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Abstract	Contribution describing the MAC Support for 802.16d OFDMA MIMO
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MAC Enhancement to Support OFDMA MIMO

1 Introduction

This document describes the MAC enhancements to support the MIMO-OFDMA PHY. The following MAC features are proposed:

- DL burst assignment to support adaptive MIMO transmission
- UL burst assignment to support adaptive MIMO transmission
- Fast feedback channel operation to support SS dynamic feedback of MIMO mode and permutation selection

2 Proposed MAC Enhancement

2.1 DL Burst Assignment to Support Adaptive MIMO Transmission

To support adaptive MIMO mode, i.e. STTD and spatial multiplexing (SM), we modify the TD_Zone_IE() in comment #204 to indicate the switch between STTD and SM. We also introduce a new DL-MAP extended information element, MIMO_DL_Basic_IE, to assign burst profile per antenna for MIMO operation.

[Modify section 8.4.5.3.4]

8.4.5.3.4 Transmit diversity (TD)/Zone switch IE format

In the DL-MAP, a ~~transmit diversity enabled~~ BS ~~(see 8.4.8)~~ may transmit DIUC=15 with the TD_Zone_IE() to indicate that the subsequent allocations shall ~~be~~ use a specific permutation, or be transmit diversity encoded. ~~No preceding downlink allocations shall be transmit diversity encoded and all subsequent downlink allocations until the end of the frame shall be transmit diversity encoded.~~The downlink frame shall start in PUSC mode with IDcell=0 and no transmit diversity. Allocations subsequent to this IE shall use the pemutation and transmit diversity mode it instructs. The STC matrix can be override on a per-assignment basis by that instructed in the MIMO_DL_Basic_IE() (see section 8.4.5.3.8).

Table x – Transmit diversity (TD)/Zone switch IE

Syntax	Size	Notes
TD_Zone_IE () {		
Extended DIUC	4 bits	~~STC = 0x01, FHDC = 0x02~~ TD/Zone = 0x01
Length	4 bits	Length = 0x0~~0~~2
Permutation	2 bits	00 = PUSC permutation 01 = FUSC permutation 10 = Optional FUSC permutation 11 = Reserved
Use_All_SC_Indicator	1 bit	0 = Do not use all subchannels 1 = Use all subchannels
Transmit_Diversity	2 bits	00 = No transmit diversity 01 = STC using 2 antennas 10 = STC using 4 antennas 11 = FHDC

Matrix_Indicator	2 bits	STC matrix (see 8.4.8.4.)
		if (Transmit_Diversity = 01)
		{
		00 = Matrix A
		01 = Matrix B
		10 – 11 = Reserved
		}
		elseif (Transmit_Diversity = 10)
		{
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C

		11 = Reserved }
IDcell	6 bits	
Reserved	3 bits	
}		

[Further, change the text below the table as follows]

Permutation
Indicates the permutation that shall be used by the transmitter for allocations following this IE. Permutation changes are only allowed on a zone boundry. The IDcell indicated by the IE shall be used as the basis of the permutation (see 8.4.6.1).

Use All SC indicator
When set, this indicator indicates transmission on all available subchannels. For FUSC permutation, transmission is always on all subchannels.

Transmit diversity
Indicates the transmit diversity mode that shall be used by the transmitter for allocations following this IE (see 8.4.8). The duration of the DIUC=15 TD_IE() allocation shall be zero. All allocations up to this allocation without transmit diversity shall be transmitted only from one antenna (antenna 0). The transmission in this allocation will be as specified in 8.4.8. After this allocation, All allocations with transmit diversity the BS shall transmit all allocations from both its antennas until the end of the allocations.

[Add a new section 8.4.5.3.8]

8.4.5.3.8 MIMO DL Basic IE format

In the DL-MAP, a MIMO-enabled BS may transmit DIUC=15 with the MIMO_DL_Basic_IE() to indicate the MIMO configuration of the subsequent downlink allocation to a specific MIMO-enabled SS' CID. The MIMO mode indicated in the MIMO_DL_Basic_IE() shall only apply to the subsequent downlink allocation until the end of frame.

Table x - MIMO DL Basic IE

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

Matrix_indicator	2 bits	STC matrix (see 8.4.8.4.)
		Transmit_diversity = transmit diversity mode indicated in the latest TD_Zone_IE().
		if (Transmit_Diversity = 01)
		{
		00 = Matrix A
		01 = Matrix B
		10 – 11 = Reserved
		}
		elseif (Transmit_Diversity = 10)
		{
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		11 = Reserved
		}

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

[Add the following text below the table]

Num_Region

This field indicates the number of the regions defined by OFDMA_Symbol_offset, Subchannel_offset, Boosting, No._OFDMA_Symbols and No._subchannels in this IE.

Matrix_indicator

The values of these three bits indicate the STC matrix (see 8.4.8.4).

Num_layer

The value of these 2 bits plus one indicate the number of MIMO transmission layers.

Layer_index

This field specifies the layer index.

2.2 UL Burst Assignment to Support Adaptive MIMO Transmission

We introduce a new extended information element, MIMO_UL_Basic_IE, to include information on the MIMO mode associated with the UL burst allocation.

[Add a new section 8.4.5.4.10]

8.4.5.4.10 MIMO UL Basic IE format

In the UL-MAP, a MIMO-enabled BS may transmit UIUC=15 with the MIMO_UL_Basic_IE() to indicate the MIMO mode of the subsequent uplink allocation to a specific MIMO-enabled SS' CID. The MIMO mode indicated in the MIMO_UL_Basic_IE() shall only apply to the subsequent uplink allocation until the end of frame.

Table x - MIMO UL Basic IE

Syntax	Size	Notes
MIMO_UL_Basic_IE () {		
Extended UIUC	4 bits	0x02
Length	4 bits	Length in bytes
Num_Assign	4 bits	Number of burst assignment
For (i = 0; i < Num_assign; i++) {		
CID	16 bits	SS basic CID
UIUC	4 bits	
MIMO_Control	1 bit	For dual transmission capable SS 0: STTD; 1: SM For Collaborative SM capable SS 0: pilot pattern A; 1: pilot pattern B
Duration	10 bits	In OFDMA slots (see 8.4.3.1)

[Add the following text below the table]

Num_assign
This field specifies the number of assignments in this IE.

MIMO_Control
MIMO_Control field specifies the MIMO mode of UL burst. For a dual transmission capable SS, the value of 0 indicates STTD mode, the value of 1 indicates SM mode; For a collaborative SM capable SS, the value of 0 indicates pilot pattern A, the value of 1 indicates pilot pattern B.

2.3 Fast Feedback Channel Operation

The fast feedback channel can be used to report CQI as well as MIMO channel coefficient as described in IEEE 802.16d/D4. In addition, we propose to use the fast feedback channel to indicate the selection of MIMO mode, i.e. between STTD and SM, by the SS. We also propose to use the fast feedback channel to indicate the selection between PUSC/FUSC and adjacent-subcarrier permutation, by the SS.

For the abovementioned selection indications, we propose to support both slow reporting for fixed application as well as fast periodic reporting for mobile application.

2.3.1 MIMO and Permutation Modes Switch Indication

Slow mode switching can be implemented by BS polling the SS for its modes selection. The FAST-FEEDBACK subheader with feedback_type field of '11' is used for BS to obtain the indication of MIMO mode and permutation mode of a SS. The polling interval is implementation dependent. Once a SS receives such a FAST-FEEDBACK sub-header, the SS shall send its indication on its assigned fast feedback channel.

[Modify Section 6.4.2.3.7]

6.4.2.3.7 FAST-FEEDBACK allocation subheader
The format of the FAST-FEEDBACK allocation subheader is specified in Table 13. The FAST-FEEDBACK allocation subheader, when used, shall always be the last per-PDU subheader as specified in 6.4.2.3. The support of the FAST-FEEDBACK allocation subheader is PHY specification specific.

Table 13 FAST-FEEDBACK allocation subheader format

Syntax	Size	Notes
FAST-FEEDBACK allocation Subheader {		
Allocation offset	6 bits	
Feedback_type	2 bits	00 – Fast DL measurement 01 – Fast MIMO feedback, antenna #0 10 – Fast MIMO feedback, antenna #1 11 – MIMO mode and permutation mode feedback
}		

[Add a new section 8.4.5.4.9.3]

8.4.5.4.9.3 Mode Selection Feedback

When the FAST-FEEDBACK subheader Feedback Type field is '11' or at a specific frame indicated in the CQICH_Alloc_IE(), the SS shall send its selection in terms of MIMO mode (STTD versus SM) or permutation mode on the assigned Fast-feedback channel. Table XX shows the encoding of payload bits.

Table XX. Encode of payload bits when Feedback_type = '11' in FAST-FEEDBACK subheader.

Value	Description
0000	STTD and PUSC/FUSC permutation
0001	STTD and adjacent-subcarrier permutation
0010	SM and PUSC/FUSC permutation
0011	SM and adjacent-subcarrier permutation
0100 - 1111	reserved

2.3.2 Dynamic CQICH Allocation with Fast Periodic MIMO / Permutation Feedback

The number of available CQICHs on the uplink is dependent on the amount of uplink sub-carriers and OFDM symbols allocated for the CQICHs. The fast CQI feedback represents non-negligible overhead on the uplink and therefore the CQICH resource should be dynamically allocated and de-allocated to different SSs. The dynamic allocation and de-allocation to different SSs should be done without incurring too much downlink signaling overhead. We therefore propose to allow the option of allocating/de-allocating the CQICH on a multiple-burst basis rather than on a per-burst basis.

A new UL-MAP IE, **CQICH_Alloc_IE()**, is introduced to dynamically allocated or de-allocated a CQICH to a SS. Once allocated, the SS transmit channel quality information on the assigned CQICH on every subsequent frames, until the SS receives a **CQICH_Alloc_IE()** to de-allocate the assigned CQICH. Fast periodic (with period specified in CQICH_Alloc_IE()) MIMO mode and permutation mode feedback is supported on the assigned CQICH.

When a SS is assigned a CQICH, there is a one-to-one mapping between the SS and the CQICH assigned. Therefore, we can replace the 16-bit basic CID by the smaller size CQICH_ID when allocating DL burst to the SS. We introduce a new information element on the DL-MAP, i.e. **MIMO_DL_Enhanced_IE()** to use CQICH_ID instead of CID to assign DL burst to the SS.

[Add a section 8.4.5.4.10 to allow the option of dynamic allocation/de-allocation of the CQICH on a multiple-burst basis]

8.4.5.4.10 CQICH Allocation IE Format

CQICH_Alloc_IE(), is introduced to dynamically allocate or de-allocate a CQICH to a SS. Once allocated, the SS transmit channel quality information on the assigned CQICH on every subsequent frames, until the SS receives a CQICH_Alloc_IE() to de-allocate the assigned CQICH.

Table x – CQICH_Alloc_IE()

Syntax	Size	Notes
CQICH_Alloc_IE() {	_	_
Extended UIUC	4 bits	0x03
Length	4 bits	Length in bytes of following fields
CQICH_ID	*variable*	Index to uniquely identify the CQICH resource assigned to the SS The size of this field is dependent on system parameter defined in DCD.
Allocation offset	6 bits	Index to the fast feedback channel region marked by UIUC = 0.
Period (=p)	2 bits	A CQI feedback is transmitted on the CQICH every 2p frames.
Frame offset	3 bits	The SS starts reporting at the frame of which the number has the same 3 LSB as the specified frame offset. If the current frame is specified, the SS should start reporting in 8 frames
Duration (=d)	3 bits	A CQI feedback is transmitted on the CQI channels indexed by the CQICH_ID for 10 x 2^d frames. If d == 0, the CQI-CH is de-allocated. If d == 111, the SS should report until the BS command for the SS to stop.
MIMO_permutation_feedback_cycle	2 bits	00 = No MIMO and permutation mode feedback 01 = the MIMO and permutation mode indication shall be transmitted on the CQICH indexed by the CQICH_ID every 4 frames. The first indication is sent on the 8th CQICH frame. 10 = the MIMO mode and permultation mode indication shall be transmitted on the CQICH indexed by the CQICH_ID every 8 frames. The first indication is sent on the 8th CQICH frame. 11 = the MIMO mode and permultation mode indication shall be transmitted on the CQICH indexed by the CQICH_ID every 16 frames. The first indication is sent on the 16th CQICH frame.
Padding	*Variable*	The padding bits is used to ensure the IE size is integer number of bytes.
}		

[add the following text below the table]

CQICH_ID
The CQICH_ID uniquely identifies a fast feedback channel on which a SS can transmit fast feedback information. With this allocation, a one-to-one relationship is established between the CQICH_ID and the SS.

MIMO_permutation_feedback_Cycle
This field specifies the MIMO and permutation mode fast feedback cycle. See Section 8.4.5.4.9.3 for fast feedback channel payload encoding for MIMO and permutation feedback.

[*Add a new section 8.4.5.3.9 to use CQICH_ID for DL burst assignment]*

8.4.5.3.9 MIMO DL Enhanced IE format

In the DL-MAP, a MIMO-enabled BS may transmit DIUC=15 with the MIMO_DL_Enhanced_IE() to indicate the MIMO mode of the subsequent downlink allocation to a specific MIMO-enabled SS identified by the CQICH_ID previously assigned to the SS. The MIMO mode indicated in the MIMO_DL_Enhanced_IE() shall only apply to the subsequent downlink allocation until the end of frame.

Table x - MIMO DL Enhanced IE

Syntax	Size	Notes
MIMO_DL_Enhanced_IE () {		
Extended DIUC	4 bits	0x06
Length	4 bits	Length in bytes
Num_Region	4 bits	
for (i = 0; i< Num_Region; i++) {		
OFDMA Symbol offset	10 bits	
Subchannel offset	5 bits	
Boosting	3 bits	
No. OFDMA Symbols	9 bits	
No. subchannels	5 bits	

Matrix_indicator	2 bits	STC matrix (see 8.4.8.4.)
		Transmit_diversity = transmit diversity mode indicated in the latest TD_Zone_IE().
		if (Transmit_Diversity = 01)
		{
		00 = Matrix A
		01 = Matrix B
		10 – 11 = Reserved
		}
		elseif (Transmit_Diversity = 10)
		{
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		11 = Reserved
		}

Num_layer	2 bits	
for (j = 0; j< Num_layer; j++) {		
if (INC_CID == 1) {		
CQICH_ID	*variable*	Index to uniquely identify the CQICH resource assigned to the SS

		The size of this field is dependent on system parameter defined in DCD.
}		
Layer_index	2 bits	
DIUC	4 bits	0-11 burst profiles
}		
}		

[Add the following text below the table]

Num_Region

This field indicates the number of the regions as defined by OFDMA_Symbol_offset, Subchannel_offset, Boosting, No._OFDMA_Symbols and No._subchannels in this IE.

Matrix_indicator

The values of these three bits indicate the STC matrix (see section 8.4.8.4).

CQICH_ID

This is the CQICH_ID assigned to a SS in the CQICH_Alloc_IE(). The CQICH_ID is used to uniquely identify a SS that is assigned a CQICH.

Num_layer

The values of these 2 bits indicate the number of MIMO transmission layers.

Layer_index

This field specifies the layer index.

[Add the following rows to table 312]

Table 312 DCD channel encodings

Name	Type	Length	Value
Size of CQICH_ID field	17	1	0 = reserved 1 = 3 bits 2 = 4 bits 3 = 5 bits 4 = 6 bits 5 = 7 bits 6 = 8 bits 7 = 9 bits