Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Beamforming MIMO mode**
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Re:	
Abstract	Beamforming MIMO mode
Purpose	Adoption of proposed changes into P802.16e D5. ~~Crossed-out indicates deleted text,~~ underlined blue indicates new text change to the Standard
Notice	
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Beam-forming MIMO mode

Intel Corporation

Abstract

Transmit beam-forming enables performance gains with multiple antennas at the BS and even a single antenna at the MS. These performance gains are derived from the array gain plus the diversity gain, which can be as much as 10 dB for a system with four antennas at the BS and a single antenna at the MS.

Currently, the IEEE 802.16-2004 standard enables transmit beam-forming through AAS mechanisms. In addition, the standard enables pre-coding for MIMO systems. AAS can be treated as a special case of MIMO pre-coding, thereby enabling a vendor to more easily design a system with beam-forming benefits as well as MIMO benefits.

All of the basic mechanisms for beam-forming are already in the standard. Payload bits can be encoded in the enhanced FAST_FEEDBACK channel (Table 297) as 0b110000 to represent beam-forming. The beam-forming weights can be computed by the MS receiver, quantized with 5-bit or 6-bit APSK "wheels", as shown in Figure 231c, and fed-back to the BS to be used as BS transmitter weights.

We propose some simple text changes to clarify this option in the standard.

1 Existing mechanisms for beam-forming MIMO mode

All of the basic mechanisms for beam-forming are already in the standard. Payload bits can be encoded in the enhanced FAST_FEEDBACK channel (Table 297, Sec 8.4.5.4.10.8) as 0b110000 to represent beam-forming.

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 BF or 3-antenna BS, 00 = Antenna group 0,1 & 1,2 For 4-antenna BS, 00 = Antenna group 0,2 & 1,3
0b110011	Antenna Group CF or 3-antenna BS, 00 = Antenna group 0,2 & 1,2 For 4-antenna BS, 00 = Antenna group 0,3 & 1,2

0b110100 - 0b111111	Reserved

The beam-forming weights can be computed by the MS receiver, quantized with 5-bit or 6-bit APSK "wheels", as shown in Figure 231c in Sec 8.4.5.4.10.6, and fed-back to the BS to be used as transmit weights.

The number of transmit antennae is indicated in Table 298a in Sec 8.4.5.4.15, as shown below.

Table 298a. 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 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.
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++) {		
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.
}		

2 Specific Text Changes

[Modify the following section in 802.16e D5 as indicated]

8.4.8.3.6 MIMO Precoding

The space time coding output or an OFDM symbol stream can be weighted by a matrix before mapping onto transmit antennas:

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where x is a vector with the output from the space-time coding (per-subcarrier), is the number of ~~antennas~~streams at the output of the space-time coding scheme. The matrix W is an weighting matrix where the quantity is the number of actual transmit antennas. The vector contains the signals after weighting for the different actual antennas. When Mt=1, then single stream precoding or beamforming mode shall be enabled with the vector W of dimension $N_t \times 1$. The labeling of the elements in the weighting matrix is performed in accordance with the example of given below for the case of 4 actual antennas and 2 space-time coding output ~~antennas~~streams:

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