Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Quality-based Reporting for Uplink CQI channel**
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Re:	This is a response to a WG Recirculation Ballot #14a on IEEE P802.16e/D2
Abstract	Scheme for quality-based reporting operation of uplink CQI channel
Purpose	The document is submitted for review by 802.16e Working Group members.
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Introduction

In this contribution we are proposing a simple method for operating uplink CQI Channel. We call it Quality Based CQI Report. In multiple cell environment, uplink CQI Channel Quality degrades as number of CQI Channel allocated to MSS increases because of intercell interference inherent in OFDMA system.

By setting CQI report threshold for MSS with CQI channel allocated, MSSs only reports back to the BS when the CINR on downlink is better then the threshold value, which in turn increases the efficiency of the CQI Channel and also potentially increasing the number of valid CQI reports.

The number of CQI channels successfully demodulated/decoded at the base actually limits the number of valid channel-state reports and determining the data rate that can be currently allocated. The fewer valid CQI reports arrive, the more capacity loss occurs. Also, if mobiles move fast, the channel quality normally drops more frequently below the required CINR (Carrier to Interference plus Noise Ratio). In the case, lost CQI reports make the capacity decrease. With the proposed method that potentially increases CINR of CQI channels, the capacity degradation due to high mobility can be reduced.

The proposed scheme is accomplished just by inserting either a MAC message (Suggestion 1 in the following) or an information field (consisting of 3 bits that is not presently used) into the existing CQICH Control IE in IEEE P802.16REVd/D5-2004 (Suggestion 2 in the following.).

Suggested Change to the Standard

Suggestion 1:

[Changes on the P802.16e/D2-2004 by the following text.]

6.3.2.3 MAC Management Message

[Add this row into the Table 14a-MAC Management messages]

Type	Message Name	Message description	Connection
TDB	CQT	CQI report threshold message	basic, broadcast

6.3.2.3.xx Channel Quality Based Reporting Threshold (CQT) message

A BS may send a CQT message to SS's in order to notify the BS requests that SS's in the cell should report on CQI only when their CINR is greater than CQT. The MAC Management Message Type for this message is given in Table 14a. The format of the message is shown in Table xxx.

A BS shall generate CQT messages including the following parameter and the actual values mapped for this parameter is given in Table yyy:

.

CQI reporting threshold

It is used for the SS to determine whether it reports current channel measurement through CQI channel if allocated in the future. If the value is set to 000, this threshold is inactive afterwards; otherwise it is activated.

Table xxx – Channel Quality Based Reporting Threshold (CQT) Message Format

Syntax	Size	Notes
Channel_Quality_Based_Reporting _Threshold_Message_Format() {		
Management Message Type = TBD	8 bits	
Connection ID	16 bits	CID to which this message refers to.
CQI reporting threshold	5 bits	
}		

Table yyy – Threshold Values

CINR [dB]	Value
CQT inactivated	00000
-9.0	00001
-8.0	00010
-7.0	00011
-6.0	00100
-5.0	00101
-4.0	00110
-3.0	00111
-2.0	01000
-1.0	01001
0.0	01010
1.0	01011
2.0	01100
3.0	01101
4.0	01110
5.0	01111
6.0	10000
7.0	10001
8.0	10010
9.0	10011
10.0	10100
11.0	10101
12.0	10110
13.0	10111
14.0	11000

15.0	11001
16.0	11010
17.0	11011
18.0	11100
19.0	11101
20.0	11110
21.0	11111

Suggestion 2:

[Changes on the P802.16-REVd/D5-2004 by the following text.]

6.3.2.3.43.5 CQICH Control IE.

[Replace the content of the Table 62 to the following:]

Table 1 Format of CQICH Control IE

Syntax	Size	Notes
CQICH_Control_IE () {	_	_
CQICH indicator	1 bit	If the indicator is set to 1, the CQICH Control IE follows.
if CQICH indicator == 1 {	_	_
Allocation Index	6 bits	Index to the channel in a frame the CQI report should be transmitted by the SS.
Period (p)	2 bits	A CQI feedback is transmitted on the CQI channels indexed by the (CQI Channel Index) by the SS in every 2^p frames.
Frame offset	3 bits	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)	4 bits	A CQI feedback is transmitted on the CQI channels indexed by the (CQI Channel Index) by the SS for 2^{d-1} frames. If d is 0000, the CQICH is de-allocated. If d is 1111, the MSS should report until the BS command for the MSS to stop.
} else {	_	_
CQI reporting threshold	3 bits	A threshold used for SS to report its CINR using CQI channel; If 000, this threshold is neglected.
}	_	_
}	_	_

Each field of the IE represents the following parameters:

Allocation Index

It indicates its position from the start of the CQICH region

Period

It informs the SS of the period of CQI reports

Frame offset

It informs the SS of when to start. The SS 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 SS should start reporting in 8 frames

Duration

It indicates when the SS should stop reporting unless the CQICH allocation is refreshed beforehand. If duration d == 0000, the BS is intended to de-allocate the CQICH. If d == 1111, the CQICH is allocated indefinitely and the SS should report until the BS commands the SS to stop, which happens it receives another MAP_IE with d =0000.

CQI reporting threshold

It is used for the SS to determine whether it reports current channel measurement through CQI channel if allocated in the future. If the value is set to 000, this threshold is inactive afterwards; otherwise it is activated.

Performance

Simulation results of using CQI reporting threshold are shown in Figure 1-3. The performance is computed as log2(1+CINR) (bps/Hz) where CINR is determined by the best CINR among the reported (that is, with greedy method). In the simulation we investigate the performance of the center cell among 19 omnicells with 1-km radius. The users are assumed uniformly located on a circle far from the center by 0.7, 0.85, and 1 km for Figure 1, 2, and 3, respectively. Thus the CINR statistics for Figure 3 represents a worst case scenario. Three cases are compared in each Figure. No CQT means that proposed CQI reporting threshold is not used as a convention. CQI reporting threshold for –2 dB and 2dB is respectively investigated. Though different mobiles can be allocated different CQI reporting thresholds, we assume all the mobiles are using the same threshold. A user allocated CQI channel below CQI reporting threshold does not report CQI. Figure 1 shows CQI reporting threshold can be used to achieve about 10% increase in the capacity when there are more than 25 CQI channels used. The decrease in the capacity of no CQT case is due to the CQI error mainly occurred by low SINR, which usually happens when many CQI channels are allocated. We use CQICH packet error expected from the simulation result reported by Samsung and Runcom as shown in Figure 4. When SINR is lower than –8 dB, 50% error is constantly assumed. If less than 15 CQI channels are allocated, we need to set CQI reporting threshold to ‘000’ that inactivates the CQI reporting threshold. Figure 2 shows the capacity gain goes to about 15%. And in the worst interference scenario as used in Figure 3, the capacity gain goes further to about 20%. Figure 5 shows the CINR distribution of CQI Channel when 40 CQI channels are allocated in each of the 19 cells.

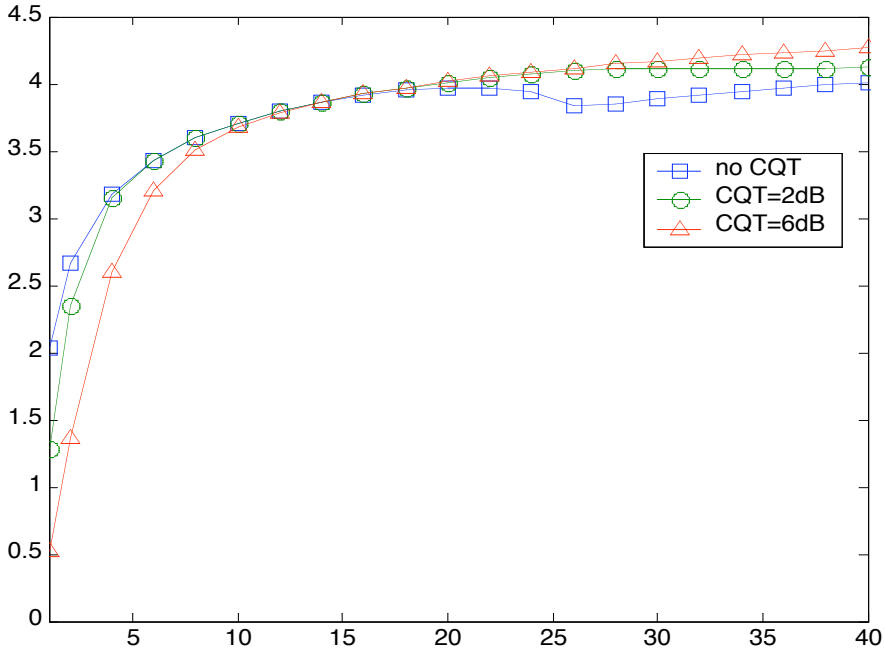

Figure 1 - Average capacity versus the number of CQI channels with user position=0.7km away from the center

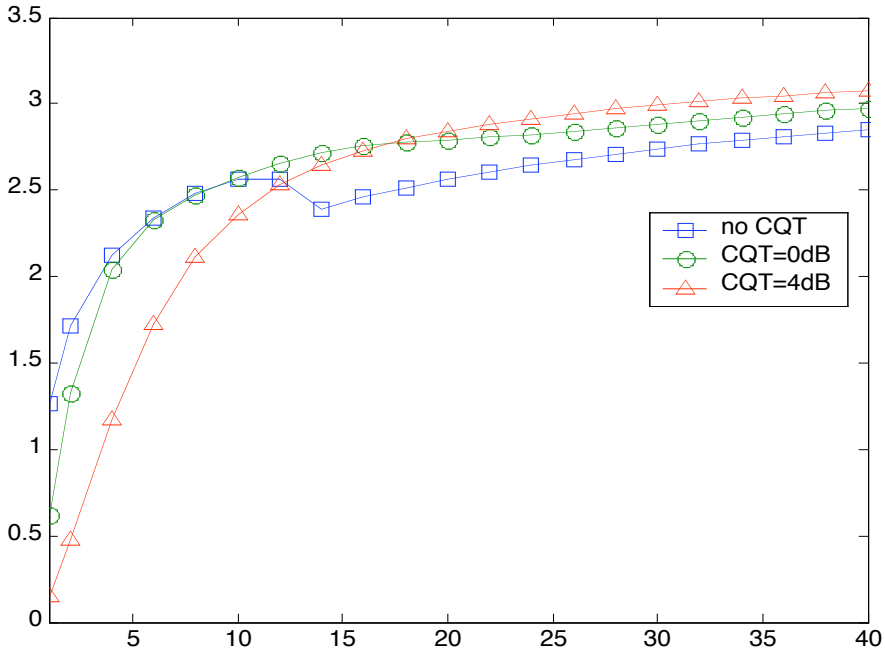

Figure 2- Average capacity versus the number of CQI channels with user position=0.85km away from the center

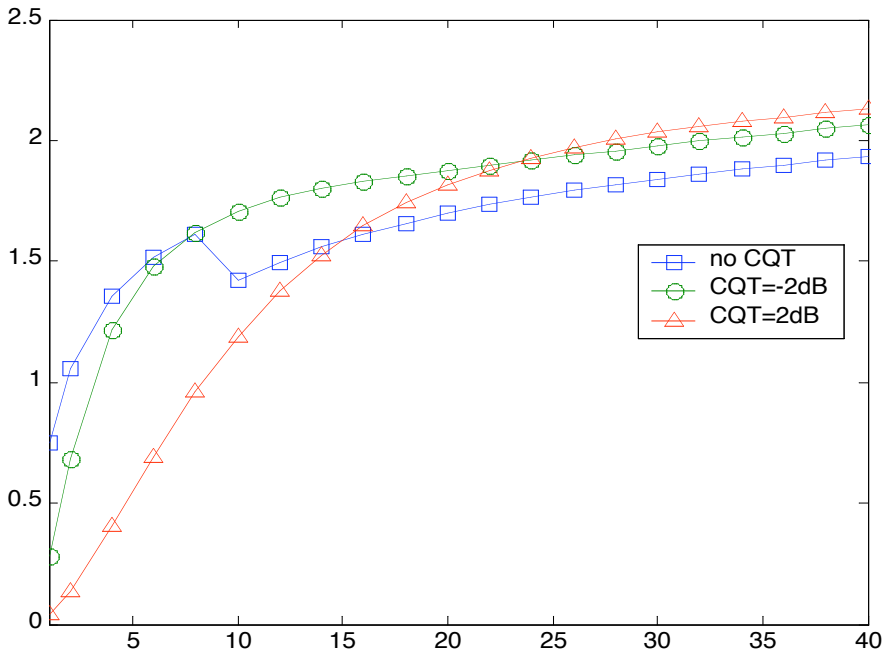

Figure 3- Average capacity versus the number of CQI channels with user position=1km away from the center

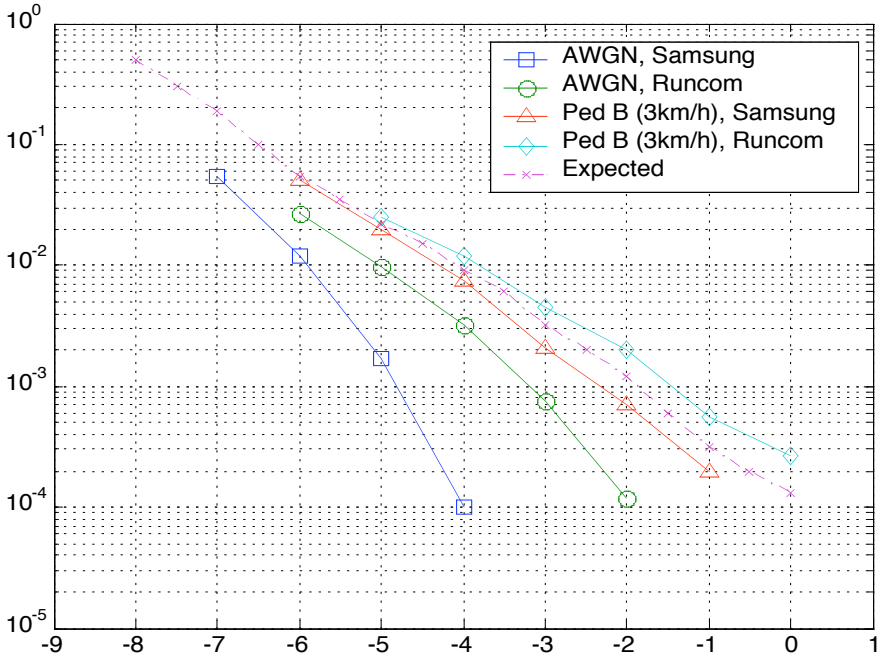

Figure 4- CQICH packet error rate versus SINR (expected)

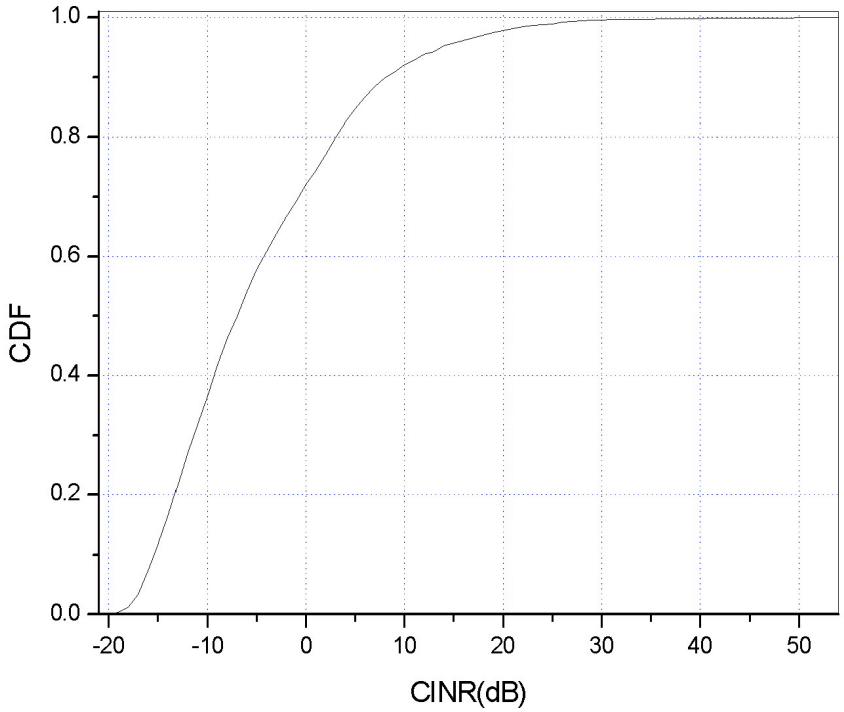

Figure 5-CINR distribution of CQI Channel with 40 CQI channel allocated.