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Abstract	Enhanced MIMO Transmission Schemes for Cellular OFDMA Systems
Purpose	Adoption of proposed changes into P802.16e
Notice	
Release	
Patent Policy and Procedures	

Enhanced MIMO Transmission Schemes for Cellular OFDMA Systems

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1. Introduction

From a pure diversity standpoint, one can enhance the fading statistics of the received signal by virtue of the multiple replicas being affected by independent channels. By sending the same signal through parallel and independent channels, the effect of multipath fading can be greatly reduced, decreasing the outage probability and hence improving the reliability of the communication link. In other approach, referred to as spatial multiplexing, different information streams are transmitted on the parallel spatial channels associated with the transmit antennas. This could be seen as a very effective method to increase spectral efficiency. We are also considering a mixed-mode combining the advantages of both methods. The mixed mode approach can be seen as a good engineering compromise, where multipath fading is effectively combated by diversity while attaining a high spectral efficiency due to spatial multiplexing. In addition, transmit antenna array (TxAA) scheme will be considered to increase the received SINR at SS.

STC enhancements with multiple antennas at BS and SS for optional FUSC and AMC zones for OFDMA PHY are provided in the current draft standard [1]. Pilots and data allocation methods are described and the transmission schemes for 2 and 4 antenna BS are also suggested. In this contribution we propose a new transmission scheme for 4 Tx which outperforms the existing one. In addition, an effort to remove the confusing matrices regarding closed-loop operation is made. Lastly, the necessary changes in MAP IEs that should be made to reflect the proposal are proposed.

2. SBC-REQ/RSP Changes for MIMO Support

For OFDMA system, the current standard [1] lacks the mechanism for an SS to report its capability to a BS during initialization period, when SS basic capabilities are conveyed to BS on SBC-REQ and confirmed by BS on SBC-RSP. The necessary TLV definitions for the MIMO support are added as follows.

2.1. Specific Text Changes

[Add a new section 11.8.3.7.6 in page 687 of [1]]

11.8.3.7.6 OFDMA SS demodulator for MIMO support

This field indicates the MIMO capability supported by a WirelessMAN-OFDMA PHY SS for downlink reception. A bit value of 0 indicates "not supported" while 1 indicates "supported".

Type	Length	Value	Scope
155	1	Bit #0: 2x TD Bit #1: 4x TD Bit #2: 2x SM Bit #3: 4x SM Bit #4: 2x SM, 2x TD	SBC-REQ (see 6.3.2.3.23) SBC-RSP (see 6.3.2.3.24)

		Bit #5: SVD capability Bit #6: Antenna weight calculation Bit #7: Reserved; shall be set to zero	

[Add a new section 11.8.3.7.7 in page 687 of [1]]

11.8.3.7.7 OFDMA SS modulator for MIMO support

This field indicates the MIMO capability supported by a WirelessMAN-OFDMA PHY SS for uplink reception. A bit value of 0 indicates "not supported" while 1 indicates "supported".

Type	Length	Value	Scope
156	1	Bit #0: 2x TD Bit #1: 2x SM Bit #2-7: Reserved; shall be set to zero	SBC-REQ (see 6.3.2.3.23) SBC-RSP (see 6.3.2.3.24)

3. MIMO Transmission Schemes

For the downlink, a MIMO SS monitors the channel quality, selects and feedbacks to the BS an appropriate MIMO mode or multiple modes among diversity, spatial multiplexing, or TxAA schemes. For the uplink, each MIMO SS operates in open-loop basis and selects the transmission scheme among diversity, multiplexing or collaborative multiplexing.

3.1. Transmission Schemes for 2 Tx

3.1.1. Specific Text Changes

[Replace the section 8.4.8.3.3 with the following]

8.4.8.3.3 Transmission schemes for 2-antenna BS in DL

The following matrices define the transmission format with the row index indicating antenna number and column index indicating OFDMA symbol time. For both DL permutation zones with 2-antenna BS, one of the following three transmission matrices shall be used:

Diversity mode :

Spatial multiplexing mode : where and may be encoded in different rates.

TxAA mode : , where are the fed-back antenna weight coefficients from SS through the fast feedback channels such as CQI channel and its mapping shall be done as shown in Figure 231. With w0 = 1, BS may implement a simplified beamforming transmission. Furthermore, antenna selection diversity is achieved when one of wi = 0. In order to facilitate fast and accurate adaptation for multiple antennas, BS may use multiple CQI channels to a certain SS (See 8.4.5.3.12.1).

[Add a new section 8.4.8.4.3]

8.4.8.4.3 Transmission schemes for 2-antenna SS in UL

The following matrices define the transmission format with the row index indicating antenna number and column index indicating OFDMA symbol time. For both UL permutation zones with 2-antenna SS, one of the following two transmission matrices shall be used:

Diversity mode :

Spatial multiplexing mode : where and may be encoded in different rates.

The mode B may also be used for two single antenna SS to share the same subchannel (collaborative spatial multiplexing).

3.2. Transmission Schemes for 4 Tx

Due to high computational complexity, most communication system would not use the full-diversity full-rate (FDFR) codes even though their performance is good. In [16d], space time block codes for 4 transmit antennas are used for optional FUSC and AMC zones. However, this scheme is outperformed by the proposed FDFR space-time codes. In fact, the diversity gain of the latter is the doubled than that of the former.

We propose a puncturing and shifting procedures after the constellation rotation process resulting in a new precoder scheme. That is

where, , ( ) C represent the information symbols and S are the new generated symbols by the proposed precoder. The proposed scheme performs better than or as good as other constellation-rotation approaches, but with a significantly lower receiver complexity.

3.2.1. Specific Text Changes

[Replace the section 8.4.8.3.4 with the following]

8.4.8.3.4 Transmission schemes for 4-antenna BS in DL

For both permutation zones with 4-antenna BS, one of the following four transmission matrices shall be used:

Diversity mode :

where,

Hybrid mode :

Spatial multiplexing mode :

TxAA mode :

3.3. MIMO DL Basic IE format

Current MIMO DL Basic IE should be changed in order to reflect the transmission schemes proposed in the previous sections.

[Modify the Table 281a in Section 8.4.5.3.8 in page 74 in [1]]

Table 281a - MIMO DL basic IE format

Syntax	Size (bits)	Notes
MIMO_DL_Basic_IE() {		
Extended DIUC	4	0x05
Length	4	Length in bytes
Num_Region	4	
For (i=0;i<Num_Region;i++) {		
OFDMA Symbol offset	10	
Subchannel offset	5	
Boosting	3	
No. OFDMA symbols	9	
No. Subchannels	5	

Matrix indicator	2	STC matrix (see 8.4.8.1.4)
		STC = STC mode
		indicated in the latest STC_Zone_IE().
		
		if (STC ==01) {
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		~~10~~ 11 = Reserved }
		elseif (STC == 10) {
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		11 = Matrix D~~Reserved~~
		}

Num_layer	2	
for (j=0;j<Num_layer;j++) {		
If (INC_CID == 1) {		
CID }	16	
Layer_index	2	
DIUC	4	0-11 burst profiles
}		
}		
}		

3.4. MIMO DL Enhanced IE format

Current MIMO DL Enhanced IE should be changed in order to reflect the transmission schemes proposed in the previous sections.

[Modify the Table 282a in Section 8.4.5.3.9 in page 74 in [1]]

Table 282a - MIMO DL Enhanced IE format

Syntax	Size (bits)	Notes
MIMO_DL_Enhanced_IE() {		
Extended DIUC	4	0x05
Length	4	Length in bytes
Num_Region	4	

For (i=0;i<Num_Region;i++) {		
OFDMA Symbol offset	10	
Subchannel offset	5	
Boosting	3	
No. OFDMA symbols	9	
No. Subchannels	5	

Matrix indicator	2	STC matrix (see 8.4.8.1.4)
		STC = STC mode
		indicated in the latest STC_Zone_IE().
		
		if (STC ==01) {
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		~~10~~ 11 = Reserved }
		elseif (STC == 10) {
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		11 = Matrix D~~Reserved~~
		}

Num_layer	2	
for (j=0;j<Num_layer;j++) {		
If (INC_CID == 1) {		
CQICH_ID }	*variable*	Index to uniquely identify the CQICH resources assigned to the SS The size of this field is dependent on system parameter defined in DCD.
Layer_index	2	
DIUC	4	0-11 burst profiles
}		
}		
}		

3.5. Mode Selection Feedback

As mentioned earlier, for the efficient MIMO operation in DL, SS needs to report the most appropriate MIMO mode(s) to BS. The current draft standard, however, is not clear on this.

[Modify the Table 296a in Section 84.5.4.10.3 in page 77 in [1]]

8.4.5.4.10.3 Mode Selection Feedback

Table 296 – Encoding of payload bits for Fast-feedback slot

Value	Description
0b0000	STTD and PUSC/FUSC permutation
0b0001	STTD and adjacent-subcarrier permutation
0b0010	SM and PUSC/FUSC permutation
0b0011	SM and adjacent-subcarrier permutation
0b0100	Hybrid~~Closed-loop SM~~ and PUSC/FUSC permutation
0b0101	Hybrid and adjacent-subcarrier permutation ~~Closed-loop SM and~~

	~~adjacent-subcarrier permutation~~
0b0110	~~Closed-loop SM +~~ Beamforming and adjacent-subcarrier permutation
~~0b0111~~	~~TD + Beamforming and adjacent-subcarrier permutation~~
0b0111~~1000~~ - 1111	Reserved

References:

[1] 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