Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Sub-channel Reuse for CQICH Fast Feed-back Channels in Multiple Antenna Base Stations**
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Re:	Recirculation of P802.16 REVe/D5
Abstract	Sub-channel reuse scheme is proposed to reduce bandwidth overhead of CQICH fast feed-back channels in multiple antenna base stations.
Purpose	Adoption of suggested changes into P802.16e/D6
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(For readers: The changes made during revision process are underlined and written in pink. The text changes proposed in the original contribution remain in blue)

Problem Definition

The required number of fast feed-back channels increases as the number of data streams increases in multiple antenna mode. To reduce the uplink bandwidth overhead, there needs to utilize the SNR gain from multiple receiver antennas at BS.

Proposed Solution

The operating point of CQICH fast feedback channels, which can be specified as signal to noise ratio per antenna, decreases as the number of received antennas at BS increases and it can be well below 0 dB SNR. Under this situation, one sub-channel region for CQICH feedback can be allocated for multiple CQICH signaling when the BS provision multiple receive antennas, wherein each of multiple CQICH sub-channels has its own codeword set and covering sequence offset for co-channel interference averaging. To keep backward compatibility, we use fast feedback orthogonal modulation vectors in Table 295 of P802.16-REVd/D5.

The simulations results in Fig. 1 below are obtained using 5 bit codeword at BS with two receive antennas. We can observe that the operating point of 1 % error rate increases to -1.5 dB when CQICH codeword are reused by factor two in AWGN channels. The original point (not shown here) was -5.0 dB. The SNR degradation of 3.5 dB would be compensated when we employ more than two receive antennas at BS. To verify this argument, additional performance simulations were carried out for 4 antenna diversity reception. The results are illustrated in Fig. 2.

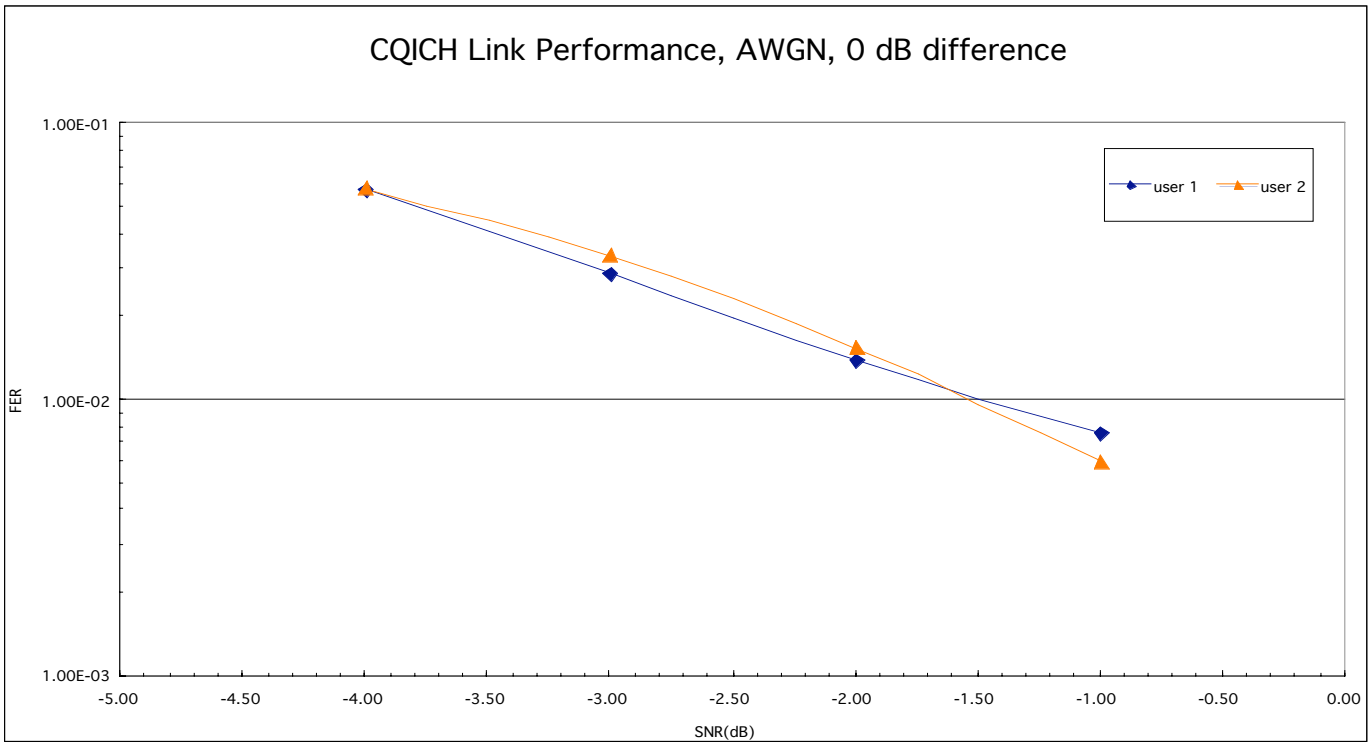

Fig. 1. Simulation results of 5 bit codeword (only covering offset applied)

In this second simulation, the 6 bit codeword set in the current text was employed when the number of receive antenna at BS is 2. For the proposed sub-channel reuse scheme, the second user employed the optimized second 6 bit codeword set with covering shift offset of 40. The results in Fig. 2 show that the SNR gain from 4 receive antenna is enough to accommodate two users in a single sub-channel. Specifically, under the operation point of 1 % PER and -4.0 dB SNR per

antenna, one sub-channel for CQICH signaling can be allocated to different two users.

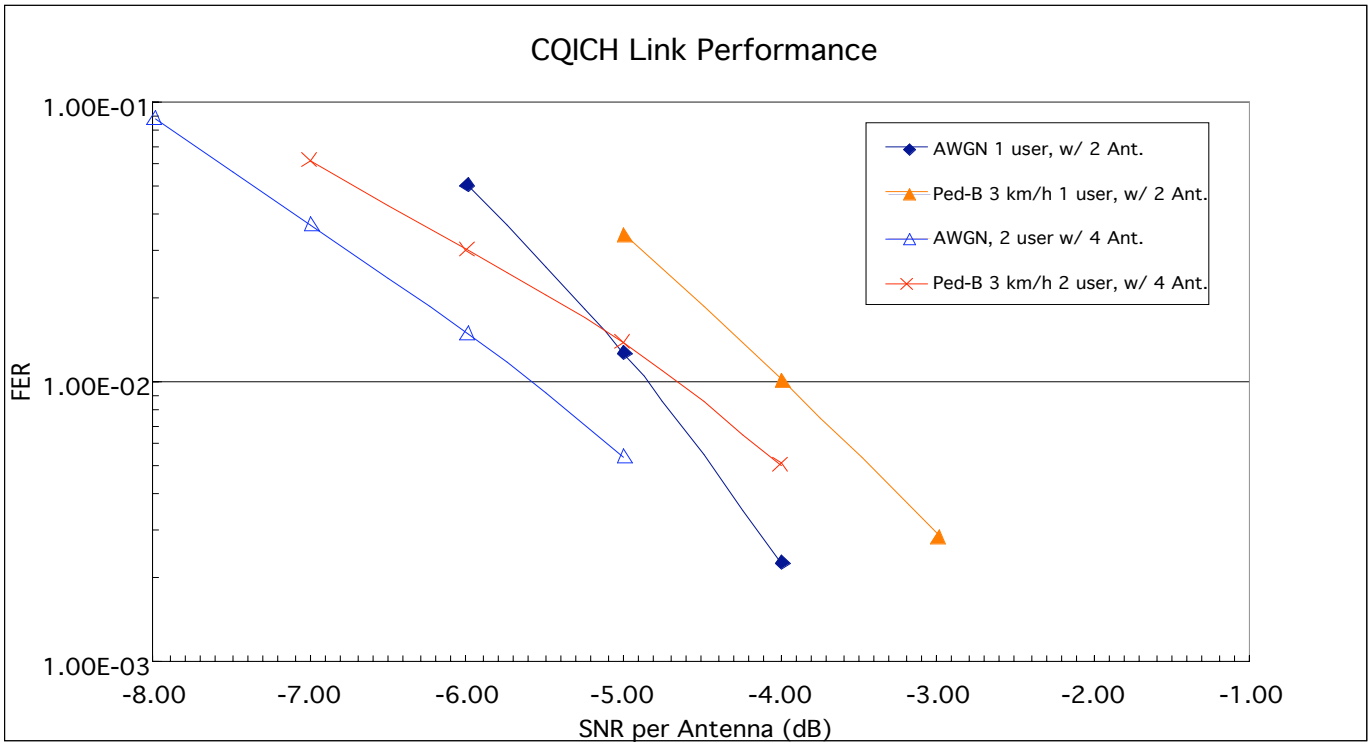

Fig. 2. Simulation results of 6 bit codeword

Suggested text changes to 16.e standard

[Create Sec. 8.4.5.4.10.10 as follows]

8.4.5.4.10.10 Optional Sub-channel Reuse for FAST_FEEDBACK channel

If BS supports multiple receive antenna for uplink reception, the number of Fast Feedback channels for a given uplink sub-channel with UIUC = 0 can be increased by using different codeword set and different covering sequence offsets as in Table aaa. The covering sequences for reused sub-channels are obtained by shifting the BS-specific covering sequences in Sec 8.4.9.4.1.

Table aaa Modulation Scheme for Re-used **Fast feedback channels**

Reuse Index	Code word set	Shift offset	Description
00	S_0	0	Use codeword set S_0 and apply BS-specific covering sequences in Sec 8.4.9.4.1.
01	S_1	40	Use codeword set S_1 and apply BS-specific covering sequences in Sec 8.4.9.4.1. shifted by 40 offset
10 - 11	Reserved	Reserved	

The reuse indexes are assigned by CQICH Enhanced allocation IE. At MS, each modulated sub-carrier in the assigned sub-channel is multiplied by covering BPSK signals, which is obtained by shifting the BS-specific sequences in Sec 8.4.9.4.1.The S_0 and S_1 for 4 bit (5 bit) signaling are obtained by taking the first and the last 16 (32) code-words in Table

296a (Table 296b). For 6 bit signaling, MS utilizes 64 code-words in Table 296b for S_0 and those in Table 296d for S_1, respectively.

Table 296d – Additional Fast Feedback channel subcarrier modulation with 6 bit

6 bit payload	Fast Feedback vector indices per Tile Tile(0), Tile(1), … ,Tile(5)
0b000000	4,6,5,2,3,1
0b000001	5,7,4,3,2,0
0b000010	6,4,7,0,1,3
0b000011	7,5,6,1,0,2
0b000100	0,2,1,6,7,5
0b000101	1,3,0,7,6,4
0b000110	2,0,3,4,5,7
0b000111	3,1,2,5,4,6
0b001000	6,2,6,4,4,4
0b001001	7,3,7,5,5,5
0b001010	4,0,4,6,6,6
0b001011	5,1,5,7,7,7
0b001100	2,6,2,0,0,0
0b001101	3,7,3,1,1,1
0b001110	0,4,0,2,2,2
0b001111	1,5,1,3,3,3
0b010000	0,5,3,5,6,0
0b010001	1,4,2,4,7,1
0b010010	2,7,1,7,4,2
0b010011	3,6,0,6,5,3
0b010100	4,1,7,1,2,4
0b010101	5,0,6,0,3,5
0b010110	6,3,5,3,0,6
0b010111	7,2,4,2,1,7
0b011000	7,0,2,7,2,3
0b011001	6,1,3,6,3,2
0b011010	5,2,0,5,0,1
0b011011	4,3,1,4,1,0
0b011100	3,4,6,3,6,7
0b011101	2,5,7,2,7,6
0b011110	1,6,4,1,4,5
0b011111	0,7,5,0,5,4
0b100000	2,1,0,3,1,5
0b100001	3,0,1,2,0,4
0b100010	0,3,2,1,3,7
0b100011	1,2,3,0,2,6
0b100100	6,5,4,7,5,1
0b100101	7,4,5,6,4,0
0b100110	4,7,6,5,7,3
0b100111	5,6,7,4,6,2
0b101000	3,3,4,0,7,2
0b101001	2,2,5,1,6,3
0b101010	1,1,6,2,5,0
0b101011	0,0,7,3,4,1
0b101100	7,7,0,4,3,6
0b101101	6,6,1,5,2,7

0b101110	5,5,2,6,1,4
0b101111	4,4,3,7,0,5
0b110000	1,7,7,6,0,7
0b110001	0,6,6,7,1,6
0b110010	3,5,5,4,2,5
0b110011	2,4,4,5,3,4
0b110100	5,3,3,2,4,3
0b110101	4,2,2,3,5,2
0b110110	7,1,1,0,6,1
0b110111	6,0,0,1,7,0
0b111000	5,4,1,1,5,6
0b111001	4,5,0,0,4,7
0b111010	7,6,3,3,7,4
0b111011	6,7,2,2,6,5
0b111100	1,0,5,5,1,2
0b111101	0,1,4,4,0,3
0b111110	3,2,7,7,3,0
0b111111	2,3,6,6,2,1

[Modify the following Table 298a in 8.4.5.4.15 "CQICH Enhanced Allocation IE Format"]

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.
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	2	00 = Fast DL measurement 01 = MIMO Antenna Feedback 10 = MIMO mode and permutation mode feedback 11 = Reserved
CQICH_Num	4	Number of CQICHs assigned to this CQICH_ID is (CQICH_Num+1)
for (i=0;i<CQICH_Num;i++) {		

Allocation index	6	Index to the fast feedback channel region marked by UIUC=0
Reuse index	2	Modulation scheme in Sec. 8.4.5.4.10.10 00 = Use S_0 and apply no shift offset (Default) 01 = Use S_1 and apply 40 shift offset 10-11 = Reserved
}		
if (Feedback_type != 10) { 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 are used to ensure the IE size is integer number of bytes.

[Add the text as follows in 11.8.3.7.7 “Uplink control channel support”]

11.8.3.7.7 Uplink control channel support

[Change the text as follows]

Type	Length	Value	Scope
xxx	1	Bit# 0: FAST_FEEDBACK Bit# 1: Enhanced FAST_FEEDBACK Bit# 2: UL ACK Bit# 3: Enhanced UL ACK Bit# 4: Optional FAST_FEEDBACK for 4 bit payload Bit# 5: Optional FAST_FEEDBACK for 5 bit payload Bit# 6: **Optional** FAST_FEEDBACK with Reuse Bit# 7: Reserved, shall be set to zero	SBC-REQ (see 6.3.2.3.23) SBC-RSP (see 6.3.2.3.24)