Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**	
Title	**Enhanced Feedback Method for Enhanced FAST_FEEDBACK channels**	
Date Submitted	**2004-11-15**	
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Re:	IEEE P802.16e/D5-2004	
Abstract	This contribution proposes to enhance the feedback content on CQICH. This is a revised contribution. Changes are highlighted in blue.	
Purpose	Review and Adopt the suggested changes into P802.16e/D5	
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1 Introduction

To enable advanced physical layer operations, such as MIMO, FBSS, band AMC and etc, a MSS is required to provide feedback to the BS. In some cases, the amount of feedback contents is large, like multiple band CQI feedback and per MIMO layer CQI feedback, which require more than one fast feedback channels to carry the feedback information. In the current standard text (p802.16e/D5), when multiple CQICHs are allocated to a MSS, each CQICH only carries one kind of feedback information. This approach is very restrictive because a particular type of feedback information may require more than the number of payload bits provided in one CQICH. On the other hand, some other type of feedback information may not require as many payload bits as provided in one CQICH. Therefore, the definition of one CQICH carrying one type of feedback information is inefficient.

In this contribution, we propose an efficient method for a MSS to map one or more types of feedback information onto one or more CQICHs.

The proposed solution is described as follows:

- The key concept of the proposal is to eliminate the payload boundaries between CQICHs allocated to a MSS. For example, the MSS is allocated two CQICHs each with 5 bits of payload every frame, and the MSS is required to feedback type 1 information of 3 bits, and type 2 information of 4 bits periodically. For frame #1, the 10-bit total payload of the two CQICHs will sequentially carry a 3-bit type 1 information, a 4-bit type 2 information, and the next 3-bit type 1 information. For frame #2, the 10-bit CQICHs payload will carry the next 4-bit type 2 information, the next 3-bit type 1 information, and the first 3 bits of the next type 1 information. This mapping process continues for subsequent frames.
- To allow the implementation flexibility of having different combination of feedback from a MSS with different feedback period, we propose the following:
  - A MSS can be instructed by the BS to provide multiple types of feedback. As an example, type 1 (average CQI), type 2 (MIMO mode selection) and type 3 (channel matrix) are required.
  - A feedback cycle is defined and specified by the BS, where each feedback cycle consists of one or more feedback types. As an example, a feedback cycle consists of *L* type 1 (e.g. average CQI) feedback, followed by *M* type 2 (e.g. MIMO mode selection) feedback, followed by *N* type 3 (e.g. channel matrix) feedback.
  - The MSS maps the feedback information defined for each feedback cycle onto the allocated CQICHs in a sequential manner. The process continues from one feedback cycle to another until either the CQICHs are de-allocated or a new feedback instruction is received from the BS.
  - We also introduce a 4-bit indication flag that is inserted by the MSS every *K* feedback cycles. The indication flag is used by the MSS to indicate to the BS its intention to change the definition of the feedback information.

The above concept is illustrated in Figure 1 below. In this example, the MSS is allocated 3 CQICHs with 5-bit payload each. The MSS is required to feedback 3 types of information: 5-bit average CQI, 3-bit MIMO mode selection, and 6-bit channel matrix. The feedback cycle is defined as 10 average CQI feedback, followed by 1 MIMO mode selection feedback and followed by 1 channel matrix feedback. An indication flag is inserted every 2 feedback cycles.

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Inserted: type of feedback information. This approach is very restrictive because a particular type of feedback information may require more than the number of payload bits provided in one CQICH. On the other hand, some other type of feedback information may not require as many payload bits as provided in one CQICH. Therefore, the definition of one CQICH carrying one type of feedback information is inefficient.

Deleted: Based on current standard, the feedback header (section 6.3.2.1.4) and fast feedback channel (CQICH) can be used for this purpose. However, how to mapping the feedback content to multiple CQICH(s) is missing in current standard (p802.16e/D5).

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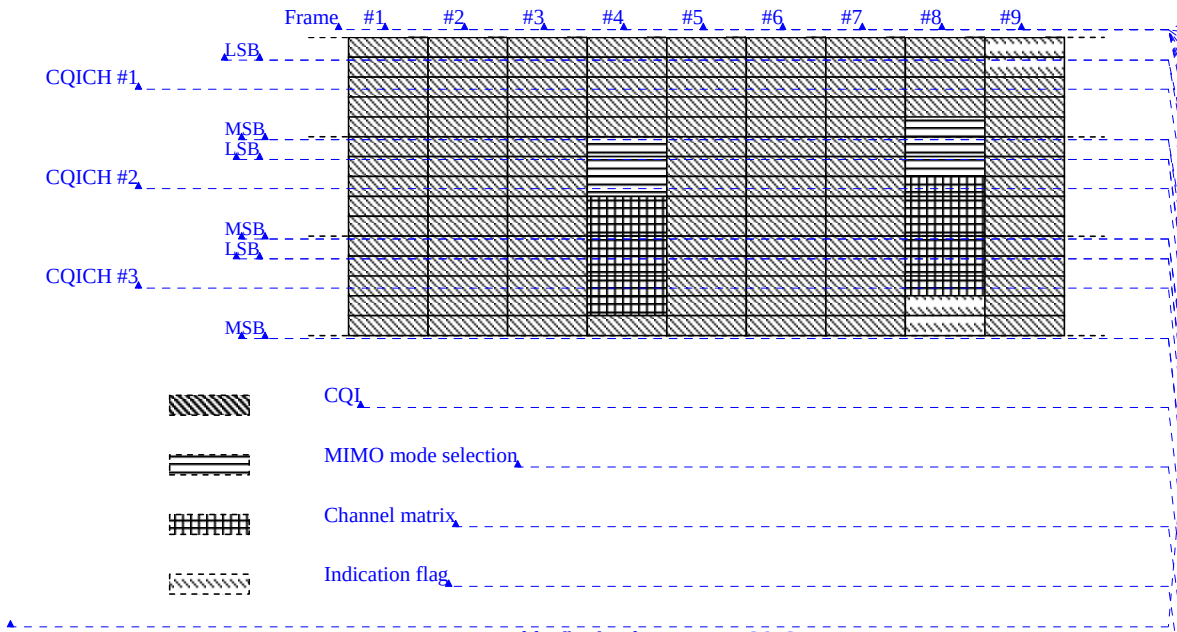

Figure 1 Mapping of feedback information on CQICHs

2 Proposed Text Changes

Remedy 1

Introduce a new IE for the BS to allocate CQICH(s) and define the required feedback information, i.e. feedback types per feedback cycle, and number of feedback cycles to insert the indication flag.

[Insert Section 8.4.5.4.23 Feedback request IE]

8.4.5.4.23 Feedback Request IE

This IE is used by BS to assign one or more fast feedback channel (CQICH) to a MSS and to specify the required feedback information.

Table x – Feedback_request IE

Syntax	Size	Notes
Feedback_Request_IE () {		
Extended UIUC	4 bits	0x??
Length	4 bits	Length in bytes of following fields
Num_Assignments	5 bits	Number of assignments in this IE

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For (i = 0; i <Num_Assignments; i++)		
{		
CID	16 bits	MSS basic CID
CQICH_ID	Variable	Index to uniquely identify the CQICH resource assigned to the MSS
Duration (=d)	3 bits	The CQICH resource is assigned to a MSS for $10x2^d$ frames; If d =0b000, the CQICH is deallocated; If d = 0b111, the MSS shall repor feedback information using the assigned resource until the BS commands for the MSS to stop
If (d !=0b000)		
{		
Num_CQICH	4 bits	Number of CQICHs allocated to the MSS, associated with the CQICH_ID
for (j=0; j<Num_CQICH; j++) {		
Allocation index	6 bits	Index to the fast feedback channel region marked by UIUC = 0.
Frame offset	3 bits	The MSS starts to provide feedback on the allocated CQICH resource at the frame which the number has the same 3LSB as the specified frame offset. If the current frame is specified, the MSS shall start transmit feedback in 8 frames
Period (=p)	2 bits	The allocated CQICH resource is transmitted every 2^p frames
}		
Num_feedback_type	2 bits	Number of feedback types per feedback cycle
Length of AMC band_index	3 bits	number of bits for the AMC band index
Length of CQI value index	2 bits	Indicate the length of CQI value index 0b00: 4 bits 0b01: 5 bits 0b10: 6bits 0b11: reserved
for (j=0;j<Num_feedback_type;j++) {		
Feedback type	4 bits	See Table Z
Num_feedback (=n)	3 bits	The feedback information of type indicated by 'Feedback type' shall be sent 2^n times.
}		
Flag_insertation_indication	1 bit	0: no indication flag is inserted between feedback cycles 1: a 4-bit indication flag is inserted between feedback cycles
If (Flag_insertation_indication ==1)		
{		
Flag_insertion_period (=m)	3 bits	Flag field is inserted every 2^m feedback cycle.

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}		
}		
}		
}		

Upon receiving the Feedback_Request_IE(), the MSS shall transmit the feedback information indicated by the Feedback types, on the assigned CQICH resource. The MSS shall map the feedback information sequentially on the payload bits of the assigned CQICHs resource.

The following example is given as an illustration. The MSS is assigned 3 6-bit CQICHs every frame. The 5 LSB of each CQICH is used to carry the feedback information. The MSS is required to feedback 3 types of information: 5-bit average CQI, 3-bit MIMO mode selection, and 6-bit channel matrix. The feedback cycle is defined as 10 average CQI feedback, followed by 1 MIMO mode selection feedback and followed by 1 channel matrix feedback. An indication flag is inserted every 2 feedback cycles. Figure yyy below illustrates how the feedback information is mapped to the CQICHs resource.

In the case where the MSS is required to feedback *n* band AMC CQIs per feedback cycle, the MSS shall report the CQI of the top *n* AMC bands per feedback cycle.

In the case where the MSS is required to feedback n antenna layer CQIs per feedback cycle, the MSS shall report the CQI of the first n layers per feedback cycle in ascending order of layer index.

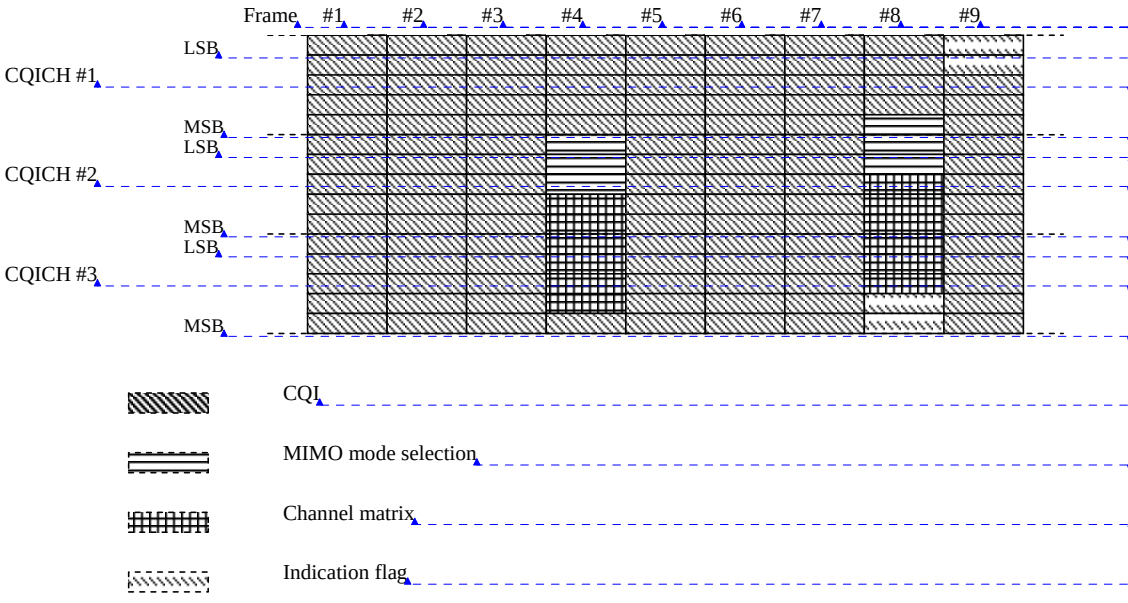

Figure yyy Mapping of feedback information on CQICHs

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Define the feedback types and the associated feedback information to be carried on the assigned CQICHs resource.

[Insert Table Z in the end of the new section 8.4.5.4.23]

Table Z Feedback types

Feedback types	Feedback contents
0000	Average CQI (number of bits = length of CQI value index indicated in the Feedback_Request_IE())
0001	Per antenna layer CQI (number of bits = length of CQI value index indicated in the Feedback_Request_IE())
0010	MIMO mode selection (3 bits)
0011	AMC band index (number of bits = length of AMC band index indicated in the Feedback_Request_IE()) + CQI of the AMC band (number of bits = length of CQI value index indicated in the Feedback_Request_IE())
0100	Closed-loop MIMO precoding matrix (? Bits)
0101	Antenna selection index (3 bits) + 'number of MSS received antenna' occurrences of the CQI values in ascending order of the antenna index. The length of each CQI value is indicated in the 'length of the CQI value index' given in the Feedback_Request_IE().
0110 – 1111	Reserved

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The solution includes the following components:

- Define feedback content formats (e.g., for per-band CQI feedback, the format is defined as “band index (6bits) + CQI of this band (5 bits)”)
- BS polling feedback from a MSS

oDefine a Feedback request IE sent from BS to a MSS, the IE mainly includes the followings:

- CQICH assignments
- The format index and the number of repetition of the contents (the number of content transmission forms feedback cycle)
- The MSS flag insertion indication. If the indication is set, the MSS shall insert a flag field between every one or multiple feedback cycle(s)

oMSS maps the feedback content bits to CQICH payload regardless of the CQICH payload boundary

- MSS autonomously provides feedback type change

oIf a MSS has CQICH(s) allocated by the above feedback request IE, the MSS can use the flag field to indicate a feedback format change

oThe feedback mapping method is the same as that of BS polling feedback

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for the MSS to provide variety of feedback.

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Frame offset	3 bits	The MSS starts to provide MIMO feedback at the frame which the number has the same 3LSB as the specified frame offset. If the current frame is specified, the MSS shall start transmit feedback in 8 frames

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After a MSS receive such a IE, the MSS shall continuously transmit the following information defined in Table XXX during the assignment duration or until the CQICH(s) is deallocated. The information bits are mapped to the assigned CQICH(s) in the following way:

For the first frame where CQICH(s) is allocated, the payload of first CQICH is first filled and the payload of second CQICH is filled up and so on until the all assigned CQICH(s) in the frame is filled up; for the following frames, the above is repeated

Table Y. MIMO feedback.

Syntax	Size	Notes
for (i=0; I < Num _feedback; i++)		If the Num_MIMO_feedback > 1, the feedback, either layer based or AMC band based, shall be in the order so that the layer or AMC band who has the maximum CQI appears first.
{		
Feedback content formatted as indicated by format index	variable	See Table xx. Feedback format.
}		
If (Flag_insertaion_indication == 1)		
Flag	4 bits	0b0000: Falg nothing 0b0001-000110: see Table Z 0b0010-1110: reserved 0b1111: a MSS requesting resource for sending a MAC header (BW request header or feedback header)

}		

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Format index	Feedback contents
1 (STTD/BLAST diversity permutation)	STTD/BLAST selection (1 bit) + Average CQI (the number of bits = length of CQI value index indicated in the corresponding MIMO_CHICH_Alloc_IE, e.g., 4/5/6 bits)
2 (STTD/BLAST antenna grouping for both diversity and AMC band permutations)	STTD/BLAST selection (1 bit) + Antenna group index (2 bits) + average CQI (the number of bits = length of CQI value index indicated in the corresponding MIMO_CHICH_Alloc_IE, e.g., 4/5/6 bits)
3 (STTD/BLAST for AMC band permutation)	Layer index (2 bits) + AMC band index (number of bits = Length of band_index indicated in the corresponding MIMO_CHICH_Alloc_IE) + CQI (the number of bits = length of CQI value index indicated in the corresponding MIMO_CHICH_Alloc_IE, e.g., 4/5/6 bits)
4 (feedback Channel H for AMC band permutation)	layer index(2 bits)+H (xx bits-depending on antenna configuration)
5 (feedback transmission weights for AMC band permutation)	layer index(2 bits)+W (xx bits-depending on antenna configuration) + CQI (the number of bits = length of CQI value index indicated in the corresponding MIMO_CHICH_Alloc_IE, e.g., 4/5/6 bits)
6 (feedback V matrix for AMC band permutation)	layer index(2 bits)+V (xx bits-depending on antenna configuration) + CQI (the number of bits = length of CQI value index indicated in the corresponding MIMO_CHICH_Alloc_IE, e.g., 4/5/6 bits)

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0011010	AMC band index (number of bits = length of AMC band index indicated in the Feedback_Request_IE()) + CQI of the AMC band (number of bits = length of CQI value index indicated in the Feedback_Request_IE())
0100011	Closed-loop MIMO precoding matrix (? Bits)

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001001	MIMO mode selection (3 bits)
0011010	AMC band index (number of bits = length of AMC band index indicated in the

	Feedback_Request_IE()) + CQI of the AMC band (number of bits = length of CQI value index indicated in the Feedback_Request_IE())

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0100011	Closed-loop MIMO precoding matrix (? Bits)
0101100	Antenna selection index (3 bits) + 'number of MSS received antenna' occurrences of the CQI values in ascending order of the antenna index. The length of each CQI value is indicated in the 'length of the CQI value index' given in the Feedback_Request_IE().

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0101100	Antenna selection index (3 bits) + 'number of MSS received antenna' occurrences of the CQI values in ascending order of the antenna index. The length of each CQI value is indicated in the 'length of the CQI value index' given in the Feedback_Request_IE().
011001 –– 1111	Reserved