Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	Enhanced MAC Support for MIMO OFDMA
Date Submitted	**2004-05-17**
Source(s)	Wonil Roh, Seungjoo Maeng, Jiho Jang, Panyuh Joo, Jaeho Jeon, Soon Young Yoon, Samsung Electronics Co., Ltd. Dong Suwon P.O.Box 105 416, Maetan-3dong, Yeongtong-gu, Suwon-city, Gyeonggi-do, Korea 442-600 wonil.roh@samsung.com Voice: +82-31-279-3868
Re:	Adoption of proposed changes into P802.16e
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

Wonil Roh, Seungjoo Maeng, Jiho Jang,
Panyuh Joo, Jaeho Jeon, Soon Young Yoon

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	5~~3~~	
}		

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 following section 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	
if (Permutation==10 | 11) {		Permutation = Permutation field in STC_Zone_IE()
Pilot_tone_set }	1	Pilot tone set indicator for the optional FUSC and the optional AMC zones (see IEEE C802.16e-04/72r1) 0 = Pilot tone set #0 1 = Pilot tone set #1
Matrix indicator	2	STC matrix (see 8.4.8. 3.4.1~~4~~) STC~~Transmit_diversity~~ = 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
}		
}		
}		

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 two bits indicate the STC matrix (see 8.4.8. 3.4.1~~4~~). All matrices in this MIMO_DL_Basic_IE() shall represent open-loop encoding schemes. When Permutation = 10 or 11 in the STC_Zone_IE() and the following conditions are met, allocation of data subchannels shall be done as follows:
if ((Permutation == 10) & (((STC==01) & (Matrix indicator == 00)) | ((STC==10) & (Matrix =00 | 01)))) {
_two consecutive symbol allocation for data subchannels in the optional FUSC}
elseif ((Permutation == 11) & (((STC==01) & (Matrix indicator == 00)) | ((STC==10) & (Matrix =00 | 01)))) {
_3x2 bin combinations selected in the optional AMC}

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, i.e., per-antenna rate control (PARC). In the adjacent-subcarrier zone (or AMC zone), however, instead of the channel power 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. This technique is often called transmit antenna array (TxAA). Some hybrid schemes of PARC and TxAA are also possible for AMC zone. In this sub-clause all the aforementioned features are implemented and their respective changes are noted.

[Remove the section 6.3.2.2.6 FAST-FEEDBACK allocation subheader in page 43 of P802.16-REVd/D5.]

[Modify the following section 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	
if (Permutation==10 or 11) {		Permutation = Permutation field in STC_Zone_IE()
Pilot_tone_set }	1	Pilot tone set indicator for the optional FUSC and the optional AMC zones (see IEEE C802.16e-04/72r1) 0 = Pilot tone set #0 1 = Pilot tone set #1

Matrix indicator	2	STC matrix (see 8.4.8. 3.4.2~~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 = 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
}		
}		
}		

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 two bits indicate the STC matrix (see 8.4.8.3.4.2~~4~~). All matrices in this MIMO_DL_Enhanced_IE() shall represent closed-loop encoding schemes and shall have different formats for different zones as described in 8.4.8.3.3.2 and 8.4.8.3.4.2.

[Modify the following section in page 544 of P802.16-REVd/D5.]

8.4.5.4.10.3 Mode Selection Feedback

When the Feedback_type is '11'~~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 TxAA) or permutation mode on the assigned Fast-feedback channel. Table XXX3 shows the encoding of payload bits.

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

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	Closed-loop SM and PUSC/FUSC permutation
0101	Closed-loop SM and adjacent-subcarrier permutation
0110	TxAA and adjacent-subcarrier permutation
0111	Hybrid #1 and adjacent-subcarrier permutation
1000	Hybrid #2 and adjacent-subcarrier permutation
1001~~0100~~ - 1111	Reserved

[Modify the following section in page 546 of P802.16-REVd/D5.]

8.4.5.4.12 CQICH Allocation IE Format

Table 298 – CQICH allocation IE format

Syntax	Size (bits)	Notes
CQICH_Alloc_IE() {		
Extended DIUC	4	0x03
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	This field indicates the actual feedback contents. 00 = Fast DL measurement 01 = MIMO channel covariance matrix **RH** 10 = Beamforming weight 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
}		
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.
}		

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.

Feedback type

This field specifies the types of the actual feedback information on CQICH.

CQICH_Num, Allocation index

if (Feedback_type == 00) {
CQICH_Num = number of BS antennas
Allocation_indices are assigned to each numbered BS antennas}
elseif ((Feedback_type == 01)&(STC==01)&(No. SS antennas ==2)) { * STC = STC field in STC_Zone_IE()
CQICH_Num = 4
Allocation_indeces are assigned in the following order in the matrix: (1,1),(1,2),(2,1),(2,2)}
elseif ((Feedback_type == 10) & (STC == 01)) {

CQICH_Num = 1
Allocation index is assigned to 2nd BS antenna}
elseif ((Feedback_type == 10) & (STC == 10)) {
CQICH_Num = 3
Allocation indices are assigned to 2nd, 3rd and 4th antennas }
elseif (Feedback_type == 11) {
CQICH_Num = number of BS antennas
Allocation indices are assigned to the top 2 or 4 modes selected by SS}
end;

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.

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