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Re:	
Abstract	Uplink control channels is proposed.
Purpose	Adoption of the proposed Uplink control channels into 802.16-REVd
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Uplink control channels

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Introduction

The CQI(Channel Quality Indicator) channel, which is traditionally used for fast C/I feedback of DL channel through a dedicated uplink control channel, is missing in the current draft standard IEEE 802.16REVd. In this contribution, the dedicated CQI channel in the subchannel structure is proposed to improve the downlink performance. Two fast CQI feedback modes are proposed in order to improve the downlink performance and reduce the control overhead : diversity and AMC user mode. The subchannel structure for CQI channel is deployed in order to provide frequency diversity. It consists of (20,5) block code for error protection and differential QPSK modulation for non-coherent demodulation.

The ACK(Acknowledgment) channel, which is traditionally used for fast ACK/NAK feedback through the dedicated uplink control channel, is missing in the current draft standard IEEE 802.16-REVd. In this contribution, the dedicated ACK channel in the subchannel structure is proposed to facilitate and improve performance of downlink hybrid-ARQ. The subchannel structure for ACK channel is deployed in order to provide frequency diversity. It consists of repetition and orthogonal modulation for non-coherent demodulation.

Proposed Text Changes

We propose the following remedies in IEEE P802.16-REVd/D3

[Insert the following section “8.4.9 Uplink control channels” below “8.4.8 Channel coding”]

8.4.9 Uplink control channels

The CQI(Channel Quality Indicator) is periodically reported by the access terminal in the uplink. There are two modes of operation of the CQI channel : Full CQI feedback mode for Diversity user and Differential CQI mode for AMC user. In the Full CQI feedback mode for diversity user, the 5-bit average C/I of Downlink preamble is sent. In the differential C/I feedback mode for AMC user, 5-bit differential C/I feedback for selected bands is sent by access terminal.

The uplink ACK (Acknowledgement) provides feedback for Downlink Hybrid ARQ. The mobile station transmits ACK or NACK feedback for Downlink packet data.

8.4.9.1 CQI channel encoding

The CQI is represented by 5-bit symbol according to the channel SNR measured in the access terminal. The CQI information is either the full CQI value or the differential CQI value. These 5 bits are encoded into a 20 bit-codeword for the error protection as shown in Table 1.

Table 1 – CQI Symbol and Codeword Assignments

Channel SNR [dB]	CQI symbol	CQI codeword
-10.0 to -9.0	00000	00000 00000 00000 00000
-9.0 to -8.0	00001	10000 10101 01010 10101

-8.0 to -7.0	00010	01000 01100 11001 10011
-7.0 to -6.0	00011	11000 11001 10011 00110
-6.0 to -5.0	00100	00100 00011 11000 01111
-5.0 to -4.0	00101	10100 10110 10010 11010
-4.0 to -3.0	00110	01100 01111 00001 11100
-3.0 to -2.0	00111	11100 11010 01011 01001
-2.0 to -1.0	01000	00010 00000 00111 11111
-1.0 to 0.0	01001	10010 10101 01101 01010
0.0 to 1.0	01010	01010 01100 11110 01100
1.0 to 2.0	01011	11010 11001 10100 11001
2.0 to 3.0	01100	00110 00011 11111 10000
3.0 to 4.0	01101	10110 10110 10101 00101
4.0 to 5.0	01110	01110 01111 00110 00011
5.0 to 6.0	01111	11110 11010 01100 10110
6.0 to 7.0	10000	00001 11111 11111 11111
7.0 to 8.0	10001	10001 01010 10101 01010
8.0 to 9.0	10010	01001 10011 00110 01100
9.0 to 10.0	10011	11001 00110 01100 11001
10.0 to 11.0	10100	00101 11100 00111 10000
11.0 to 12.0	10101	10101 01001 01101 00101
12.0 to 13.0	10110	01101 10000 11110 00011
13.0 to 14.0	10111	11101 00101 10100 10110
14.0 to 15.0	11000	00011 11111 11000 00000
15.0 to 16.0	11001	10011 01010 10010 10101
16.0 to 17.0	11010	01011 10011 00001 10011
17.0 to 18.0	11011	11011 00110 01011 00110
18.0 to 19.0	11100	00111 11100 00000 01111
19.0 to 20.0	11101	10111 01001 01010 11010
20.0 to 21.0	11110	01111 10000 11001 11100
21.0 to 22.0	11111	11111 00101 10011 01001

8.4.9.2 ACK channel modulation

The ACK channel is orthogonally modulated. The acknowledgement bit B_n^{ACK} of the *n*-th ACK channel shall be '0' (ACK) if the corresponding downlink packet has been successfully received; otherwise, it shall be a '1' (NAK). The *k*-th orthogonal modulation symbol of the *n*-th ACK channel, $M_{n,k}^{ACK}$ (*k*=0,1,…,5 and *n*=0,1,…, $N_{CQI}-1$) is made as shown in Table 2.

Table 2 – Orthogonal modulation for ACK channel

B_n^{ACK}	$M_{n,k}^{ACK}$
0	1 1 -1 -1 1 1
1	1 -1 -1 1 1 -1

Then the modulated symbols are mapped to the subcarriers allocated to the *n*-th ACK channel, as follows.

$$c_{n,k}^{ACK} = \begin{cases} M_{n,k}^{ACK} & if\ k = 0,1,\cdots,5 \\ -M_{n,k-6}^{ACK} & elsewhere \end{cases} \quad (1.)$$

where

$c_{n,k}^{ACK} = Carrier^{ACK}(n,k)$ of Equation (7) and the symbol and subcarrier index of the *k*-th ACK subcarrier in the *n*-th ACK channel

$M_{n,k}^{ACK}$ = modulation symbol index of the *k*-th modulation symbol made from the *n*-th ACK bit as shown in Table 2

n = ACK channel index from the set [0 ~ $N_{ACK} - 1$]

k = ACK subcarrier index of an ACK channel from the set [0 ~ 11]

An ACK channel spans 3 uplink symbols in the time domain and the same modulation symbol shall be transmitted in the same subcarrier during 3 symbols.

8.4.9.3 CQI channel modulation

The CQI channel is differentially QPSK modulated. After CQI encoding, the CQI codeword symbols are entered serially to the differential QPSK modulator. Then the differentially modulated symbols are mapped to the subcarriers which are allocated to a CQI channel. The 20-bit codeword is separated into two 10-bit groups and the first 10 bits make one group and the last 10 bits make another group. Each group is modulated separately and mapped to two of 2-subcarrier by 3-symbol bunches according to the CQI allocation. The first group is mapped to the first and the third bunches and the second group is mapped to the second and the fourth bunches.

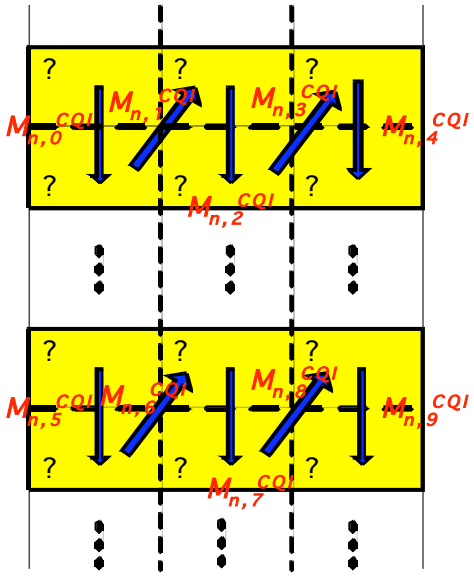


Figure 1 – Differential Modulation and Subcarrier Mapping for a CQI channel

Differential QPSK modulation is divided into 2 stages. QPSK modulation symbols are made at first and then the modulated symbols are differentially encoded. Two code symbols of the CQI codeword make one QPSK modulation symbol. The *k*-th QPSK modulation symbol of the *n*-th CQI channel, $M_{n,k}^{CQI}$ (*k*=0,1,…,9 and *n*=0,1,…, $N_{CQI}-1$) is made from the *(2k)*-th and *(2k+1)*-th code symbols of the *n*-th CQI channel codeword, $C_{n,2k}^{CQI}C_{n,2k+1}^{CQI}$ as shown in Table 3.

Table 3 – QPSK modulation for CQI channel

CQI codeword, $C_{n,2k}^{CQI}C_{n,2k+1}^{CQI}$	**Modulation symbol,** $M_{n,k}^{CQI}$
00	**1**
01	**j**
11	**-1**
10	**-j**

Then the modulated symbols are differentially encoded and mapped to the subcarriers allocated to the *n*-th CQI channel. Differential encoding and subcarrier mapping is done as follows. For k=0 to 5,

$$c_{n,0}^{CQI} = \frac{1}{\sqrt{2}}(1+j)$$

$$c_{n,k}^{CQI} = c_{n,k-1}^{CQI} \cdot M_{n,k-1}^{CQI} \qquad if\ \ k = 1,2,\cdots,5$$

For k=6 to 11,

$$c_{n,6}^{CQI} = -\frac{1}{\sqrt{2}}(1+j)$$

$$c_{n,k}^{CQI} = c_{n,k-1}^{CQI} \cdot M_{n,k-2}^{CQI} \qquad if\ k = 7,8,\cdots,11$$

For k=12 to 17

$$c_{n,12}^{CQI} = \frac{1}{\sqrt{2}}(1+j)$$

$$c_{n,k}^{CQI} = c_{n,k-1}^{CQI} \cdot M_{n,k-13}^{CQI} \qquad if\ k = 13,14,\cdots,17$$

For k=18 to 23

$$c_{n,18}^{CQI} = -\frac{1}{\sqrt{2}}(1+j)$$

$$c_{n,k}^{CQI} = c_{n,k-1}^{CQI} \cdot M_{n,k-14}^{CQI} \qquad if\ k = 19,20,\cdots,23$$

where

$c_{n,k}^{CQI} = Carrier^{CQI}(n,k)$ of Equation (7) and the symbol and subcarrier index of the *k*-th CQI subcarrier in the *n*-th CQI channel

$M_{n,k}^{CQI}$ = modulation symbol index of the *k*-th modulation symbol made from the *n*-th CQI codeword as shown in Table 3

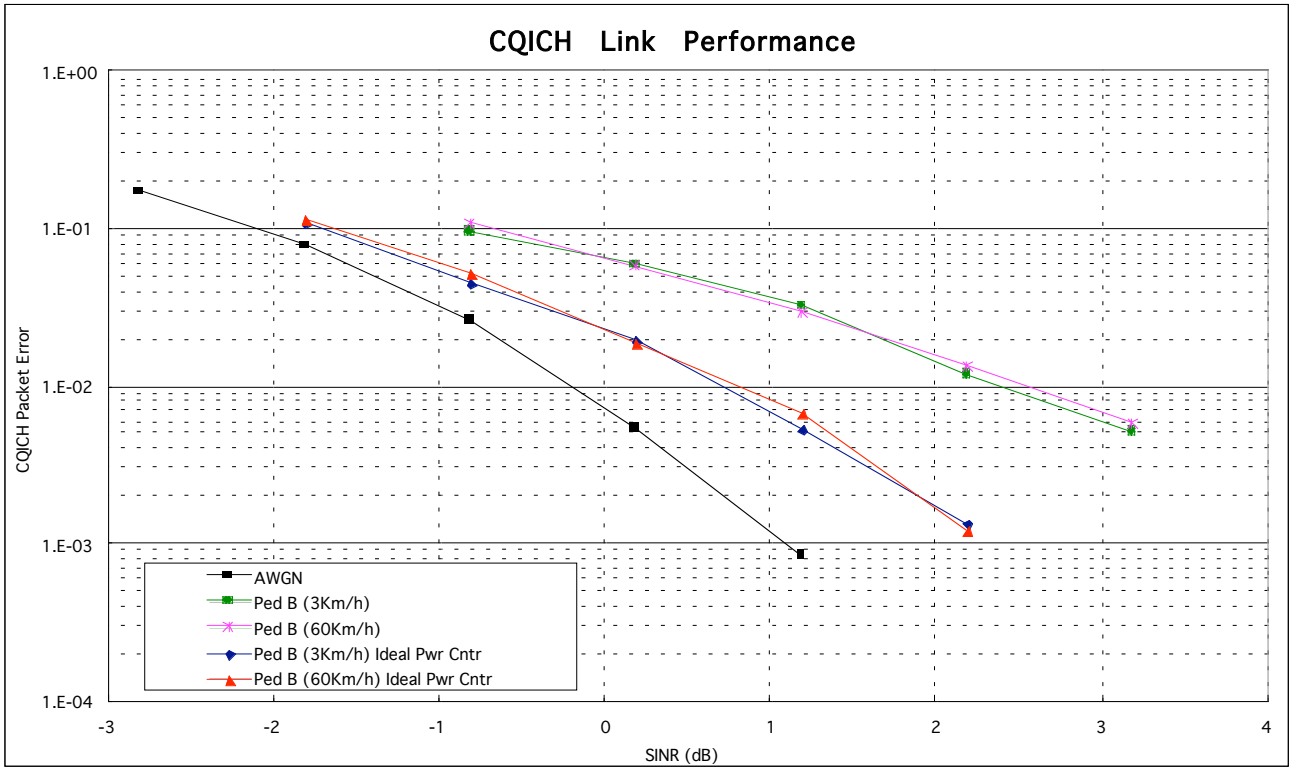
n = CQI channel index from the set [0 ~ $N_{CQI} - 1$]

k = CQI subcarrier index of an CQI channel from the set [0 ~ 23]

Annex A. CQICH Link Performance

Simulation Results of CQICH are following,

- Channel : AWGN, Pedestrian-B channel with mobile speed of 3km/h and 60km/h
- The case with ideal power control and without power control.
- SINR = Signal to Interference and Noise Ratio per a subcarrier.



Annex B. ACK channel Link Performance

Simulation Results of ACK channel are following,

- Channel : AWGN, Pedestrian-B channel with mobile speed of 3km/h
- The case with ideal power control.
- SINR = Signal to Interference and Noise Ratio per a subcarrier.