Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Reuse of CQICH Fast Feed-back Sub-channel for Base Stations with Diversity Antenna Reception.**
Date Submitted	**2005-01-~~11~~20**
Source(s)	Inseok Hwang ,Jaehee Cho, Seungjoo Maeng, Jaeho Jeon, Soonyoung Yoon, Jeong-Heon Kim, Jaehyok Lee, Myungkwang Byun, Panyuh Joo, Jiho Jang, Sanghoon Sung, Hoon Huh, janghoon yang, Jihyun Kim Samsung Electronics Co. Ltd.	is91.hwang@samsung.com
Re:	Recirculation of P802.16 REVe/D5a
Abstract	Reuse scheme is proposed to increase the spectral efficiency of CQICH fast feed-back sub-channels. The proposed scheme is fully backward compatible and useful for base stations with diversity antenna reception.
Purpose	Adoption of suggested changes into P802.16e/D6
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>.

Problem Definition

The required number of fast feed-back sub-channels increases as the number of data streams increases. To reduce the uplink bandwidth signaling overhead, there needs to utilize the SNR gain from multiple antenna reception 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 clock 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, which has been proposed for non-coherent detection in low SNR regime.

The simulations results in Fig. 1 below are obtained by shifting the BS-specific covering sequences in Sec 8.4.9.4.1. For the second user, covering sequence clock offset of 40 was applied and two antenna diversity reception at BS was assumed. The simulation was carried out in PUSC and O-PUSC permutation zone and non-coherent energy detection was employed in the receiver to avoid performance degradation from channel estimation error in low SNR regime. We can observe that the operating point of 1 % error rate increases to -1.5 dB when CQICH code words 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.
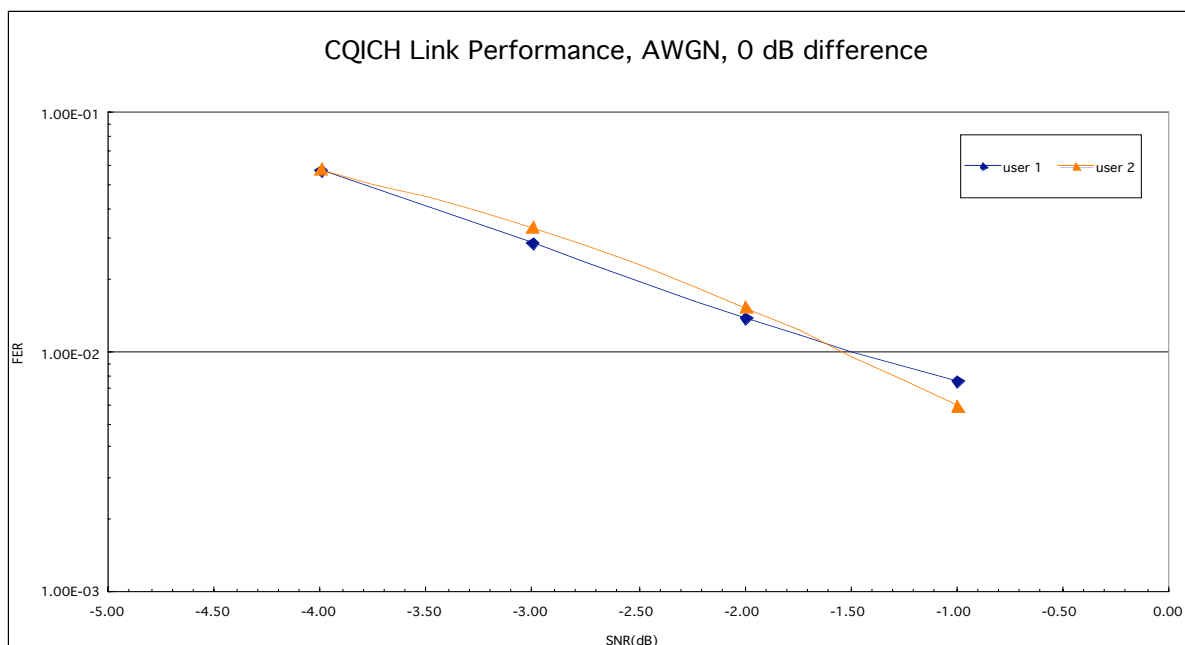

Fig.1. 5 bit codeword (only covering sequence clock offset applied)

In the second simulation, the 6 bit codeword set in the current text was employed when the number of receive antenna at BS is 2 and 4. For the proposed sub-channel reuse scheme, the second user employed the optimized second 6 bit codeword set with covering sequence clock 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 although the performance curve of 4 Rx. antenna with 2 user case was not steeper than 2 Rx. antenna with one user case. This is a final compromise between diversity

reception and jamming effects cased by interference between co-channel users. Table I summarized the whole simulation results in terms of required SNR per antenna for 1 % error rate. In conclusion, 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 using the proposed scheme. Alternatively, one fast feedback sub-channel can be used for the signaling of channel quality information of two different DL MIMO layers of one user. In this scenario, the proposed scheme doesn't suffer performance degradation from power imbalance between co-channel users. For 2 user allocations, BS may reduce the performance loss from power imbalance by employing SIC (serial-interference cancellation) and/or receiver beam-forming after estimating user's spatial signature.
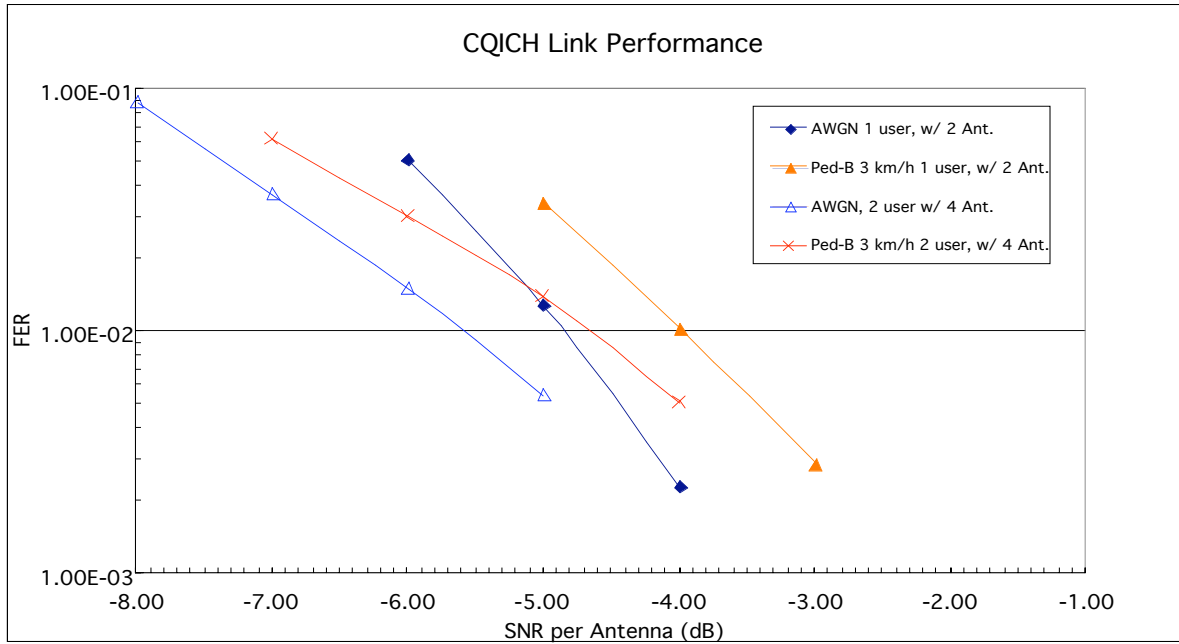

Fig. 2. 6 bit codeword (covering sequence clock offset and different code-word set)
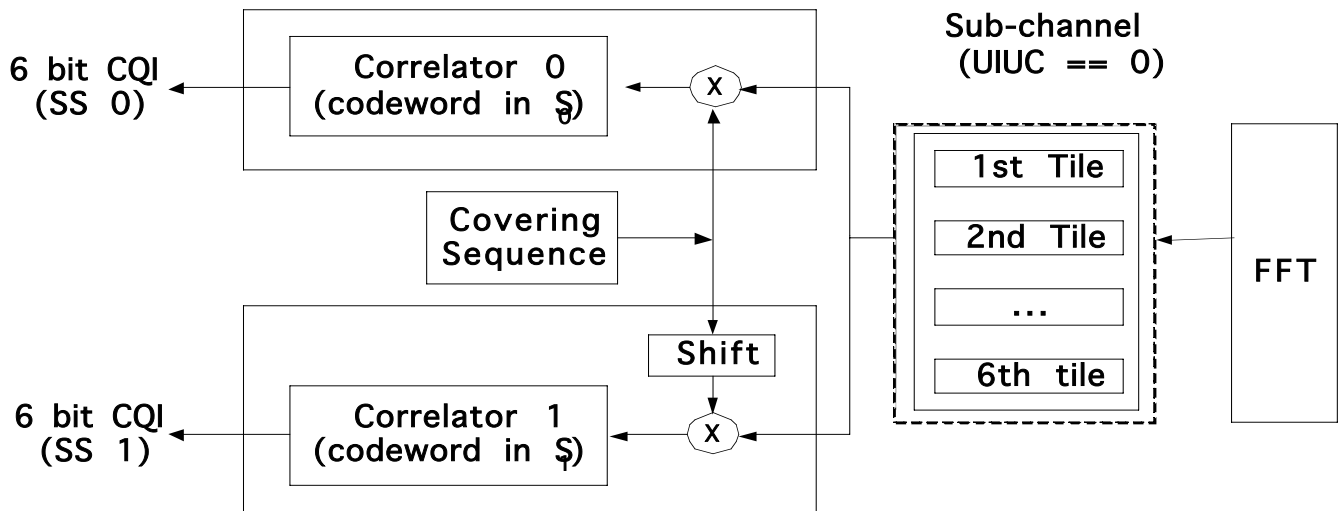

Fig. 3. Operation at BS in the proposed scheme

Table I. Required SNR per Antenna for 1 % Error

Simulation Case	Applied Scheme for 2nd User	AWGN	PED-B 3 km/h
1 User, 2 Rx. Ant at BS, 5 bit CQICH	NA	− 5.0 dB	-
1 User, 2 Rx. Ant at BS, 6 bit CQICH	NA	− 4.8 dB	− 4.0 dB
2 User, 2 Rx. Ant at BS, 5 bit CQICH	Covering Sequence Clock Offset	− 1.5 dB	-
2 User, 4 Rx. Ant at BS, 6 bit CQICH	**Covering Sequence Clock Offset and Codeword Set**	**− 5.5 dB**	**− 4.6 dB**

Suggested text changes to 16.e standard

[Create Sec. 8.4.5.4.10.10 as follows]

8.4.5.4.10.xx 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 clock offsets as in Table aaa. The covering sequences for sub-carriers in 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
0	S_0	0	Use codeword set S_0 and apply BS-specific covering sequences in Sec 8.4.9.4.1.
1	S_1	40	Use codeword set S_1 and apply BS-specific covering sequences in Sec 8.4.9.4.1. shifted by 40 clock offset

The reuse indexes are assigned by CQICH Enhanced allocation IE. At SS, 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. SS should utilize 64 code-words in Table 296b for S_0 and those in Table 296d for S_1, respectively.

Table 296d – Additional Fast-Feedback channel sub-carrier 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	1	Modulation scheme in Sec. 8.4.5.4.10.10 0 = Use S_0 and apply 0 clock offset (Default) 1 = Use S_1 and apply 40 clock offset
}		
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.