatrix} \text{ for DSFBC, } \mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} \text{ for SM,} \qquad \text{(Equation 11.8.2.1.1.2-7)}$$

The output of the MIMO encoder is a 4 × 2 matrix (DSFBC case) or a 4 × 1 vector (SM case)

$$\mathbf{z} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \\ s_3 & -s_4^* \\ s_4 & s_3^* \end{bmatrix} \text{ for DSFBC, } \mathbf{z} = \mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} \text{ for SM,} \qquad \text{(Equation 11.8.2.1.1.2-8)}$$

the output of the precoder is a 4 × 2 matrix

$$\mathbf{y} = \mathbf{W} \times \mathbf{z}, \qquad \text{(Equation 11.8.2.1.1.2-9)}$$

where **W** is defined as follows:

$$\mathbf{W} = \mathbf{W}_1 \times \mathbf{W}_2, \qquad \text{(Equation 11.8.2.1.1.2-10)}$$

$\mathbf{W}_1$ is a 8x4 matrix which is implementation specific, $\mathbf{W}_2$ is a 4 × 4 unitary precoder (DSFBC case) or 4 x 2 unitary precoder (SM case).

When using DSFBC with precoding, $\mathbf{W}_2$ is a set of N_p =3 antenna circulation matrices.

$$\mathbf{W}_2 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix}, \qquad \text{(Equation 11.8.2.1.1.2-11)}$$

When SM with precoding, $\mathbf{W}_2$ is a set of N_p =6 antenna circulation matrices.

$$\mathbf{W}_2 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}, \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix}, \begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 0 \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix}, \qquad \text{(Equation 11.8.2.1.1.2-12)}$$

In DSFBC case, $\mathbf{W}_2$ can be changed every pair of tones or every symbol. In SM case, $\mathbf{W}_2$ can be changed every tone or symbol.

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

$$\mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \end{bmatrix}, \quad \text{(Equation 11.8.2.1.1.2-13)}$$

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

$$\mathbf{z} = \mathbf{x}, \quad \text{(Equation 11.8.2.1.1.2-14)}$$

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

$$\mathbf{y} = \mathbf{W} \times \mathbf{z}, \quad \text{(Equation 11.8.2.1.1.2-15)}$$

where **W** is a 4 × 3 unitary precoder. Note that **W** may be frequency and/or time dependent as described in section 11.8.2.1.1. $\mathbf{W}$ is a set of N_p =4 antenna circulation matrices.

$$\mathbf{W} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}, \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}, \quad \text{(Equation 11.8.2.1.1.2-16)}$$

$\mathbf{W}$ can be changed every tone or symbol.

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

$$\mathbf{y} = \mathbf{W} \times \mathbf{z}, \quad \text{(Equation 11.8.2.1.1.2-17)}$$

where **W** is defined as follows:

$$\mathbf{W} = \mathbf{W}_1 \times \mathbf{W}_2, \quad \text{(Equation 11.8.2.1.1.2-18)}$$

$\mathbf{W}_1$ is a 8x4 matrix which is implementation specific, $\mathbf{W}_2$ is a 4x3 unitary precoder which consists of a set of N_p =4 antenna circulation matrices.

$$\mathbf{W}_2 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}, \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}, \quad \text{(Equation 11.8.2.1.1.2-19)}$$

$\mathbf{W}_2$ can be changed every tone or symbol.

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

$$\mathbf{x} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \end{bmatrix}, \qquad \text{(Equation 11.8.2.1.1.2-20)}$$

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

$$\mathbf{z} = \mathbf{x}, \qquad \text{(Equation 11.8.2.1.1.2-21)}$$

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

$$\mathbf{y} = \mathbf{z}, \qquad \text{(Equation 11.8.2.1.1.2-22)}$$

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

$$\mathbf{y} = \mathbf{W} \times \mathbf{z}, \qquad \text{(Equation 11.8.2.1.1.2-23)}$$

where **W** is a 8 × 4 precoder which is implementation specific.

The permutation rule of the AH precoders for spatial multiplexing mode (including SM and DSFBC) is defined as follows:

- Let f is the index of the subcarrier starting from 0 (0 <= f <= N_{fft}-1). Note that f denotes the index of a physical tone not a logical tone. N_{fft} is the FFT size according to the bandwidth.
- Let t denote the OFDM symbol index starting form 0 (0<= t <= 5)
- The AH precoder set contains N_p (=3,4, or 6) precoders
- n = floor(N_p / 2)
- p denotes the precoder index used for a specific tone (0<= p <= N_p-1)

p = { floor(t / n) + t * floor(N_p / n) + f } mod N_p for SM (Equation 11.8.2.1.1.2-24)

p = { floor(t / n) + t * floor(N_p / n) + floor(f / 2) } mod N_p for DSFBC (Equation 11.8.2.1.1.2-25)

------------------------------------End text proposal-----------------------------------