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Re:	This is a response to a Call for Comments on IEEE P802.16e-D5a
Abstract	STC sub-packet combining scheme can be enhanced in OFDMA. Revised texts are noticed with yellow background
Purpose	This document is submitted for review by 802.16e Working Group members
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Patent Policy and Procedures	

Enhanced STC sub-packet combining in OFDMA

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1. Introduction

1.1 STC subpacket combining

In OFDMA of the current 802.16 standard, STC sub-packet retransmission schemes for 2, 3 and 4-antenna spatial multiplexing scheme are provisioned in section '8.4.8.9 STC sub-packet combining'. This scheme gives the efficient retransmission in the low mobility because the pairs of transmit antennas consist of STTD structure.

Received signal with the initial and retransmission packets are written as follows:

$$x_{init} = H_{init}\, s + v_1$$

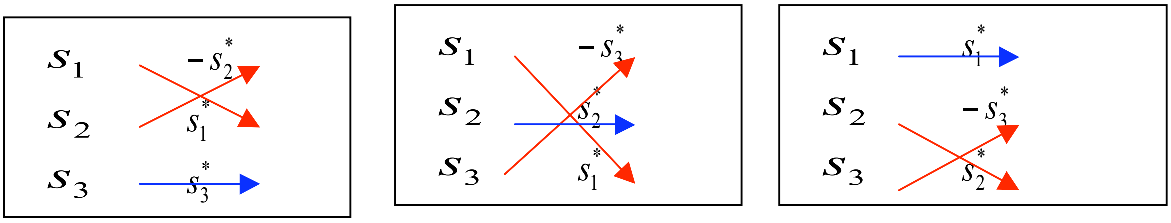
$$x_{retx} = H_{retx}\, s_{retx} + v_2$$

where $\begin{bmatrix} s & s_{retx} \end{bmatrix} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \\ s_3 & s_3^* \end{bmatrix}$ for 3 tx antenna and $\begin{bmatrix} s & s_{retx} \end{bmatrix} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \\ s_3 & -s_4^* \\ s_4 & s_3^* \end{bmatrix}$ for 4 tx antennas as shown in table 315m and 315n. In the current specification, the retransmission subpacket has a fixed form as above, however, retransmission subpacket format adaptation according to channel condition can improve the system performance. There are two more alternative retransmission formats in 3 and 4 transmit antennas system as follows:

$$\text{For 3 transmit antenna system, Alternative 1}: \begin{bmatrix} -s_{i+2}^* \\ s_{i+1}^* \\ s_{i+3}^* \end{bmatrix},\quad \text{Alternative 2}: \begin{bmatrix} -s_{i+3}^* \\ s_{i+2}^* \\ s_{i+1}^* \end{bmatrix},\quad \text{Alternative 3}: \begin{bmatrix} s_{i+1}^* \\ -s_{i+3}^* \\ s_{i+2}^* \end{bmatrix}$$

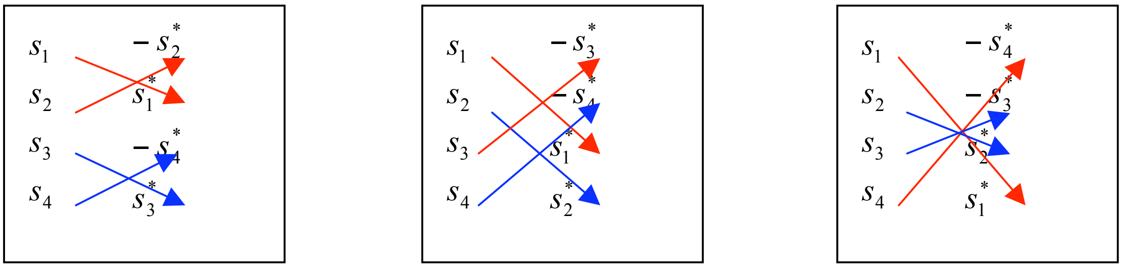
$$\text{For 4 transmit antenna system, Alternative 1}: \begin{bmatrix} -s_{i+2}^* \\ s_{i+1}^* \\ -s_{i+4}^* \\ s_{i+3}^* \end{bmatrix},\quad \text{Alternative 2}: \begin{bmatrix} -s_{i+3}^* \\ -s_{i+4}^* \\ s_{i+1}^* \\ s_{i+2}^* \end{bmatrix},\quad \text{Alternative 3}: \begin{bmatrix} -s_{i+4}^* \\ -s_{i+3}^* \\ s_{i+2}^* \\ s_{i+1}^* \end{bmatrix}$$

For 3 transmission antennas, alternative 1 retransmission sub-packet and initial transmission sub-packet consist of STTD structure with antenna 1 and antenna 2, alternative 2 and initial sub-packet form STTD structure with antenna 1 and antenna 3, and alternative 3 and initial sub-packet consist of STTD structure with antenna 2 and antenna 3 as shown in Figure 1. For 4 transmission antennas, there are same principles as shown in Figure 2.



(a) alternative 1 (b) alternative 2 (c) alternative 3

Figure 1. STTD structure in each alternative for 3 tx antennas



(a) alternative 1 (b) alternative 2 (c) alternative 3

Figure 2. STTD structure in each alternative for 4 tx antennas

With the proposed scheme for 4 tx antenna system, the first re-transmission sub-packet combining with the initial transmission constitutes a double STTD, the receiver can combine sub-packets with MMSE receiver, the 2nd and 3rd re-transmissions follows the same structure as the previous two, and it can be further combined in energy with the result of first MMSE result of the first pair of double STTD. However, we can further exploit the diversity gain from the 2nd and 3rd re-transmissions, in this case, the mapping of the s_1, s_2 between s_3, s_4 can be swapped to achieve the full diversity for 4 transmit antennas. The similar principle applies for 3 tx antenna system. This proposed retransmission scheme is a harmonized scheme of those presented in C80216e-04_509r4 and C80216e-05_083r1. The proposed solutions are listed in Table 315m and Table 315n.

Follow the same reason, the idea of sub-packet combining can be applied to rate-2 STTD with 3 and 4 transmit antennas. Notice that for such a system, the principle of antenna grouping should already have been applied in the first transmission, as discussed above. However, for the 2nd retransmission, the antenna assignment needs to be switched to achieve quasi-orthogonality and enhanced diversity.

1.2 ACK/NACK Signaling with alternatives

To send back one of alternatives with NACK signal, it is required to add the one value to current ACK/NACK values.

Then there are four values indicating ACK, NACK with alternative 1, 2 and 3.

2. Proposed Text Change

[Replace Table 318m and Table 318n in section 8.4.8.9 STC subpacket combining]

Table 318m – STC subpacket combining (3–transmit antenna case)

	initial transmission	odd retransmission	even retransmission
Space time code incremental redundancy for C	$S^{(0)} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \end{bmatrix}$	$S^{(odd)}_{\text{ALT1}} = \begin{bmatrix} -s_2^* \\ s_1^* \\ s_3^* \end{bmatrix}$ $S^{(odd)}_{\text{ALT2}} = \begin{bmatrix} -s_3^* \\ s_2^* \\ s_1^* \end{bmatrix}$ $S^{(odd)}_{\text{ALT3}} = \begin{bmatrix} s_1^* \\ -s_3^* \\ s_2^* \end{bmatrix}$	$S^{(even)}_{\text{ALT1}} = \begin{bmatrix} s_3 \\ s_1 \\ s_2 \end{bmatrix}$ $S^{(even)}_{\text{ALT2}} = \begin{bmatrix} s_2 \\ s_3 \\ s_1 \end{bmatrix}$ $S^{(even)}_{\text{ALT3}} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \end{bmatrix}$

Table 318n – STC subpacket combining (4 –transmit antenna case)

	initial transmission	odd retransmission	even retransmission
Space time code incremental redundancy for C	$S^{(0)} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \end{bmatrix}$	$S^{(odd)}_{\text{ALT1}} = \begin{bmatrix} -s_2^* \\ s_1^* \\ -s_4^* \\ s_3^* \end{bmatrix}$ $S^{(odd)}_{\text{ALT2}} = \begin{bmatrix} -s_3^* \\ -s_4^* \\ s_1^* \\ s_2^* \end{bmatrix}$ $S^{(odd)}_{\text{ALT3}} = \begin{bmatrix} -s_4^* \\ -s_3^* \\ s_2^* \\ s_1^* \end{bmatrix}$	$S^{(even)}_{\text{ALT1}} = \begin{bmatrix} s_3 \\ -s_4 \\ -s_1 \\ s_2 \end{bmatrix}$ $S^{(even)}_{\text{ALT2}} = \begin{bmatrix} s_2 \\ s_1 \\ s_4 \\ s_3 \end{bmatrix}$ $S^{(even)}_{\text{ALT3}} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \end{bmatrix}$

[***Apply the following into the 8.4.5.4.17 Optional Enhanced UL ACK channels***]

8.4.5.4.17 Optional Enhanced UL ACK channels

The uplink ACK (Acknowledgement) provides feedback for Downlink Hybrid ARQ. This channel shall only be supported by MSS supporting H-ARQ. The MSS transmits ACK or NAK feedback for Downlink packet data. One ACK channel occupies a half subchannel, which is 3 pieces of a 3x3 uplink tile in the case of optional PUSC or 3 pieces of a 4x3 uplink tile in the case of PUSC. The acknowledgement ~~bit~~ of the n-th ACK channel shall be ~~'0' (ACK)~~`ACK' if the corresponding downlink packet has been successfully received; otherwise, it shall be ~~'1' (NAK)~~`NAK'. This ~~1-bit~~ acknowledgement is encoded into a length 3 codeword over an 8-ary alphabet for the error protection as shown in Table 298c.

Table 298c-ACK channel subcarrier modulation

ACK ~~1-bit~~ Symbol	Vector Indices per Tile Tile(0), Tile(1), Tile(2)
ACK	0,0,0
NACK (with alternative 1 if H-ARQ mode = MIMO STC H-ARQ)	4,7,2
NACK with alternative 2 (if H-ARQ mode= MIMO STC H-ARQ)	1,2,3
NACK with alternative 3 (if H-ARQ mode= MIMO STC H-ARQ)	3,6,5

3. Simulation results

In order to evaluate the benefit of the proposed solution, we present the post MMSE combiner SNR increment CDF distribution; in this the statistic of the 4 sub-packet re-transmissions for the current IEEE802.16e, the contribution C80216e-05_083r1, C802162-04_509r4 and the proposed combining are shown in Figure 3 and Figure 4. As we can see the proposed sub-packet combing gives the more post SNR increment at MMSE combiner.

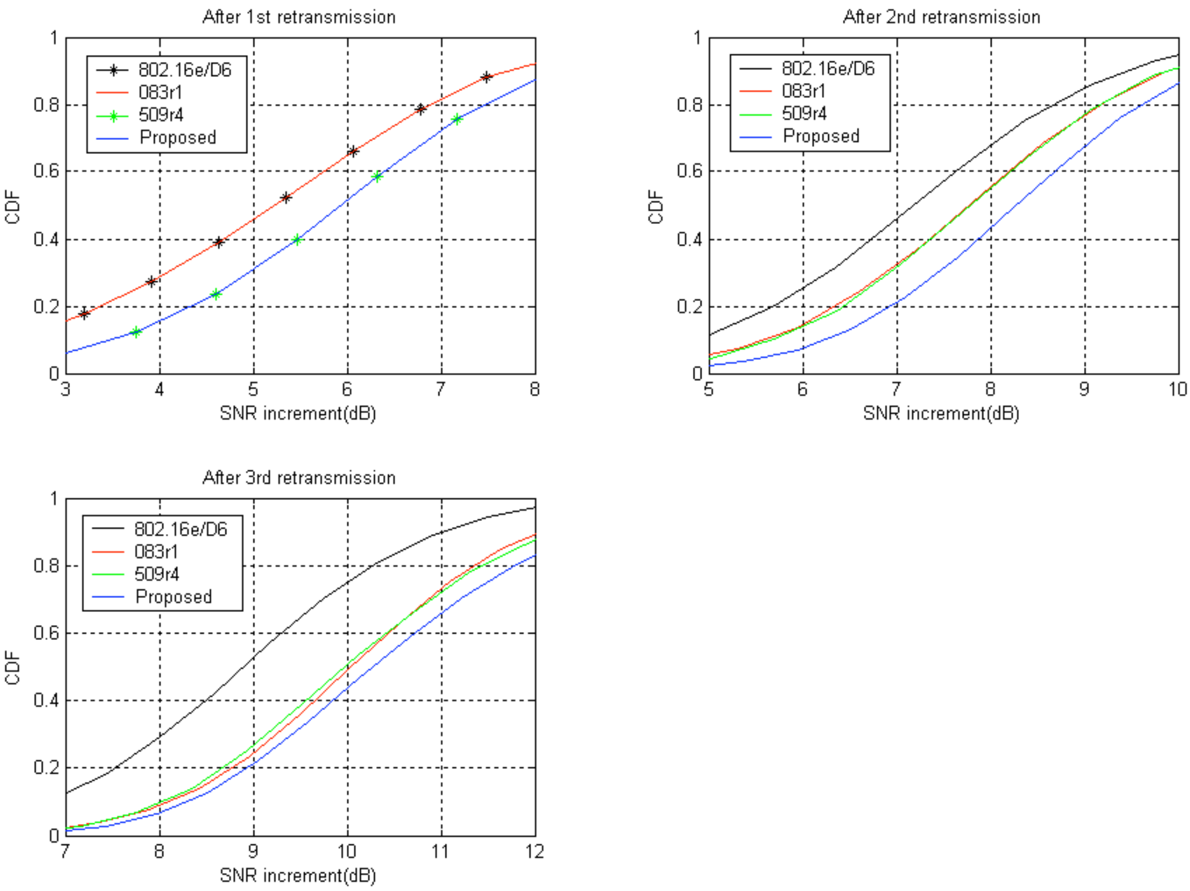


Figure 3. Post SNR increment distribution for sub-packet re-transmissions of 4 tx antennas (3km/h, subpacket retransmission delay=10ms)

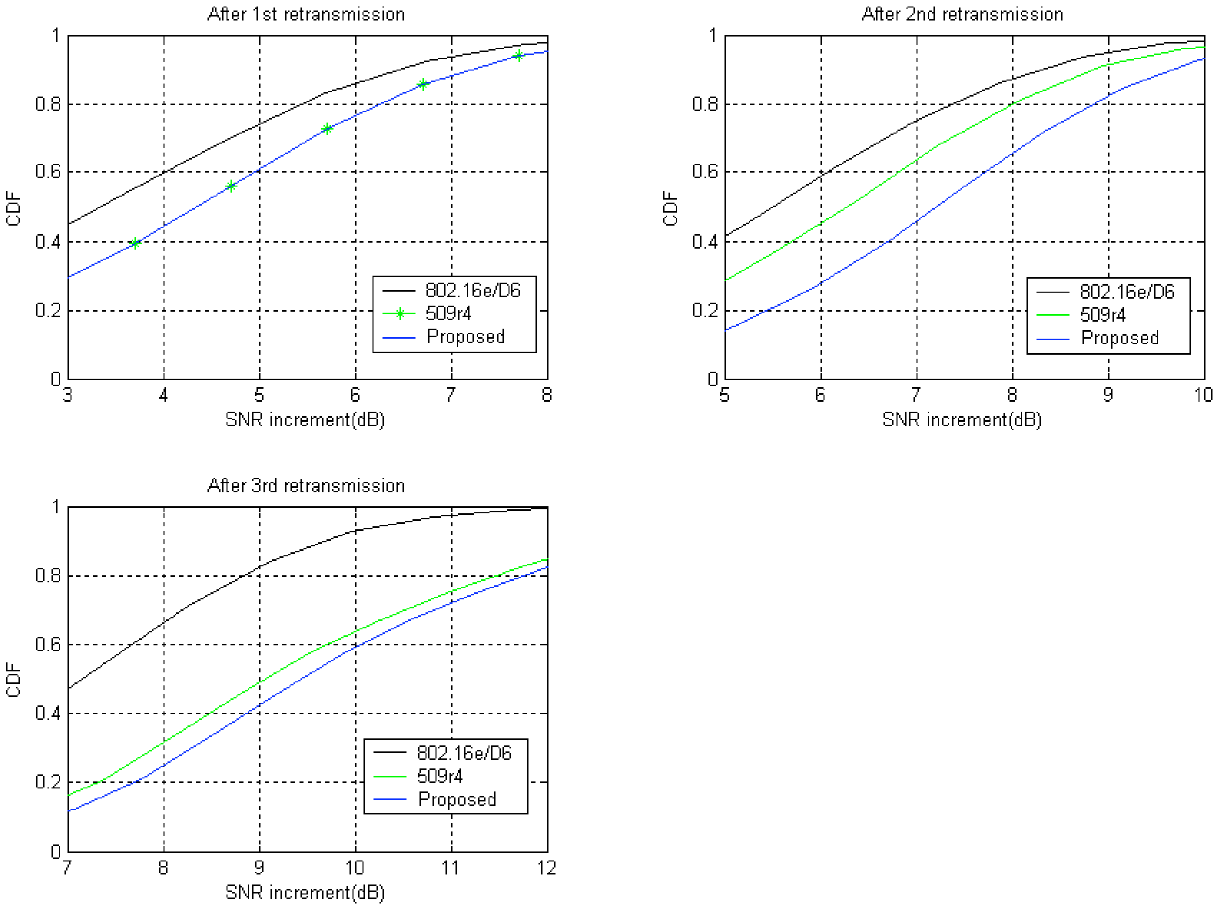


Figure 4. Post SNR increment distribution for sub-packet re-transmissions of 3 tx antennas (3km/h, subpacket retransmission delay=10ms)

Figure 5 shows the ACK/NACK packet error rate under AWGN and Ped_B 3km/h and 2 rx antennas at BS, in which degradation of detection error of the 4-value ACK/NACK proposed in this contribution is about two times of the 2-value ACK/NACK signaling.

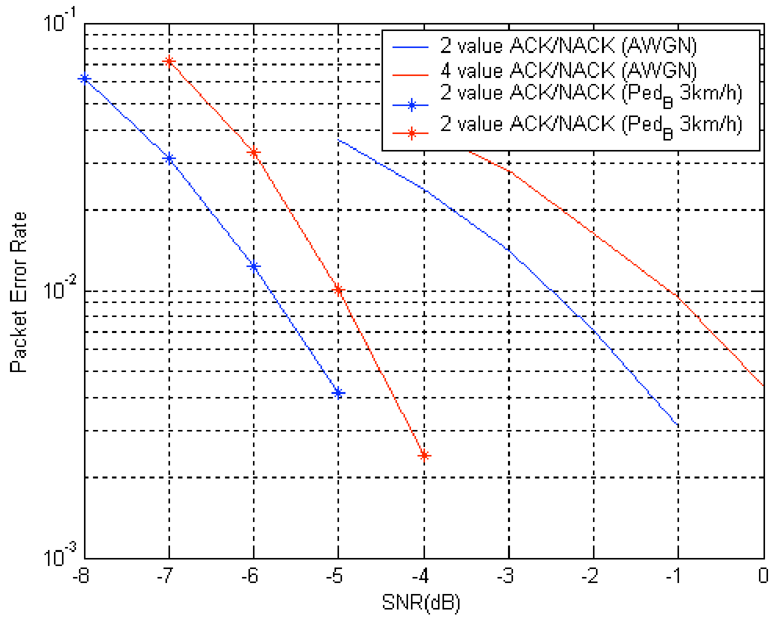


Figure 5. ACK/NACK packet error rate

However, even though considering this ACK/NACK error rate, the proposed retransmission scheme can get the about 10% more throughput as shown in Figure 6, where the simulation was performed under the condition of convolutional coding 1/2, QPSK, Ped_B 3km/h, 4 tx antennas and 10ms time gap between the even retransmission sub-packet and the odd retransmission sub-packet. ACK/NACK error rates are 2% and 1% at the proposed scheme and the current scheme, respectively.

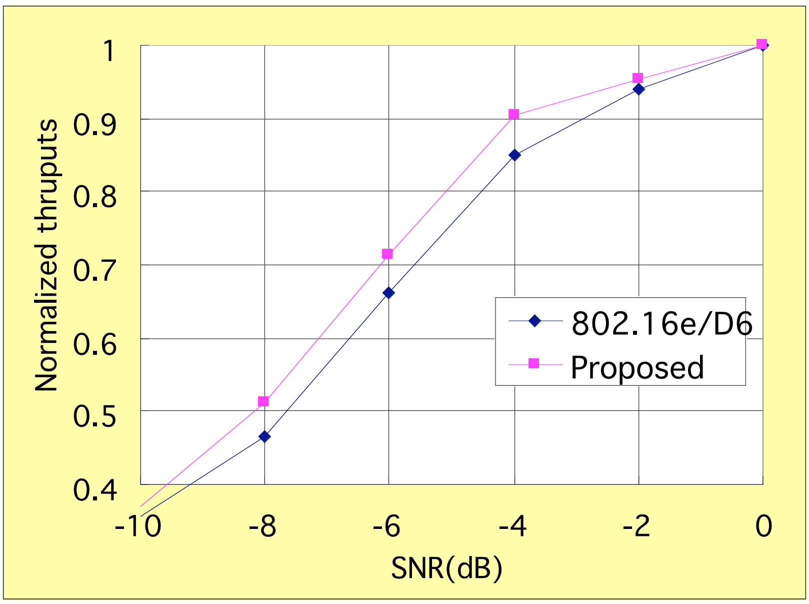


Figure 6. Link throughput between the current scheme and the proposed scheme