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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
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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. A suite of solutions is described in this document in order to cover various channel conditions and operational scenarios. The suite of solutions includes antenna selection, antenna grouping, vector/matrix codebooks, and direct channel coefficient feedback. 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.

The organization of the contribution is shown as follows

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.

[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 control Bit #2 Capable of calculating channel matrix Bit #3 Capable of antenna grouping Bit #4 Capable of antenna selection Bit #5 Capable of code book based precoding Bit #6-7 Reserved.	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)

[End of 'Insert the following sections as indicated']

3. CQICH Signaling for CL-MIMO

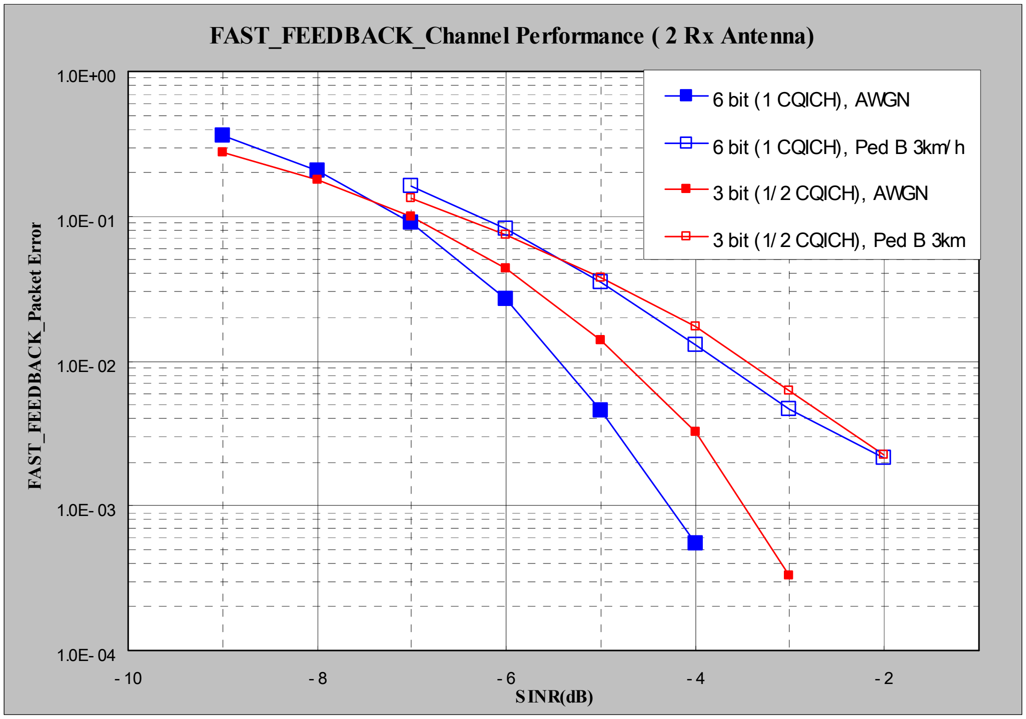
In this section a three-bit feedback scheme using a half of CQICH is proposed. Each 3bit-MIMO Fast feedback consists of a half CQICH slot mapped in a manner similar to the mapping of ACK Channel. The 3-bit fast feedback slot uses QPSK modulation on the 24 data sub-carriers it contains, and can carry a data payload of 3 bits. Table 1 defines the mapping between the payload bit sequences and the subcarriers modulation for 3 bit payload.

Table 1—3bit-MIMO Fast-feedback channel subcarrier modulation

3 bit payload	Fast Feedback vector indices per Tile Even = {Tile(0), Tile(2),Tile(4)} or Odd = {Tile(1), Tile(3),Tile(5)}
0b000	0,0,0
0b001	1,1,1
0b010	2,2,2
0b011	3,3,3
0b100	4,4,4
0b101	5,5,5
0b110	6,6,6

0b111	7,7,7

Figure 1 Channel Performance of 3-bit CQICH



[Modify Section 8.4.5.4.10.4 as indicated in the following]

8.4.5.4.10.4 ~~Optional~~ Enhanced FAST FEEDBACK Channels

Enhanced Fast feedback slots may be individually allocated to an MSS for transmission of PHY related information that requires fast response from the MSS. The allocations are done either in a unicast manner through the FAST_FEEDBACK MAC subheader (see 6.3.2.2.6), or through the CQICH_Control IE() (see 6.3.2.3.43.5), or through the CQICH_Alloc_IE() (see 8.4.5.4.12), or through the CQICH_Enhanced_Alloc_IE() (see 8.4.5.4.12.1), or through the MIMO Compact DL-MAP IE() (see 6.3.2.3.43.6.7), and the transmission takes place in a specific UL region designated by UIUC = 0.

Each enhanced 3bit-MIMO Fast-feedback slot consists of 1/2 OFDMA slots mapped in a manner similar to the mapping of ACK Channel. An enhanced Fast-feedback slot uses QPSK modulation on the 24 data sub-carriers it contains, and can carry a data payload of 3 bits. Table xxx defines the mapping between the payload bit sequences and the subcarriers modulation.

Table xxx—3bit-MIMO Fast-feedback channel subcarrier modulation

3 bit payload	Fast Feedback vector indices per Tile Even = {Tile(0), Tile(2),Tile(4)} or Odd = {Tile(1), Tile(3),Tile(5)}
0b000	0,0,0
0b001	1,1,1
0b010	2,2,2
0b011	3,3,3

0b100	4,4,4
0b101	5,5,5
0b110	6,6,6
0b111	7,7,7

Each enhanced Fast-feedback slot consists of 1 OFDMA slots mapped in a manner similar to the mapping of normal uplink data. An enhanced Fast-feedback slot uses QPSK modulation on the 48 data sub-carriers it contains, and can carry a data payload of 6 bits. Table 296a defines the mapping between the payload bit sequences and the subcarriers modulation.

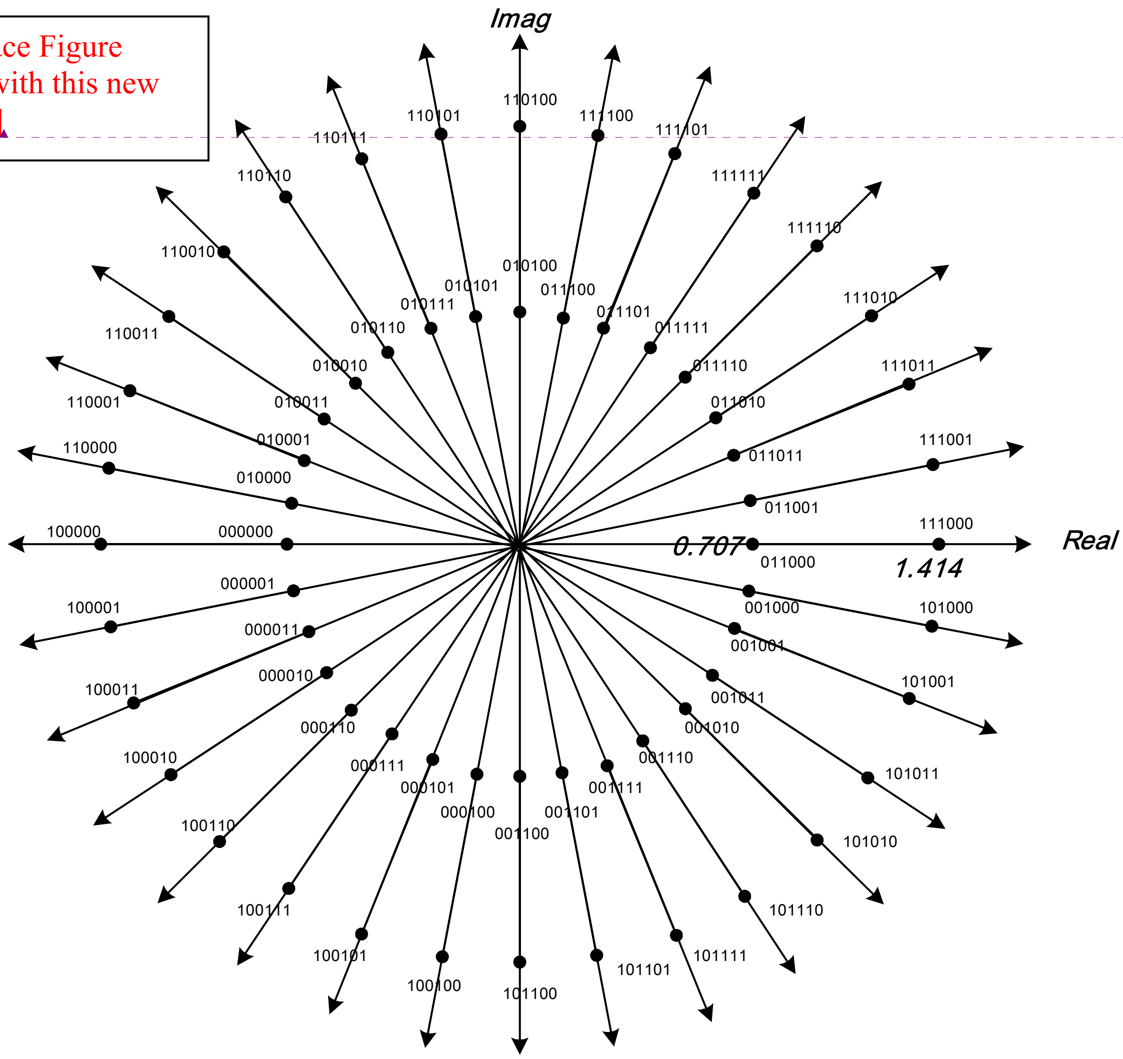
[Modify Section 8.4.5.4.10.6 as suggested in the following]

8.4.5.4.10.6 Fast MIMO Feedback of Quantized Precoding Weight 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 011, or the CQI Feedback Type field in CQICH_Enhanced_Alloc_IE() (see 8.4.5.4.1512.1) is 011, the MSS 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 231c, and the SS shall construct the 6 CQI bits with 0 as the MSB and the mapped code as the remaining LSBs. 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.

Figure 231c - Mapping of MIMO coefficients for quantized precoding weight for enhanced fast MIMO feedback payload bits

[Replace Figure 231c with this new figure]



[Replace Section 8.4.5.4.10.7 with the following]

8.4.5.4.10.7 MIMO Mode Feedback for Enhanced FAST_FEEDBACK channel

When the enhanced FAST FEEDBACK channel is employed, the SS may report the MIMO mode feedback on the assigned CQICH when the FAST_FEEDBACK subheader Feedback Type field is ‘00’, or the CQI Feedback Type field in the MIMO Compact DL-MAP IE() (see 6.3.2.3.43.6.7) is 000, 001, or 010, or the CQI Feedback Type field in CQICH_Enhanced_Alloc_IE() (see 8.4.5.4.15) is 000, 001, or 010. The encoding of payload bits is shown in Table 296d.

Table 296d —Encoding of payload bits for MIMO Mode Feedback with Enhanced FAST FEEDBACK Channel

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
0b101110-0b110110	Interpretation according to table 296e, 296f or 296g, depending on if antenna grouping, antenna selection or a reduced precoding matrix code book is used.
0b110111	Closed loop precoding with 1 stream.
0b111000	Closed loop precoding with 2 streams.
0b111001	Closed loop precoding with 3 streams.
0b111010	Closed loop precoding with 4 streams.
0b111011 - 0b111111	Reserved

Clarification of streams concept:
The number of streams is the number of outputs from the space-time code.

Table 296e —Interpretation of code words 0b101110-0b110110 in Table 296d in the case of using antenna grouping

Value	Description
0b101110	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
0b101111	Antenna Group A2 for rate 1
0b110000	Antenna Group A3 for rate 1
0b110001	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
0b110010	Antenna Group B2 for rate 2
0b110011	Antenna Group B3 for rate 2
0b110100	Antenna Group B4 for rate 2 (only for 4-antenna BS)
0b110101	Antenna Group B5 for rate 2 (only for 4-antenna BS)
0b110110	Antenna Group B6 for rate 2 (only for 4-antenna BS)

Table 296f —Interpretation of code words 0b101110-0b110110 in Table 296d in the case of using antenna selection

Value	Description
0b101110	Antenna selection option 0
0b101111	Antenna selection option 1
0b110000	Antenna selection option 2
0b110001	Antenna selection option 3
0b110010	Antenna selection option 4
0b110011	Antenna selection option 5
0b110100	Antenna selection option 6

0b110101	Antenna selection option 7
0b110110	Reserved

Table 296g —Interpretation of code words 0b101110-0b110110 in Table 296d in the case of using reduced precoding matrix code book

Value	Description
0b101110	Reduced Precoding matrix code book entry 0
0b101111	Reduced Precoding matrix code book entry 1
0b110000	Reduced Precoding matrix code book entry 2
0b110001	Reduced Precoding matrix code book entry 3
0b110010	Reduced Precoding matrix code book entry 4
0b110011	Reduced Precoding matrix code book entry 5
0b110100	Reduced Precoding matrix code book entry 6
0b110101	Reduced Precoding matrix code book entry 7
0b110110	Reserved

[End of "Replace Section 8.4.5.4.10.7 with the following"]

[Remove the entire Section 8.4.5.4.10.8]

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 .

Table 297 —Encoding of payload bits for MIMO feedback with 6 bit payload

Value	Description
0b101000	STC and PUSC/FUSC permutation
0b101001	STC and adjacent-subcarrier permutation
0b101010	SM and PUSC/FUSC permutation
0b101011	SM and adjacent-subcarrier permutation
0b101100	Closed-loop SM and PUSC/FUSC permutation
0b101101	Closed-loop SM and adjacent-subcarrier permutation
0b101110	Hybrid and PUSC/FUSC permutation
0b101111	Hybrid and adjacent-subcarrier permutation
0b110000	Beamforming and adjacent-subcarrier permutation
0b110001	Antenna Group A For 3-antenna BS, 00 = Antenna group 0,1 & 0,2 For 4-antenna BS, 00 = Antenna group 0,1 & 2,3
0b110010	Antenna Group BFor 3-antenna BS, 00 = Antenna group 0,1 & 1,2 For 4-antenna BS, 00 = Antenna group 0,2 & 1,3

0b110011	Antenna Group CFor 3-antenna BS, 00 = Antenna group 0,2 & 1,2 For 4-antenna BS, 00 = Antenna group 0,3 & 1,2
0b110100 – 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. This IE shall only be used with enhanced FAST FEEDBACK channel in 8.4.5.4.10.4. Once allocated, the SS transmit feedback information of the specified type on the assigned CQICH with the determined period, 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 UDIUC	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)	24	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.
NT 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+1;i++) {		
Feedback_type	3	000 = Fast DL measurement/Default Feedback with antenna grouping

		001 = Fast DL measurement/Default Feedback with antenna selection 010 = Fast DL measurement/Default Feedback with reduced code book 011 = Quantized precoding weight feedback 100 = Index to precoding matrix in code book 101 = Channel Matrix Information 101 = Per stream power control 110 = Adaptive bit loading 111 = Reserved
Allocation index	6	Index to the fast feedback channel region marked by UIUC=0
CQICH Type	2	00 = 6 bit CQI, 01 = DIUC-CQI, 10 = 3 bit CQI (even), 11 = 3 bit CQI(odd)
}		
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 feedback types 000-010 it instructs the SS to transmit the feedback of the specified type using the 5 LSBs on its assigned CQICH as in Table 296d. In this case the MSB is set to 0. In addition, for feedback types 000-010, the SS may transmit, on its assigned CQICH, the feedback information specified in 8.4.5.4.10.7. 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 bits. 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

[Add section 6.3.2.3.59]

6.3.2.3.59 MIMO precoding setup/tear-down

The BS can setup longterm precoding with feedback from a particular SS by sending the MAC-manage message PRC-LT-CTRL to the SS. The BS can also use the same MAC-management message to tear-down the longterm precoding with feedback.

The precoding feedback delay of the base station, in number of frames, should be signaled from the BS to the SS in the PRC-LT-CTRL MAC-management message.

Table 108a – Setup/Tear-down of long term MIMO precoding (PRC-LT-CTRL) message format

Syntax	Size	Notes
PRC-LT-CTRLformat(){		
Management message type = 64	8 bits	
Setup/Tear-down long term precoding with feedback	1 bit	1=Turn on 0=Turn off
BS precoding application delay	2 bits	k, delay in number of frames beyond the minimal delay of 1 frame for when precoding information fed back from the SS to the BS can or will be applied.
}		

[End of adding text]

[Modify Section 6.3.2.3 MAC Management messages]

[Add row to Table 14a, MAC Management messages according to the Table below:]

[Row to be added to Table 14a—MAC Management messages]

Type	Message description	Connection
64	Setup/Tear-down of long term MIMO precoding	Basic

[End of Modification to Section 6.3.2.3 MAC Management messages]

[Modify the following table at the end of section 6.3.2.1.4.1]

Table 7b. Feedback Type and feedback content.

Feedback Type	Feedback contents	Description
0b0000	Set as described in table 296d.	MIMO mode and permutation. Feedback
0b0001	DL average CQI (5bits)	5 bits CQI feedback
0b0010	Number of index, L (2 bits) + L occurrences of Antenna index (2 bits) + MIMO coefficients (5 bits, 8.4.5.4.10.6)	MIMO coefficients feedback
0b0011	Preferred-DIUC (4 bits)	Preferred DL channel DIUC feedback
0b0100	UL-TX-Power (7 bits) (see table 7a)	UL transmission power
0b0101	Preferred DIUC(4 bits) + UL-TX-Power(7 bits) + UL-headroom (6 bits) (see Table 7a)	PHY channel feedback
0b0110	Number of bands, N (2 bits) + N occurrences of ‘band index (6 bits) + CQI (5 bits)’	CQIs of multiple AMC bands
0b0111	Number of feedback types, O (2 bits) + O occurrences of ‘feedback type (4bits) + feedback content (variable)’	Multiple types of feedback
0b01000	Feedback of index to long term precoding matrix in code book (6 bits), rank of precoding code book (2 bits) and FEC and QAM feedback (6 bits) according to Table Z.	Long term precoding feedback
0b01001	Life span of short term precoding feedback (2 bits) according to Table Z.	The recommended number of frames the short term precoding feedback can be used for.
0b1001-0b1111	Reserved for future use	

[End of "Modify the following table at the end of section 6.3.2.1.4.1"]

[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:

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

Short term closed loop precoding:

When Mt=1, then single stream precoding or beamforming shall be applied with the vector W of dimension $N_t \times 1$. The transmission scheme before the precoder is the regular single antenna transmission. When Mt=2, 3 or 4, then the two, three or four STC output streams shall be transmitted with the 2, 3 or 4 Tx pure spatial multiplexing transmission scheme with a precoding matrix of dimension $N_t \times 2$, $N_t \times 3$ or $N_t \times 4$.

Long term closed loop precoding

The rank of the precoding matrix is indicated in the long term precoding feedback from the SS. The number of columns in the precoding matrix equals its rank. The STC scheme used, Matrix A, B or C, is selected from the set of STC schemes associated with the number of transmit antennas equaling the rank of the long term precoding matrix used. For example, if the rank of the long term precoding matrix is 2 and the spatial rate used is 1 then the Matrix A scheme for 2 Tx antennas is used.

When the long term closed loop precoding is turned on, the life span of short term precoding information, the rank of the long term precoding code book used and the index to the precoding matrix in the specified long term precoding code book is fed back with MAC-header feedback messages 0b0000 and 0b0001. If a short term precoding matrix is available, the BS shall use this short term matrix. If not, the BS shall use the fed back long term precoding matrix, if available.

Table Z – Feedback for long term precoding in MAC feedback header message

MAC-header feedback type bit indication	Feedback element	Number of bits	Description
0b01000	Feedback of index to long term precoding matrix in code book	6	Index to long term precoding matrix element in code book
0b01000	Rank of precoding code book	2	k, Rank of precoding code book = k+1
0b01000	FEC and QAM feedback	6	FEC and QAM specification

Precoding state feedforward and precoding application delay

If the precoding state is not fed forward in the DL burst allocation IE, then the BS shall apply precoding according to the precoding feedback from the SS (antenna grouping, antenna selection or code book based) with a predetermined number of frames delay.

[End of modification of the following section as indicated]

5. MIMO Precoding Operation for H-ARQ MAP

Some clarification is made on burst mapping for H-ARQ when multiple MIMO layers are transmitted on the same physical resource. The multiple layer transmission is enabled when spatial multiplexing (SM) schemes are employed with multiple modulation and coding blocks implemented for each spatial layer. We call it horizontal encoding (HE) and this mode enables adaptive rate control for each spatial layer. The other class of spatial multiplexing schemes is called vertical encoding (VE) and it features a common modulation and coding block. Transmit diversity (TD) can be also regarded as single layer technique. Figure 2 shows an example of 2x2 VE MIMO system, whereas Figure 3 illustrates that of 2x2 HE MIMO system. In both figures, L equals the number of layers, Mt the number of STC output streams, Nt the number of BS transmit antennas, and W denotes the precoding matrix. Their relations according to the current standard are tabularized in Table 1.

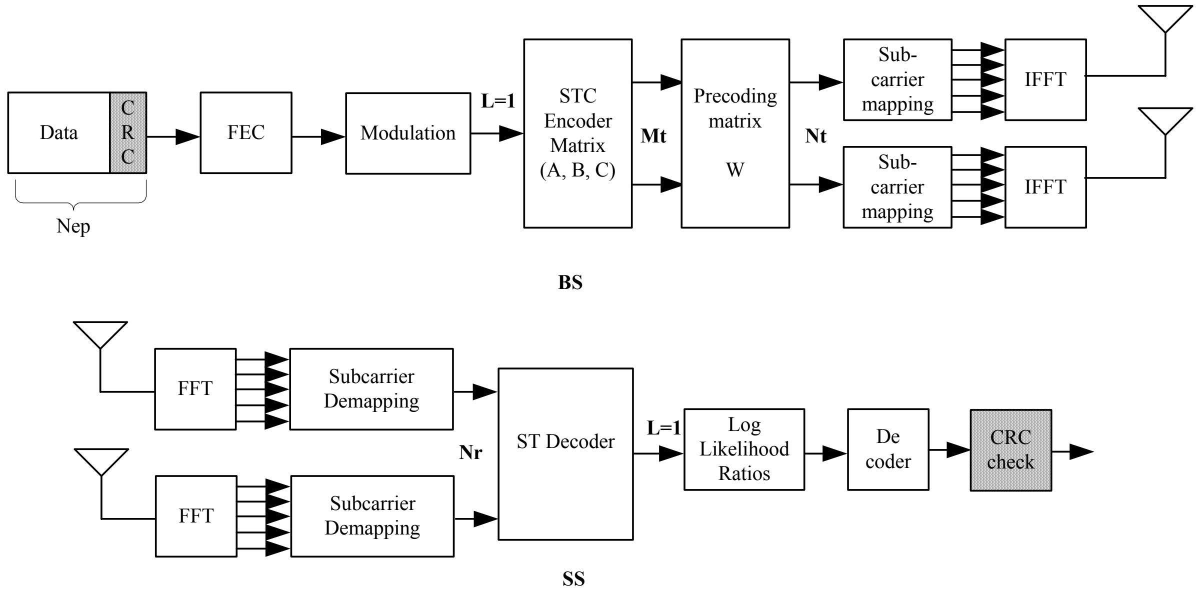


Figure 2 H-ARQ Enabled Vertically Encoded 2x2 MIMO System

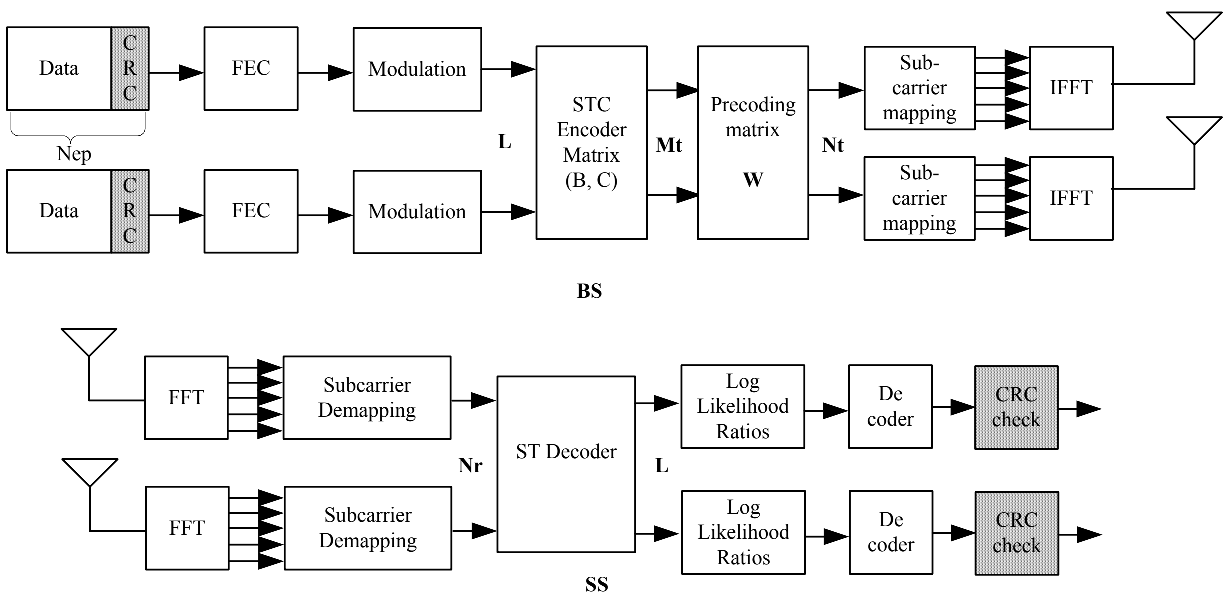


Figure 3 H-ARQ Enabled Horizontally Encoded 2x2 MIMO System

Layer = 1 (TD or VE only)				L = 2 (HE only)			L = 3 (HE only)		L = 4 (HE only)
Mt=1	**2**	**3**	**4**	**Mt=2**	**3**	**4**	**Mt=3**	**4**	**Mt=4**
AAS	A (TD)	A (TD)[1]	A (TD)[1]						
		B (VE)[1]	B (VE)[1]		B (HE)[1]	B (HE)[1]			
	C (VE)	C (VE)	C (VE)	C (HE)			C (HE)		C (HE)

Table 1 Clarification on Layer, Mt and Matrix

In both Figure 1 and Figure 2, when there is no precoding matrix at Tx, Mt becomes the number of transmit antennas. In Table 1, the existing open-loop matrices (A, B, or C) are noted and the superscript [1] indicates the applicability of the antenna grouping technique.

[Replace the following table in Section 6.3.2.3.43.6.7 as follows]

6.3.2.3.43.6.7 MIMO Compact DL MAP IE format

Table 99a—MIMO Compact DL-MAP IE format

Syntax	Size (bits)	Notes
MIMO_Compact_DL-MAP_IE() {		
_Compact DL-MAP Type	3	Type = 7
_DL-MAP Sub-type	5	MIMO = 0x01
_Length	4	Length of the IE in Bytes
_MIMO_Type	2	Type of MIMO Mode 00 = Open-loop 01 = Antenna Grouping 10 = Antenna Selection 11 = Closed-loop code book based precoding
_Num_layer	2	Number of multiple coding/modulation layers 00 – 1 layer 01 – 2 layers 10 – 3 layers 11 – 4 layers
_Mode_Change	1	Indicates Change of MIMO Mode 0 = No change from previous allocation 1 = Change of MIMO Mode
_If (Mode_Change) {		
___Matrix Indicator	2	Indicates open-loop matrix (See 8.4.8.3) 00 = Matrix A (Transmit Diversity) 01 = Matrix B (Hybrid scheme. Applicable only for 3 and 4 antennas) 10 = Matrix C (Pure Spatial Multiplexing) 11 = Reserved
___Feedforward_precoding_state	1	0 – Don't feed forward the precoding state. The precoding feedback from SS is applied by the BS after the precoding application delay. 1 – Feed forward the precoding state. The BS can apply arbitarty precoding.
___If (Feedfoward_precoding_state){		
____Mt	2	Indicates number of STC output streams 00 = 1 stream 01 = 2 streams 10 = 3 streams 11 = 4 streams
____if (MIMO_Type == 01) {		
______Antenna Grouping Index }	4	Indicates the index of antenna grouping See 8.4.8.3.4 and 8.4.8.3.5
____if (MIMO_Type == 10) {		

Antenna Selection Index }	4	Indicates the index of antenna selection See 8.4.8.3.4 and 8.4.8.3.5
if (MIMO_Type == 11) {		
Code book precoding matrix index }	12	Indicates the index of precoding matrix W in code book.
}		
}		
for (j=1;j<Num_layer+1; j++) {		This loop specifies the Nep for layers 2 and above when required for STC. The same Nsch and RCID applied for each layer

if (H-ARQ Mode =CTC Incremental Redundancy) {
Nep }
elseif (H-ARQ Mode = Generic Chase) {
DIUC
}
	4	H-ARQ Mode is specified in the H-ARQ Compact_DL-MAP IE format for Switch H-ARQ Mode.

if (CQICH indicator == 1) {		CQICH indicator comes from the preceding Compact DL-MAP IE
Allocation Index }	6	Index to CQICH assigned to this layer. For the multi-layer MIMO transmission, the feedback type for this CQICH and that of the preceding Compact DL-MAP IE shall be 000.
}		
CQICH_Num	4	The number of additional CQICHs allocated to this SS. (0 – 15 CQICHs)
If (CQICH_Num != 0) {		
Feedback_type	3	Type of contents on CQICH for this SS 000 = Fast DL measurement/Default Feedback with antenna grouping 001 = Fast DL measurement/Default Feedback with antenna selection 010 = Fast DL measurement/Default Feedback with reduced code book 011 = Quantized precoding weight feedback 100 = Index to precoding matrix in code book 101 = Channel Matrix Information 101 = Per stream power control 110 = Adaptive bit loading 111 = Reserved
Period (p)	4	Period of the additional (CQICH_Num) CQI channels in frame
for (i=0;i<CQICH_Num;i++) {		
Allocation index	6	Index to uniquely identify the additional CQICH resources assigned to the SS
CQICH Type	2	00 = 6 bit CQI 01 = DIUC-CQI 10 = 3 bit CQI (even) 11 = 3 bit CQI(odd)
}		
}		
Padding	variable	The padding bits are used to ensure the IE size is integer number of bytes
}		

[Modify the following text in line 1 through line 30 in page 43 as follows]

Mt
This field indicates the number of streams at the STC output if STC is deployed. The single stream precoding or AAS shall be enabled with Mt=00, Num_layer=00 and MIMO_Type=11.

Precoding Index
This field indicates the index of precoding matrix which is being used in the current burst.

Matrix Indicator
This field indicates MIMO matrix for the burst.
~~For 2-antenna BS, 00 = Matrix A; 01 = Matrix B; 10-11 = Reserved.~~
~~For 3-antenna BS, 00 = Matrix A; 01 = Matrix B; 10 = Matrix C; 11 = Reserved.~~
~~For 4-antenna BS, 00 = Matrix A; 01 = Matrix B; 10 = Matrix C; 11 = Reserved.~~

```
if (Num_layer=1) {
   if (Mt = 1) {
      SISO or AAS mode}
   elseif (Mt = 2) {
      00 = A (TD); 01 = C (VE); 10 – 11 = Reserved}
   elseif (Mt = 3) {
      00 = A (TD); 01 = B (VE); 10 = C (VE); 11 = Reserved}
   elseif (Mt = 4) {
      00 = A (TD); 01 = B (VE); 10 = C (VE); 11 = Reserved}
}
elseif (Num_layer = 2) {
   if (Mt = 2) {
      00 = C (HE); 01 – 11 = Reserved}
   elseif (Mt = 3) {
      00 = B (HE); 01 – 11 = Reserved}
   elseif (Mt = 4) {
      00 = B (HE); 01 – 11 = Reserved}
}
elseif (Num_layer = 3) {
   if (Mt = 3) {
      00 = C (HE); 01 – 11 = Reserved}
}
elseif (Num_layer = 4) {
   if (Mt = 4) {
      00 = C (HE); 01 – 11 = Reserved}
}
```

TD means transmit diversity;
VE means vertical encoding (see 8.4.8.3)
HE means horizontal encoding (see 8.4.8.3)

Antenna Grouping Index
This field indicates antenna grouping index for the current burst. For the actual description of the following matrices, see 8.4.8.3.4 and 8.4.8.3.5.

```
if (Num_layer=1) {
   if (Mt = 3) {
      0000 = A1; 0001 = A2; 0010 = A3;
      0011 = B1 (VE); 0100 = B2 (VE); 0101 = B3 (VE);
      0110-1111 = Reserved}
   elseif (Mt = 4) {
      0000 = A1; 0001 = A2; 0010 = A3;
      0011 = B1 (VE); 0100 = B2 (VE); 0101 = B3 (VE); 0110 = B4 (VE); 0111 = B5 (VE); 1000 = B6 (VE);
      1001-1111 = Reserved}
}
```

elseif (Num_layer = 2) {
  if (Mt = 3) {
    0000 = B1 (HE); 0001 = B2 (HE); 0010 = B3 (HE);
    0011-1111 = Reserved}
  elseif (Mt = 4) {
    0000 = B1 (HE); 0001 = B2 (HE); 0010 = B3 (HE); 0011 = B4 (HE); 0100 = B5 (HE); 0101 = B6 (HE);
    0110-1111 = Reserved}}

Antenna Selection Index
This field indicates antenna selection index for the current burst. For the actual description of the following matrices, see 8.4.8.3.4 and 8.4.8.3.5.

CQI Feedback Type
For feedback types 000-010 it instructs the SS to transmit the feedback of the specified type using the 5 LSBs on its assigned CQICH as in Table 296d. In this case the MSB is set to 0. In addition, for feedback types 000-010, the SS may transmit, on its assigned CQICH, the feedback information specified in 8.4.5.4.10.7. ~~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 bits. 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.~~

Period (p)
For the additional CQICH whose number is specified by CQICH_Num, the feedback whose type is specified by CQI_Feedback_type is transmitted on each CQICH in every 2^p frames. The same Frame offset and Duration (d) as specified in the preceding Compact DL-MAP IE shall be applied to the additional (CQICH_Num) CQI channels.

Allocation Index
It indicates its position from the start of the CQICH region.

For each layer, a codeword shall be constructed according to 8.4.9.2.3.5 with the Nep and Nsch combination and mapped onto the corresponding layer. Multiple codewords from multiple layers shall be interpreted as one H-ARQ channel whose parameters are given in the preceding Compact DL-MAP IE.
At the receiver, an ACK shall be transmitted only when there is no CRC error detected on every layer. Otherwise, a NACK shall be transmitted.

6. Direct Channel Coefficient Feedback

Direct channel coefficient feedback provides an enhancement to the uplink sounding that is already in the standard. With the direct channel coefficient feedback, FDD operation is enabled for the uplink sounding. This section provides the signaling framework for the direct channel coefficient feedback.

---------------------- Beginning of Text Changes -------------------------------------

[In Section 8.4.6.2.7, modify Table 311 as follows:]

Table 311: UL_Sounding_Command_IE()

Syntax	Size	Notes
UL_Sounding_Command_IE(){		
Extended UIUC	4 bits	0x09
Length	4 bits	Variable
Sounding_Type	1 bit	0 = Type A 1 = Type B
Send Sounding Report Flag	1 bit	
Include additional feedback	2 bits	00 = No additional feedback

		01 = include channel coefficients (See Section 8.4.6.2.7.3) 10 = include received pilot coefficients 11 = include feedback message
If (Sounding_Type == 0) {		
Num_Sounding_symbols	3 bits	Total number of sounding symbols being allocated, from 1 ("000") to 2^3=8 ("111")
Separability Type	1 bit	0: occupy all subcarriers in the assigned bands; 1: occupy decimated subcarriers
if (Separability type==0) {		(using cyclic shift separability)
Max Cyclic Shift Index P	2 bits	00: P=4; 01: P=8; 10: P=16, 11: P=32
} Else {		(using decimation separability)
Decimation Value D	3 bits	Sound every D^{th} subcarrier within the sounding allocation. Decimation value D is 2 to the power of (2 plus this value), hence 4,8,… up to maximum of 64.
Decimation offset randomization	1 bit	0= no randomization of decimation offset 1= decimation offset pseudo-randomly determined
}		
For (i=0;i<Num_Sounding_symbols;i++){		
Sounding symbol index	3 bits	Symbol index within the Sounding Zone, from 1 (bits "000") to 2^3=8 (bits "111")
Number of CIDs	4 bits	Number of CIDs sharing this sounding allocation
For (j = 0; j<Num. of CIDs; j++) {		
Shorted basic CID	12 bits	12 LS bits of the MSS basic CID value
Starting Frequency Band	7 bits	Out of 96 bands at most (FFT size dependent)
Number of frequency bands	7 bits	Contiguous bands used for sounding
Power Assignment Method	2 bits	0b00 = equal power; 0b01 = reserved; 0b10 = Interference dependent. Per subcarrier power limit; 0b11 = Interference dependent. Total power limit
Power boost	1 bit	0 = no power boost 1= power boost
Multi-Antenna Flag	1 bit	0=MSS sounds first antenna only 1=MSS sounds all antennas
if (Separability type==0) {		
Cyclic time shift index m	5 bits	Cyclically shifts the time domain symbol by multiples (from 0 to P –1) of N/P where N=FFT size, and P=Max Cyclic Shift Index.
} Else {		
Decimation Offset d	6 bits	Relative starting offset position for the first sounding occupied subcarrier in the sounding allocation
}		
Periodicity	~~2~~ 3 bits	~~00=single command, not periodic, or terminate periodicity~~ ~~01=repeat sounding once per frame until terminated~~ ~~10= repeat instructions once per 2 frames~~ ~~11= repeat instructions once per 4 frames~~ 000 = single command, not periodic, or terminate periodicity. Otherwise, repeat sounding once per r frames, where r = 2^(n-1), where n is the decimal equivalent of the periodicity field

}		
}		
} else {		
Permutation	2 bits	0b00 = PUSC perm. 0b01 = FUSC perm. 0b10 = Optional FUSC perm. 0b11 = Adjacent subcarrier perm.
IDcell	6 bits	
Num_Sounding_symbols	3 bits	
for (i=0;i<Num_Sounding_symbols;i++){		
Number of CIDs	7 bits	
For (j=0; j<Number of CIDs; j++) {		
Shortend basic CID	12 bits	12 LS bits of the MSS basic CID value
Subchannel offset	7 bits	The lowest index subchannel used for carrying the burst, starting from subchannel 0
Number of subchannels	3 bits	The number subchannels with subsequent indexes, used to carry the burst.
Periodicity	~~2~~ 3 bits	~~00=single command, not periodic, or terminate periodicity~~ ~~01=repeat sounding once per frame until terminated~~ ~~10= repeat instructions once per 2 frames~~ ~~11= repeat instructions once per 4 frames~~ 000 = single command, not periodic, or terminate periodicity. Otherwise, repeat sounding once per r frames, where r = 2^(n-1), where n is the decimal equivalent of the periodicity field
Power Assignment Method	2 bits	0b00 = equal power; 0b01 = reserved; 0b10 = Interference dependent. Per subcarrier power limit; 0b11 = Interference dependent. Total power limit
Power boost	1 bit	0 = no power boost 1= power boost
}		
}		
}		
Padding	Variable	Pad IE to octet boundary. Bits shall be set to 0
}		

If the field "Include Channel Coefficients" is enabled, then the UL Sounding Command IE() enables the MSS to perform the direct transmission of DL channel coefficients to the BS along with the UL sounding waveform. For the description of the direct channel coefficient encoding method, see Section 8.4.6.2.7.3.

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/D5a 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

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