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Re:	80216m-07/040: Call for Contributions on Project 802.16m System Description Document (SDD)
Abstract	In this contribution, we propose a general structure for MIMO transmission which supports a variety of MIMO modes.
Purpose	Adoption of proposed text into SDD
Notice	
Release	
Patent Policy	

General Structure for MIMO Transmission

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Introduction

The 16m system supports MIMO techniques for achieving diversity and/or providing spatial degree of freedom to increase spectral efficiency and support communication with multiple users using the same time-frequency resources as well. In this contribution, we propose a general structure for MIMO transmission which supports a variety of MIMO modes.

General Structure for MIMO Transmission

This section describes a general structure for MIMO transmission.

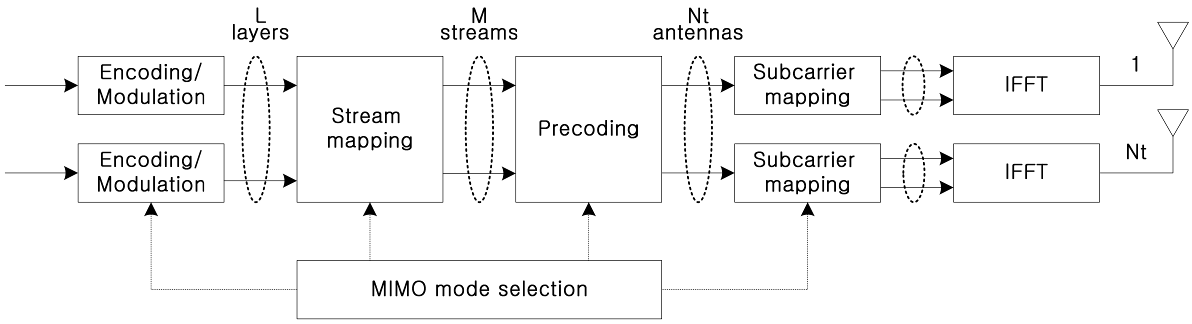


Figure 1- General structure for MIMO transmission[1]

The MIMO transmission illustrated in Figure 1 is represented in the following steps:

- The MIMO mode selection block decides a MIMO mode that can be applied in the precoding as downlink (uplink) data transmission scheme using multiple transmit antennas to (from) a single or multiple MSs.
- The encoding and modulation block generates complex-valued modulation symbols with a single FEC encoded layer or multiple separately FEC encoded layers to be transmitted over multiple antennas.
- The stream mapping block converts L (≥ 1) layers of modulation symbols onto M $(\geq L)$ parallel transmission streams which are fed to the precoding block.
- The precoding block takes as input the transmission streams of modulation symbols and generates antenna specific or beam specific data symbols according to the selected MIMO mode.
- The subcarrier mapping block allocates the precoded symbols to time-frequency resources on each of transmission antennas.

[1] For uplink multiple MS transmission, the structure shown in Figure 1 can be copied to the number of MSs transmitting simultaneously.

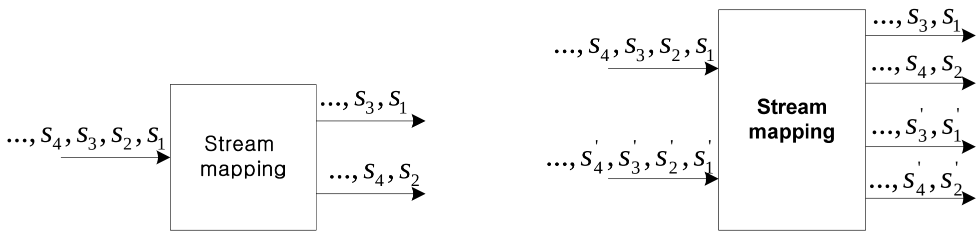
A “layer” is defined as an information path fed to the stream mapping block. The number of layers in a system with vertical encoding is 1, but in case of horizontal encoding it depends on the number of encoding/modulation paths.
A “stream” is defined as each information path that is passed to the precoding block. The number of streams in both vertical and horizontal encoding systems is the same as the number of different data symbols to be transmitted at a space-time/frequency coding block through multiple transmit antennas.

MIMO Modes

MIMO modes can typically be categorized into open-loop MIMO and closed-loop MIMO depending on whether the feedback of channel state information (CSI) from a receiver to a transmitter is needed or not. The feedback of CSI contains quantized channel coefficients, antenna or beam index, codeword index, etc. Both open-loop MIMO and closed-loop MIMO may require the feedback of channel quality information (CQI) such as SINR, rank information, etc. BS controls the scheduling and transmission strategies based on the types of CSI and CQI at the transmitter. The open-loop MIMO includes space time coding (STC) and spatial multiplexing (SM), and the closed-loop MIMO includes transmit beamforming and closed-loop SM. In addition, BS can transmit to multiple MSs simultaneously over the same time-frequency resource, and multiple MSs can simultaneously transmit to a single BS over the same time-frequency resource.

Stream Mapping

The stream mapping block sequentially takes modulation symbols from each layer and distributes them to one or multiple streams, where the number of streams is the same as the number of different data symbols to be transmitted at a space-time/frequency coding block. For example, if the selected MIMO mode is the space-time/frequency block code (i.e., matrix A in [1]) or SM (i.e., matrix B in [1]) for 2 antennas with vertical encoding, the stream mapping block distributes 1-layer symbols onto 2 parallel streams as in Figure 2 (a). If the selected MIMO mode is to transmit 2 layered modulation symbols through 4 streams, the stream mapping block may work as in Figure 2 (b).



(a) Vertical encoding **(b) Horizontal encoding**

Figure 2- Stream mapping block

Precoding

The precoding block takes as input one or several transmission streams of the complex-valued modulation symbols from the stream mapping and generates a block of N_t weighted symbols to be mapped onto each of the transmit antennas. The precoding can be represented, regardless of the type of the selected MIMO mode, as follows:

$$\mathbf{z} = \mathbf{W}\mathbf{x}, \quad (1)$$

where $\mathbf{x}$ is a vector consisting of streams of modulation symbols and M is the number of the streams. The matrix $\mathbf{W}$ is a weighting matrix for precoding according to the selected MIMO mode. The vector $\mathbf{z}$ contains the precoded data symbols by weighting $\mathbf{x}$ with $\mathbf{W}$.

The precoded data of any MIMO mode selected in MIMO mode selection in Figure 1 can be expressed as (1). For example, if the selected MIMO mode is SM for 2 transmit antennas, the precoded data symbols can be simply given as

$$\mathbf{z} = \mathbf{W}_{SM}\mathbf{x},$$

where $\mathbf{x} = [s_1 \quad s_2]^T$ and $s_i,\ i = 1, 2$ are streams from the stream mapping , and

$$\mathbf{W}_{SM} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}.$$

If the selected MIMO mode is the space-time/frequency block code (i.e., matrix A in [1]) for 2 transmit antennas, the output vector $\mathbf{z} = \begin{bmatrix} \mathbf{z}_1^T & \mathbf{z}_2^T \end{bmatrix}^T$ of the precoding block is obtained from the followings [2]:

$$\begin{bmatrix} \mathbf{z}_1 \\ \mathbf{z}_2 \end{bmatrix} = \mathbf{W}_{STC}\mathbf{x},$$

where $\mathbf{z}_i$ is $N_t \times 1$ vector whose index i denotes time or frequency, $\mathbf{x} = \begin{bmatrix} \mathrm{Re}(\mathbf{s}^T) & \mathrm{Im}(\mathbf{s}^T) \end{bmatrix}^T$, $\mathbf{s} = [s_1 \quad s_2]^T$, and the weighting matrix is

$$\mathbf{W}_{STC} = \begin{bmatrix} 1 & 0 & j & 0 \\ 0 & 1 & 0 & j \\ 0 & -1 & 0 & j \\ 1 & 0 & -j & 0 \end{bmatrix}.$$

For closed-loop SM for 2 stream transmission with 2 transmit antennas, the precoded vector is

$$\mathbf{z} = \mathbf{W}_{CLSM}\mathbf{x},$$

where $\mathbf{x} = [s_1 \quad s_2]^T$ is the vector of the modulation symbols. The weighting matrix is given as

$$\mathbf{W}_{CLSM} = \begin{bmatrix} w_{11} & w_{12} \\ w_{21} & w_{22} \end{bmatrix},$$

where w_{nm} is the weight of the n-th transmit antenna for the m-th stream.

Summary

In this contribution, we propose a general structure for MIMO transmission which can support a variety of MIMO modes, as illustrated in Figure 1. Any MIMO mode applied to 16m system can be expressed as (1).

Proposed subsection in ToC

[Adopt the following text in the ToC of P802.16m System Description Document (SDD).]

[x.x. MIMO]
x.x.1. General Structure for MIMO Transmission

Proposed Text

[Add the following text in the beginning part of MIMO section of P802.16m SDD.]

---------- Start text proposal ----------

[x.x. MIMO]
x.x.1. General Structure for MIMO Transmission
[IEEE 802.16m system supports MIMO techniques for achieving diversity and/or providing spatial degree of freedom to increase spectral efficiency and support communication with multiple users using the same time-frequency resources as well. This section describes a general structure for MIMO transmission which supports a variety of MIMO modes.

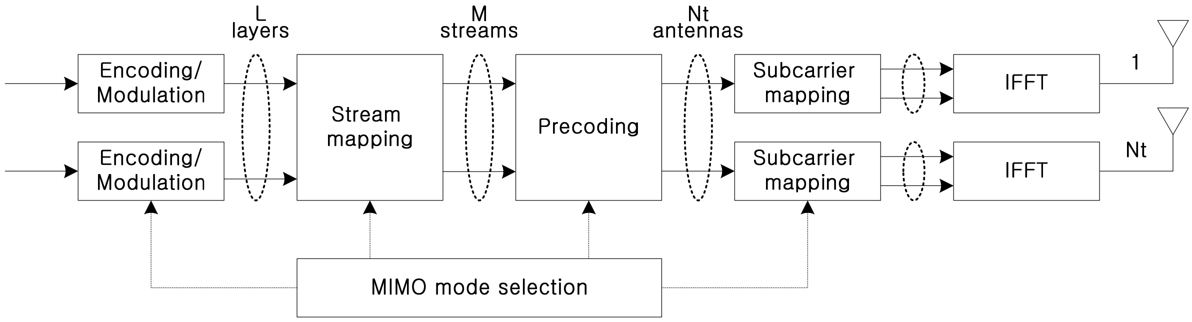


Figure 1- General structure for MIMO transmission[1]

The MIMO transmission illustrated in Figure 1 is represented in terms of the following steps:

- The MIMO mode selection block decides a MIMO mode that can be applied in the precoding as downlink (uplink) data transmission scheme using multiple transmit antennas to (from) a single or multiple MSs.
- The encoding and modulation block generates complex-valued modulation symbols with a single FEC encoded layer or multiple separately EEC encoded layers to be transmitted over multiple antennas.
- The stream mapping block converts L (≥ 1) layers of modulation symbols onto M $(\geq L)$ parallel transmission streams which are fed to the precoding block.
- The precoding block takes as input the transmission streams of modulation symbols and generates antenna specific or beam specific data symbols according to the selected MIMO mode.
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A "layer" is defined as an information path fed to the stream mapping block. The number of layers in a system with vertical encoding is 1, but in case of horizontal encoding it depends on the number of encoding/modulation paths.
A "stream" is defined as each information path that is passed to the precoding block. The number of streams in both vertical and horizontal encoding systems is the same as the number of different data symbols to be transmitted at a space-time/frequency coding block through multiple transmit antennas.

The precoding block in Figure 1 takes as input one or several transmission streams of the complex-valued modulation symbols from the stream mapping and generates a block of N_t weighted symbols to be mapped onto each of the transmit antennas. The precoding can be represented, regardless of the type of the selected MIMO mode, as follows:

$$\mathbf{z} = \mathbf{W}\mathbf{x}, \quad (1)$$

where $\mathbf{x}$ is a vector consisting of streams of modulation symbols and the matrix $\mathbf{W}$ is a weighting matrix for precoding according to the selected MIMO mode. The vector $\mathbf{z}$ contains the precoded data symbols by

[1] For uplink multiple MS transmission, the structure shown in Figure 1 can be copied to the number of MSs transmitting simultaneously.

weighting $\mathbf{x}$ with $\mathbf{W}$.

If the selected MIMO mode is SM, then $\mathbf{x}$ is a vector of M streams and $\mathbf{W}=\mathbf{I}_{N_t}$. For closed-loop SM, $\mathbf{x}$ is an $M\times 1$ vector of streams and $\mathbf{W}$ is an $N_t\times M$ weighting matrix selected based on feedback information. If the selected MIMO mode is one of STC type, $\mathbf{x}$ is a $2M\times 1$ vector consisting of M streams of the form of $\mathbf{x}=\left[\mathrm{Re}(\mathbf{s}^T) \quad \mathrm{Im}(\mathbf{s}^T)\right]^T$, where $\mathbf{s}=\left[s_1, \quad s_2, \quad ..., \quad s_M\right]^T$ is a vector from the stream mapping. The matrix $\mathbf{W}$ is an $N_tT\times 2M$ weighting matrix, where T is the number of time intervals or subcarriers for space-time/frequency coding. Each column of the selected STC consists of N_t consecutive elements of $\mathbf{Wx}$. For instance, the space-time/frequency block code $\begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix}$ can be obtained from

$$\mathbf{Wx}=\begin{bmatrix} 1 & 0 & j & 0 \\ 0 & 1 & 0 & j \\ 0 & -1 & 0 & j \\ 1 & 0 & -j & 0 \end{bmatrix}\begin{bmatrix} \mathrm{Re}(s_1) \\ \mathrm{Re}(s_2) \\ \mathrm{Im}(s_1) \\ \mathrm{Im}(s_2) \end{bmatrix}.$$

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

References

[1] P802.16Rev2/D0b (June 2007), *Part 16: Air Interface for Broadband Wireless Access Systems*.
[2] 3GPP TS 36.211, 3GPP TSG-EUTRA, *Physical channels and modulation*, September 2007.