Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Soft packet combing for STC re-transmission to improve H-ARQ performance in MIMO mode**
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Source:	Wen Tong, Peiying Zhu, Ming Jia, ,Jianglei Ma, Hang Zhang and Mo-Han Fong Nortel Networks 3500 Carling Avenue Ottawa, ON. K2H 8E9 CANADA Voice: (613)-763-1315 Fax: (613)-765-7723 wentong@nortelnetworks.com
Re:	IEEE 802.16e D3 Draft
Abstract	Soft packet combing for STC re-transmission to improve H-ARQ performance in MIMO mode This is a revision of the contribution. Inserted texts are highlighted in blue. The deleted texts are stroked out.
Purpose	To incorporate the changes here proposed into the 802.16e D4 draft.
Notice	
Release	
Patent Policy and Procedures	

Soft packet combing for STC re-transmission to improve H-ARQ performance in MIMO mode

1 Background

The current HARQ scheme in IEEE802.16REVd/D5 [1] is designed for single antenna operation. If a user is experiencing a deep fading and moving slowly, many retransmissions may be needed in order to recover the transmitted data. In MIMO mode, we can exploit spatial diversity to enhance the HARQ performance through proper arrangement of the re-transmission packet. In this contribution, we first discuses the soft packet combing for MIMO, then proposes the text to be incorporated into the standard.

1.1 Soft packet combing for MIMO

In the MIMO mode transmission, if the packet at receiver decoding is in error, then a re-transmission is requested, the MIMO transmitter can use the same STC format to re-send the packet. In this case, the packet can be re-transmitted use the same FEC encoded packet or can be re-transmitted using different FEC redundancy, the re-transmitted packet and erroneous packet can be combined in soft symbol form or can be decoded with the re-transmitted packet and erroneous packet as a code coming. This is so called hybrid ARQ. However, the benefit of the H-ARQ can be further extended to the space time domain in the MIMO mode. This is so called soft MIMO packet combining. The key advantage of the soft MIMO packet combining over the existing FEC based HARQ is that MIMO packet combing can further exploit the spatial diversity of the MIMO channel, this is particular effective when the channel fading is slow, since the conventional FEC based H-ARQ mainly relies on time diversity to improve the throughput. As we can see that the MIMO packet combing can significantly reduce the re-transmission number and reduce the packet re-transmission time. In what follows, we present a solution for IEEE802.16d. Assume the first transmit MIMO packet is a spatial multiplexing: $\begin{bmatrix} s_1 \\ s_2 \end{bmatrix}$, if the re-transmission of the same packet is send in the form of $\begin{bmatrix} -s_2^* \\ s_1^* \end{bmatrix}$ then the 1st and 2nd transmission can be jointly decoder as an Alamouti space time block code. In additional to the soft combing gain, such a re-transmission allows further exploiting the space time block coding gain. If the 2nd transmission is still in error, then the 3rd re-transmission can be sent as $\begin{bmatrix} s_1 \\ s_2 \end{bmatrix}$ such that the 2nd and 3rd transmission to form a space time block code, they can be jointly decoded. After STC decoding, the 1st STC decoding output and 2nd STC decoding output can be combing at FEC code symbol level by using Chase combing. The major advantage of this technique is in the slow fading case, where the coherent time is large; the temporal diversity of the conventional FEC based H-ARQ causes long packet retransmission delay, e.g. when in the deep fade. The issue associated with the STC based MIMO soft-packet combing is the in the fast fading, the channel can vary significantly between the re-transmission; therefore, the straightforward Alamouti decoding becomes not effective. To solve this problem, we could treat the re-transmission packet as additional virtual receive antennas and jointly decode the consecutive transmission as a zero-forcing receiver for the 2x4 spatial multiplexing mode.

$$\begin{bmatrix} r_{1,t_1} \\ r_{2,t_1} \\ r_{1,t_2}^* \\ r_{2,t_2}^* \end{bmatrix} = \begin{bmatrix} h_{11,t_1} & h_{12,t_1} \\ h_{21,t_1} & h_{22,t_1} \\ h_{12,t_2}^* & -h_{11,t_2}^* \\ h_{22,t_2}^* & -h_{21,t_2}^* \end{bmatrix} \begin{bmatrix} s_1 \\ s_2 \end{bmatrix}$$

We have $\vec{r} = H\vec{s}$ then the soft MIMO packet combing output is $\vec{s} = \left(H^* H\right)^{-1} H^* \vec{r}$, note that here the soft combing is simply a re-use of the spatial multiplexing receiver. Figure 1 shows the performance advantages of the soft MIMO packet combing solution for the 2x2 spatial multiplexing transmissions. In this case, the 5ms re-transmission delay and one re-transmission are assumed. It can be seen clearly that space time diversity improves significantly the packet re-transmission performance. For the 3km/h speed Alamouti decoder and zero-forcing SM decoder have the same performance. For the

100km/h speed, and zero-forcing SM decoder is used. The zero-forcing receiver can be generally used to handle all the mobile speed range.

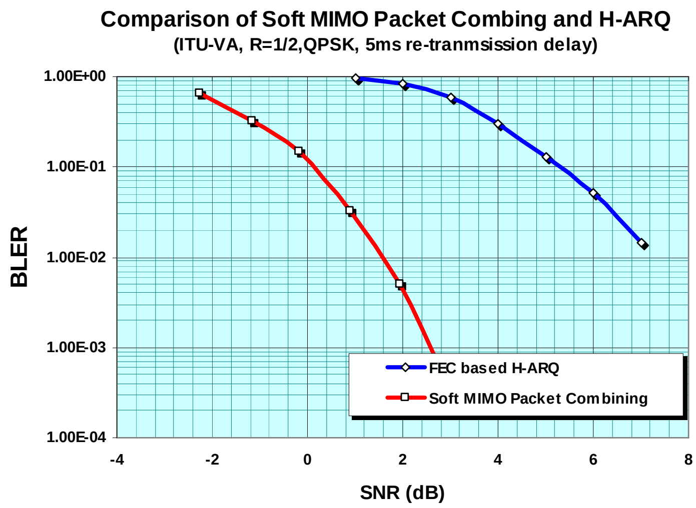

Figure 1 Performance for soft MIMO packet combining at 3km/h

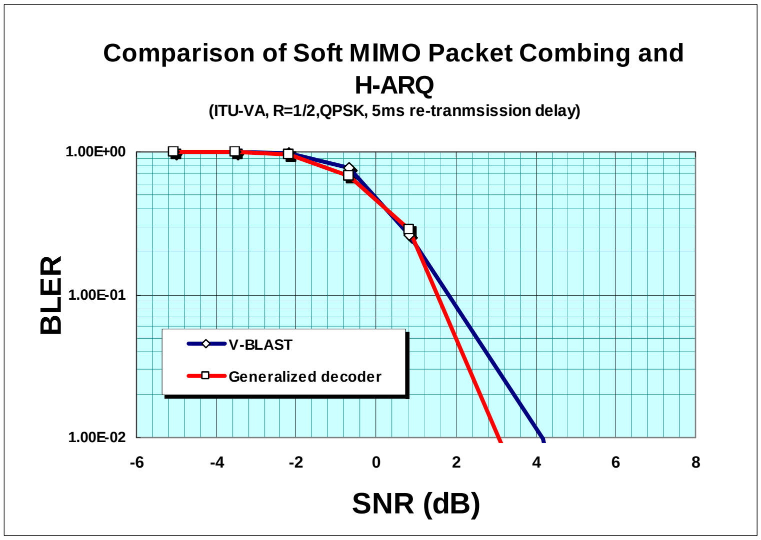

Figure 2 Performance for soft MIMO packet combining at 100km/h

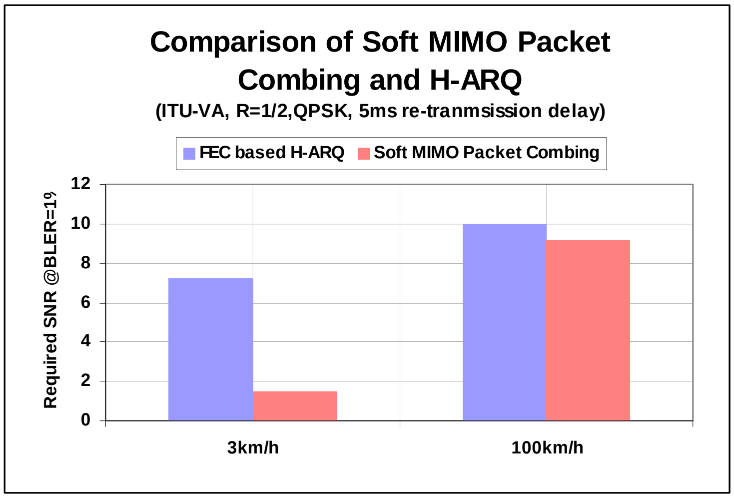

Figure 3 Performance for soft MIMO packet combining

In Figure 1,2,3, the SNR are the long term average SNR value; the soft MIMO packet combing can provide significant gain and H-ARQ receiver can reuse the zero-forcing receiver for the spatial multiplexing mode.

2 Specific text changes

2.1 *Soft packet combing for MIMO*

[Add new section 8.4.8.9]

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8.4.8.92.3.6 STC sub-packet combing

In the STC transmission, for both downlink and uplink, the STC sub-packet re-transmission can be generated by using the Space time code incremental redundancy version. The transmission rule for space time coded incremental redundancy codes set is listed in Table aaa-2 and Table aaa-3.

Table aaa-2 H-ARQ Incremental space time coding redundancy (2-transmit antenna case)

	initial transmission	odd re-transmission	even re-transmission
Space time code incremental redundancy for matrix A	$S_2^{(0)} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix}$	$S_2^{(odd)} = \begin{bmatrix} -s_2^* & s_1 \\ s_1^* & s_2 \end{bmatrix}$	$S_2^{(even)} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1 \end{bmatrix}$
Space time code incremental redundancy for matrix A	$S_2^{(0)} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix}$	$S_2^{(odd)} = \begin{bmatrix} -s_2^* \\ s_1^* \end{bmatrix}$	$S_2^{(even)} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix}$

Table aaa-3 H-ARQ Incremental space time coding redundancy (4-transmit antenna case)

	initial transmission	odd re-transmission	even re-transmission

Space time code incremental redundancy for matrix A	$S_4^{(0)} = \begin{bmatrix} s_1 & -s_2^* & 0 & 0 \\ s_2 & s_1^* & 0 & 0 \\ 0 & 0 & s_3 & -s_4^* \\ 0 & 0 & s_4 & s_3^* \end{bmatrix}$	$S_4^{(odd)} = \begin{bmatrix} -s_2^* & s_1 & 0 & 0 \\ s_1^* & s_2 & 0 & 0 \\ 0 & 0 & -s_4^* & s_3 \\ 0 & 0 & s_3^* & s_4 \end{bmatrix}$	$S_4^{(even)} = \begin{bmatrix} s_1 & -s_2^* & 0 & 0 \\ s_2 & s_1^* & 0 & 0 \\ 0 & 0 & s_3 & -s_4^* \\ 0 & 0 & s_4 & s_3^* \end{bmatrix}$
Space time code incremental redundancy for matrix B	$S_4^{(0)} = \begin{bmatrix} s_1 & -s_2^* & s_5 & -s_7^* \\ s_2 & s_1^* & s_6 & -s_8^* \\ s_3 & -s_4^* & s_7 & s_5^* \\ s_4 & s_3^* & s_8 & s_6^* \end{bmatrix}$	$S_4^{(odd)} = \begin{bmatrix} -s_2^* & s_1 & -s_7^* & s_5 \\ s_1^* & s_2 & -s_8^* & s_6 \\ -s_4^* & s_3 & s_5^* & s_7 \\ s_3^* & s_4 & s_6^* & s_8 \end{bmatrix}$	$S_4^{(even)} = \begin{bmatrix} s_1 & -s_2^* & s_5 & -s_7^* \\ s_2 & s_1^* & s_6 & -s_8^* \\ s_3 & -s_4^* & s_7 & s_5^* \\ s_4 & s_3^* & s_8 & s_6^* \end{bmatrix}$
Space time code incremental redundancy for matrix C	$S_4^{(0)} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \end{bmatrix}$	$S_4^{(odd)} = \begin{bmatrix} -s_2^* \\ s_1^* \\ -s_4^* \\ s_3^* \end{bmatrix}$	$S_4^{(even)} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \end{bmatrix}$

The MSS shall process the initial transmission, 1st re-transmission and 2nd re-transmission etc in the form of space time decoding. The re-transmission of FEC code word shall use the Chase combing re-transmission version, in this case, the sub-packet index SPID is always set to zero in section 8.4.9.2.3.6.

---------End text proposal-------

[Section 6.3.2.3.43.5]

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Table 92—H-ARQ_Control IE format

Syntax	Size	Notes
H-ARQ_Control_IE () {		In DL/UL-MAP
Prefix	1 bit	0 = Temporary disable H-ARQ 1 = enable H-ARQ
if (Prefix ==1){		
AI_SN	1 bits	H-ARQ ID Seq. No
SPID	2 bits	Subpacket ID
ACID	4 bits	H-ARQ CH ID
} else{		
Reserved	3 bit	
}		
}		
}		

Prefix
Indicates wether H-ARQ is enable or not
AI_SN
Defines ARQ Identifier Sequence Number. This is toggled between '0' and '1' on successfully transmitting each encoder packet with the same ARQ channel, when set SPID = 0, the MIMO HARQ is enabled
SPID
Defines SubPacket ID, which is used to identify the four subpackets generated from an encoder packet.
ACID

Defines H-ARQ Channel ID, which is used to identify H-ARQ channels. Each connection can have multiple H-ARQ channels, each of which may have an encoder transaction pending

---------End text proposal-------

[Insert section 11.8.3.7.6]

---------Start text proposal-------

11.8.3.7.6 OFDMA MIMO Support

This field indicates the different STC options supported by a WirelessMAN-OFDMA PHY MSS. A bit value of 0 indicates "not supported" while 1 indicates "supported"

Type	Length	Value	Scope
155	1	Bit #0: Single receive antenna capable of STC Bit #1: Two receive antennas capable of STC only Bit #2: Two receive antennas capable of STC and SM Bit #3: Four receive antennas capable of STC only Bit #4 : Four receive antennas capable of STC and SM Bit #5: Two transmit antennas Bit #6: Single transmit antenna capable of cooperative MIMO SM Bit #7: MIMO HARQ	SBC-REQ(see 6.3.2.3.23) SBC-RSQ(see 6.3.2.3.24)

---------End text proposal-------

[1] IEEE P802.16-REVd/D5-2004 Air Interface For Fixed Broadband Wireless Access Systems