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Re:	In response to Comment #65, 191, 192, 233 as a combined reply comment	
Abstract	Enhanced MAC Support for MIMO OFDMA	
Purpose	Adoption of proposed changes into P802.16e	
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Enhanced MAC Support for MIMO OFDMA

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1 Motivation

Current standard specification [1] does not provide a clear picture of MIMO operation, particularly with the currently available CQICH feedback. Several recent contributions and comments, including [2], tried to tackle this problem, but still lack in terms of completeness and effectiveness. In this contribution, an effort to make MIMO operation with CQICH more transparent and comprehensive is made. First, we provide MAC support for the two optional permutation zones with the corresponding MAP IE changes in Section 2.1. Then, in Section 2.2, the focus is shifted to the closed-loop MIMO with CQI feedbacks, which a mechanism that enables allocation of multiple CQICH to a MIMO SS is introduced in order to better support mobile MIMO users.

2 Specific Text Changes

2.1 MIMO Enhancements for the optional FUSC and the optional AMC zones

In this subclause, enhancements to MIMO mode for the two optional zones are made and some editorial changes in the MAP IEs are proposed.

[Modify the following section in page 526 of P802.16-REVd/D5.]

8.4.5.3.4 Space-Time Coding (STC)~~Transmit diversity (TD)~~/Zone switch IE format for DL

In the DL-MAP, a BS may transmit DIUC=15 with the STC~~TD~~_ZONE_IE() to indicate that the subsequent allocations shall use a specific permutation, or be STC~~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 permutation and transmit diversity mode it instructs.

Table 277-OFDMA downlink TD_ZONE IE format

Syntax	Size (bits)	Notes
STC~~TD~~_ZONE_IE() {		
Extended DIUC	4	STC~~TD~~/ZONE=0x01
Length	4	Length = 0x02
Permutation	2	00 = PUSC permutation 01 = FUSC permutation 10 = Optional FUSC permutation 11 = Optional adjacent subcarrier permutation
Use All SC indicator	1	0 = Do not use all subchannels 1 = Use all subchannels
STC~~Transmit Diversity~~	2	00 = No STC~~transmit diversity~~ 01 = STC using 2 antennas 10 = STC using 4 antennas 11 = FHDC using 2 antennas

Matrix indicator	2	Antenna STC/FHDC matrix (see 8.4.8) 00 = Matrix A 01 = Matrix B 10 = Matrix C (applicable to 4 antennas only) 11 = Reserved
IDcell	6	
Reserved	3~~2~~	Shall be set to zero
}		

Permutation
Indicates the permutation that shall be used by the transmitter for allocations following this IE. Permutation changes are only allowed on a zone boundary. 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.

STC~~Transmit Diversity~~
Indicates the STC~~Transmit Diversity~~ mode that shall be used by the transmitter for allocations following this IE (see 8.4.8). All allocations without STC~~Transmit Diversity~~ shall be transmitted only from one antenna (antenna 0). All allocations with STC~~Transmit Diversity~~ the BS shall transmit from both its antennas.

[Modify the Table 281 in page 528 of P802.16-REVd/D5.]

8.4.5.3.8 MIMO DL Basic IE Format

Table 281 - 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~~Transmit_divesity~~ = STC~~transmit diversity~~ mode indicated in the latest STC~~TD~~_Zone_IE(). if (STC~~Transmit_diversity~~ ==01) { 00 = Matrix A 01 = Matrix B 10-11 = Reserved }

		elseif (STC~~Transmit_diversity~~ == 10) {
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		11 = 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
}		
}		
}		

[Modify the Table 282 in page 530 of P802.16-REVd/D5.]

8.4.5.3.9 MIMO DL Enhanced IE Format

Table 282 – MIMO DL enhanced IE format

Syntax	Size (bits)	Notes
MIMO_DL_Enhanced_IE() {		
Extended DIUC	4	0x06
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~~Transmit_divesity~~ = STC~~transmit diversity~~ mode indicated in the latest STC~~TD~~_Zone_IE().
		
		if (STC~~Transmit_diversity~~ ==01) {
		00 = Matrix A
		01 = Matrix B
		10-11 = Reserved }
		elseif (STC~~Transmit_diversity~~ == 10) {

		00 = Matrix A 01 = Matrix B 10 = Matrix C 11 = 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
}		
}		
}		

2.2 Fast and dynamic CQICH allocation for MIMO-OFDMA

Due to the inherent latency in decoding of the MAC subheaders, FAST_FEEDBACK allocation should be made at MAP instead of subheaders. In addition, with the current amount of CQI feedback for each CQI-allocated SS, the closed-loop MIMO may not work as intended due to slow adaptation with just 4 bits, that is, the channel measurements and antenna weights can not be adjusted fast enough to account for fast fading. This problem may be alleviated to a certain extent by reducing the required feedback with some efficient feedback mechanism, which would still limit the gain by multiple antennas for a highly mobile SS. The need to allocate multiple CQICH to some certain MIMO capable SS's, therefore, arises. In this contribution we propose a mechanism that enables allocation of multiple CQICHs to a certain SS when conditions are met.

The actual information fed back on CQICH may also be changed from single-input single-output (SISO) cases. In the mandatory FUSC zone for SISO systems, the average DL channel power shall be quantized and its level is fed back on 4-bit CQICH. For MIMO systems in FUSC zones the same DL channel average power shall be fed back for each BS transmit antenna, which may be used to enable rate control for each antenna. In the adjacent-subcarrier zone (or AMC zone), however, instead of the received SNR itself CQICH may deliver the optimum antenna weights for BS antennas which are calculated at SS using DL preambles and shall maximize the received SNR(or SINR) at SS. Some hybrid schemes are also possible for AMC zones. In this sub-clause all the aforementioned features are implemented and their respective changes are noted.

[Modify the Table 296 in Section 84.5.4.10.3 in page 544 of P802.16-REVd/D5.]

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	Closed-loop SM and PUSC/FUSC permutation
0b0101	Closed-loop SM and adjacent-subcarrier permutation
0b0110	Closed-loop SM + Beamforming and adjacent-subcarrier permutation
0b0111	TD + Beamforming and adjacent-subcarrier permutation
0b1000~~0100~~ - 1111	Reserved

[Insert the following section in page 547 of P802.16-REVd/D5.]

8.4.5.4.12.1 CQICH Enhanced Allocation IE Format

Table zzz – CQICH Enhanced allocation IE format

Syntax	Size (bits)	Notes
CQICH_Enhanced_Alloc_IE() {		
Extended DIUC	4	0x09
Length	4	Length in bytes of following fields
CQICH_ID	*variable*	Index to uniquely identify the CQICH resource assigned to the SS
Period (=p)	2	A CQI feedback is transmitted on the CQICH every 2^p frames
Frame offset	3	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	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.
Feedback_type	2	00 = Fast DL measurement 01 = Layer specific channel strengths 10 = Antenna weight associated with specific antenna (See Figure 231) 11 = MIMO mode and permutation zone feedback
CQICH_Num	2	Number of CQICHs assigned to this CQICH_ID is (CQICH_Num +1)
for (i=0;i<CQICH_Num;i++) {		
Allocation index~~offset~~	6	Index to the fast feedback channel region marked by UIUC=0
}		
if (Feedback_type !=11) { MIMO_permutation_feedback cycle }	2	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 permutation 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 permutation 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.
}		

References

[1] IEEE P802.16-REVd/D5-2004 Air Interface For Fixed Broadband Wireless Access Systems

[2] IEEE C802.16d-04/80r1 Leiba et al, MAC Enhancements to Support OFDMA MIMO