Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Framework for Enabling Closed-loop MIMO for OFDMA**
Date Submitted	**2004-11-4**
Source(s)	Wonil Roh, JeongTae Oh, Chan-Byoung Chae, Kyunbyoung Ko, Hongsil Jeong, Sung-Ryul Yun, Seungjoo Maeng, Jaeho Jeon, Jaeyeol Kim, Soonyoung Yoon wonil.roh@samsung.com Voice: +82-31-279-3868 **Samsung Electronics Co., Ltd.** Young-Ho Jung, Seung Hoon Nam , Jaehak Chung, Yungsoo Kim, Sung-Jin Kim, Hojin Kim **Samsung Advanced Institute of Technology**
Re:	
Abstract	Framework for Enabling Closed-loop MIMO for OFDMA
Purpose	Adoption of proposed changes into P802.16e ~~Crossed-out indicates deleted text,~~ underlined blue indicates new text change to the Standard
Notice	This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.
Patent Policy and Procedures	The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures (Version 1.0) <http://ieee802.org/16/ipr/patents/policy.html>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, if there is technical justification in the opinion of the standards-developing committee and provided the IEEE receives assurance from the patent holder that it will license applicants under reasonable terms and conditions for the purpose of implementing the standard." Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair <mailto:r.b.marks@ieee.org> as early as possible, in written or electronic form, of any patents (granted or under application) that may cover technology that is under consideration by or has been approved by IEEE 802.16. The Chair will disclose this notification via the IEEE 802.16 web site <http://ieee802.org/16/ipr/patents/notices>.

Framework for Enabling Closed-loop MIMO for OFDMA

1. Introduction

In this contribution, a framework which enables closed-loop MIMO (CL-MIMO) for OFDMA systems is provided. It includes redefinition of CQICH feedback mechanism, the required changes of payload, and clarification of precoding operation and the necessary text changes on the relevant sections in the standard.

2. MIMO Related Basic Capabilities

When SS reports its capabilities through the SBC_REQ message, it should be allowed to report all its MIMO capabilities, including closed-loop ones if any.

[Note to the Editor:
Please note that the following TLV subsections are missing in the current draft standard. They were accepted by WG at Sep. meeting in Seoul (C802.16e-04/362r3) and reproduced here to help the Editor to reflect the necessary changes on the standard. The changes suggested at this document are indicated in the conventional way]

[Insert the following sections as indicated]

11.8.3.7.6 OFDMA SS Demodulator for MIMO Support

This field indicates the MIMO capability of OFDMA SS demodulator. A bit value of 0 indicates "not supported" while 1 indicates "supported".

Type	Length	Value	Scope
155	1	Bit #0 Two receive antennas Bit #1 Three receive antennas Bit #2 Four receive antennas Bit #3 Capable of transmit diversity Bit #4 Capable of spatial multiplexing Bit #5-#7 Always set to zero	SBC-REQ (See 6.3.2.3.23) SBC-RSP (See 6.3.2.3.24)

11.8.3.7.7 OFDMA SS Closed-Loop Feedback Demodulator for MIMO Support

This field indicates the closed-loop MIMO capability of OFDMA SS demodulator. A bit value of 0 indicates "not supported" while 1 indicates "supported".

Type	Length	Value	Scope

156	1	Bit #0 Capable of calculating precoding weight Bit #1 Capable of adaptive rate feedback Bit #2 Capable of calculating channel matrix Bit #3-#7 Always set to zero	SBC-REQ (See 6.3.2.3.23) SBC-RSP (See 6.3.2.3.24)

11.8.3.7.8 OFDMA SS Modulator for MIMO Support

This field indicates the MIMO capability of OFDMA SS modulator. A bit value of 0 indicates "not supported" while 1 indicates "supported".

Type	Length	Value	Scope
15~~5~~7	1	Bit #0 Two transmit antennas Bit #1 Capable of transmit diversity Bit #2 Capable of spatial multiplexing Bit #3 Capable of beamforming Bit #4 Capable of adaptive rate control Bit #5-#7 Always set to zero	SBC-REQ (See 6.3.2.3.23) SBC-RSP (See 6.3.2.3.24)

3. Clarification on CQICH Signaling for CL-MIMO

[Note to the Editor:
Please note that the following subsections are missing in the current draft standard. They were accepted by WG at Sep. meeting in Seoul (C802.16e-04/362r3) and reproduced here to help the Editor to reflect the necessary changes on the standard. The additional changes suggested at this document are indicated in the conventional way]

[Modify the following sections as indicated]

8.4.5.4.10.6 Fast MIMO feedback for enhanced FAST_FEEDBACK channel

When the FAST_FEEDBACK subheader Feedback Type field is '01' or '10', or the CQI Feedback Type field in the MIMO Compact DL-MAP IE() (see 6.3.2.3.43.6.7) is 001, or the CQI Type field in CQICH_Enhanced_Alloc_IE() (see 8.4.5.4.12.1) is 001, the SS shall report the MIMO coefficient the BS should use for best DL reception (see 8.4.8.1.6). The mapping for the complex weights is shown in Figure 230c. For this type of feedback, if *N* is the number of BS transmit antennas, then *(N-1)* CQICH shall be allocated to the SS and SS shall report the desired antenna weights of antenna 1 through *N-1* based on antenna 0.

[Remove the following section as indicated]

~~**8.4.5.4.10.7 Mode Selection Feedback for enhanced FAST_FEEDBACK channel**~~

~~For 5 bit payload case, when the FAST_FEEDBACK subheader Feedback Type field is '11' or at a specific frame indicated in the CQICH_Alloc_IE(), or when the Type field is '010' in CQICH_Enhanced_Alloc_IE() and MIMO Compact DL-MAP 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 294c shows the encoding of payload bits for the enhanced FAST_FEEDBACK slot with 5 bit payload.~~

~~Table 294c—Encoding of payload bits for Fast-feedback slot with 5 bit payload~~

~~Value~~	~~Description~~
~~0b00000~~	~~STTD and PUSC/FUSC permutation~~
~~0b00001~~	~~STTD and adjacent subcarrier permutation~~
~~0b00010~~	~~SM and PUSC/FUSC permutation~~
~~0b00011~~	~~SM and adjacent subcarrier permutation~~
~~0b00100~~	~~Hybrid and PUSC/FUSC permutation~~
~~0b00101~~	~~Hybrid and adjacent subcarrier permutation~~
~~0b00110~~	~~Beamforming and adjacent subcarrier permutation~~
~~0b00111~~	~~Closed loop SM and PUSC/FUSC permutation~~
~~0b01000~~	~~Closed loop SM and adjacent subcarrier permutation~~
~~0b01001 – 0b11111~~	~~Reserved~~

[Modify the following section as indicated]

8.4.5.4.10.8 MIMO related Type Independent Feedback for enhanced FAST_FEEDBACK channel

For 6 bit payload case, MIMO related feedback shall be encoded as is shown in Table 294d regardless of feedback type.

Table 296d —Encoding of payload bits for MIMO related Type Independent Feedback with 6 bit payload

Value	Description
0b101000	STTD and PUSC/FUSC permutation
0b101001	STTD and adjacent-subcarrier permutation
0b101010	SM and PUSC/FUSC permutation
0b101011	SM and adjacent-subcarrier permutation
0b101100	Hybrid and PUSC/FUSC permutation
0b101101	Hybrid and adjacent-subcarrier permutation
0b101110	~~Beamforming and adjacent subcarrier permutation~~ Closed-loop Precoding and adjacent subcarrier permutation
0b101111	~~Closed loop SM and PUSC/FUSC permutation~~ Antenna Group A1 for rate 1 For 3-antenna BS, See 8.4.8.3.4 For 4-antenna BS, See 8.4.8.3.5
0b110000	~~Closed loop SM and adjacent subcarrier permutation~~ Antenna Group A2 for rate 1
0b110001	Antenna Group A3 for rate 1

0b110010	Antenna Group B1 for rate 2 For 3-antenna BS, See 8.4.8.3.4 For 4-antenna BS, See 8.4.8.3.5
0b110011	Antenna Group B2 for rate 2
0b110100	Antenna Group B3 for rate 2
0b110101	Antenna Group B4 for rate 2 (only for 4-antenna BS)
0b110110	Antenna Group B5 for rate 2 (only for 4-antenna BS)
0b110111	Antenna Group B6 for rate 2 (only for 4-antenna BS)
0b111000 - 0b111111	Reserved

[Modify the following section as indicated]

8.4.5.4.15 CQICH Enhanced Allocation IE Format

CQICH_Enhanced_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_Enhanced_Alloc_IE() to de-allocate the assigned CQICH.

Table 298a. CQICH Enhanced allocation IE format

Syntax	**Size (bits)**	**Notes**
CQICH_Enhanced_Alloc_IE() {		
Extended ~~D~~UIUC	4	0x09
Length	4	Length in bytes of following fields
CQICH_ID	variable	Index to uniquely identify the CQICH resource assigned to the MSS
Period (=p)	2	A CQI feedback is transmitted on the CQICH every 2^p frames
Frame offset	3	The MSS 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 MSS 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 CQICH is de-allocated. If d == 111, the MSS should report until the BS command for the MSS to stop.
~~N_t actual BS antennas~~	~~3~~	~~001 = Reserved~~ ~~010 = 2 actual antennas~~ ~~011 = 3 actual antennas~~ ~~100 = 4 actual antennas~~ ~~101 = 5 actual antennas~~

		~~110 = 6 actual antennas~~ ~~111 = 7 actual antennas~~ ~~000 = 8 actual antennas~~
~~Feedback_type~~	~~3~~	~~000 = Fast DL measurement/Default Feedback~~ ~~001 = Precoding weight matrix information~~ ~~010 = Channel matrix H~~ ~~011 = MIMO mode and permutation zone~~ ~~100 = Open loop precoding~~ ~~101–111 = Reserved~~
CQICH_Num	4	Number of CQICHs assigned to this CQICH_ID is (CQICH_Num +1)
for (i=0;i<CQICH_Num;i++) {		
Feedback_type	3	000 = Fast DL measurement/Default Feedback 001 = Precoding Weight Matrix Information 010 = Channel Matrix Information 011 = Adaptive Rate Control Information 100 = Antenna Selection Index 101 - 111 = Reserved
Allocation index	6	Index to the fast feedback channel region marked by UIUC=0
}		
~~if ((Feedback_type != 011) & (! 6-bit CQICH)) {~~ ~~MIMO_permutation_feedback cycle }~~	~~2~~	~~This field exists only for 4-bit and 5-bit CQI payload.~~ ~~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 are used to ensure the IE size is integer number of bytes.
}		

Feedback Type
For 4-bit ~~or 5-bit~~ CQI payload, the type dependent feedback in 16 ~~or 32~~ levels shall be feedback~~, respectively~~. For 6-bit CQI payload, however, the MSB of 6-bit payload from a SS is the indicator of the usage for the remaining 5 LSB~~bit~~s. When the MSB is set to '0' with 6-bit payload, the following 5-bit payload shall be used for the type dependent feedback, and '1' indicates the following 5-bit payload shall be used for type independent feedback in Table 294d.

4. MIMO Precoding

[Modify the following section as indicated]

8.4.8.3.6 MIMO Precoding

The space time coding output can be weighted by a matrix before mapping onto transmit antennas:

$$z = Wx,$$

where x is a $M_t \times 1$ vector with the output from the space-time coding (per-subcarrier), M_t is the number of ~~antennas~~streams at the output of the space-time coding scheme. The matrix W is an $N_t \times M_t$ weighting matrix where the quantity N_t is the number of actual transmit antennas. The vector z contains the signals after weighting for the different actual antennas. The labeling of the elements in the weighting matrix W is performed in accordance with the example of W given below for the case of 4 actual antennas and 2 space-time coding output ~~antennas~~streams:

$$W = \begin{bmatrix} w_{11} & w_{12} \\ w_{21} & w_{22} \\ w_{31} & w_{32} \\ w_{41} & w_{42} \end{bmatrix}$$

In adjacent subcarrier permutation zone, when midamble in 8.4.8.5 is present in the frame, pilot subcarriers within the allocated burst may or may not be precoded with the matrix W. When the midamble is not present in the frame, however, pilot subcarriers within the allocated burst shall not be precoded. For the case of un-precoded pilots, the information on W shall be transmitted to SS through the DL MAP burst allocation IE.

References:

[1] IEEE P802.16-REVd/D5-2004 Draft IEEE Standards for local and metropolitan area networks part 16: Air interface for fixed broadband wireless access systems

[2] IEEE P802.16e/D5 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

,