

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	
Date Submitted	2004-05-17	
Source:	Wen Tong, Peiyong 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 D2 Draft	
Abstract	Soft packet combing for STC re-transmission to improve H-ARQ performance in MIMO mode	
Purpose	To incorporate the changes here proposed into the 802.16e D2 draft.	
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 < http://ieee802.org/16/ipr/patents/policy.html >, including the statement "IEEE standards may include the known use of patent(s), including patent applications, provided the IEEE receives assurance from the patent holder or applicant with respect to patents essential for compliance with both mandatory and optional portions of 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:chair@wirelessman.org > as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard being developed within the IEEE 802.16 Working Group. The Chair will disclose this notification via the IEEE 802.16 web site < http://ieee802.org/16/ipr/patents/notices >.	

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 discuss the soft packet combing for MIMO, then propose 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 combining 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 combining 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 to further exploit 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 $\bar{r} = H\bar{s}$ then the soft MIMO packet combing output is $\bar{s} = (H^*H)^{-1}H^*\bar{r}$, 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. 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.

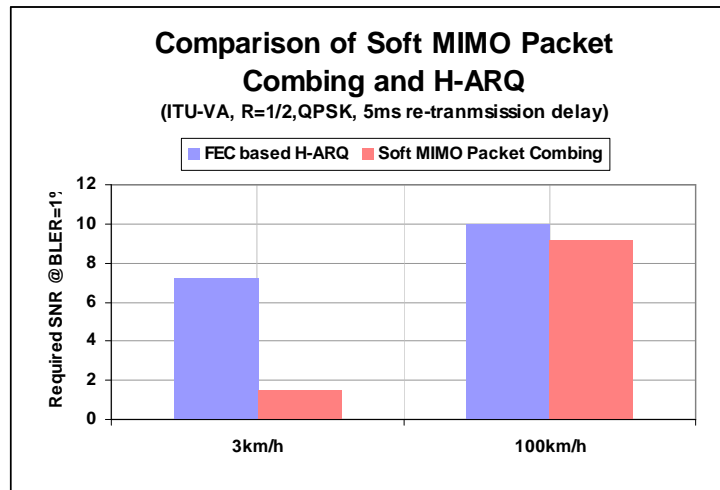


Figure 1 Performance for soft MIMO packet combining

2 Specific text changes

2.1 Soft packet combining for MIMO

[Add new section 8.4.8.9]

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

8.4.8.9 MIMO sub-packet combining

In the MIMO transmission, for both downlink and uplink, the MIMO 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	$S_{2 \times N_R}^{(0)} = \begin{bmatrix} s_1 & s_3 \\ s_2 & s_4 \end{bmatrix}$	$S_{2 \times N_R}^{(odd)} = \begin{bmatrix} -s_2^* & -s_4^* \\ s_1^* & s_3^* \end{bmatrix}$	$S_{2 \times N_R}^{(even)} = \begin{bmatrix} s_1 & s_3 \\ s_2 & s_4 \end{bmatrix}$

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	$S_{4 \times N_R}^{(0)} = \begin{bmatrix} s_1 & s_5 \\ s_2 & s_6 \\ s_3 & s_7 \\ s_4 & s_8 \end{bmatrix}$	$S_{4 \times N_R}^{(odd)} = \begin{bmatrix} -s_2^* & -s_6^* \\ s_1^* & s_5^* \\ -s_4^* & -s_8^* \\ s_3^* & s_7^* \end{bmatrix}$	$S_{4 \times N_R}^{(even)} = \begin{bmatrix} s_1 & s_5 \\ s_2 & s_6 \\ s_3 & s_7 \\ s_4 & s_8 \end{bmatrix}$

The SS 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 is always set to zero in section 8.4.9.2.3.6.

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

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