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Source(s)	Bin-Chul Ihm, Yongseok Jin, Jinyoung Chun LG Electronics, Inc. 533,Hogye-1dong, Dongan-gu, Anyang-shi, Kyongki-do, Korea Voice: 82-31-450-7187 Fax: 82-31-450-7912 [mailto: {bcihm, jayjay, jychun03}@lge.com] Ran Yaniv, Tal Kaitz Alvarion Ltd. [mailto:{ran.yaniv, tal.kaitz@alvarion.com}]
Re:	This is a response to a Call for Comments on IEEE P802.16e-D5a
Abstract	STC sub-packet combining scheme can be applied with adaptive antenna grouping in OFDMA. The revised text is in pink color.
Purpose	This document is submitted for review by 802.16e Working Group members
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STC sub-packet combining with antenna grouping for 3 and 4 transmit antennas in OFDMA

Bin-chul Ihm, Jinyoung Chun and Yongseok Jin
LG Electronics

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:

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

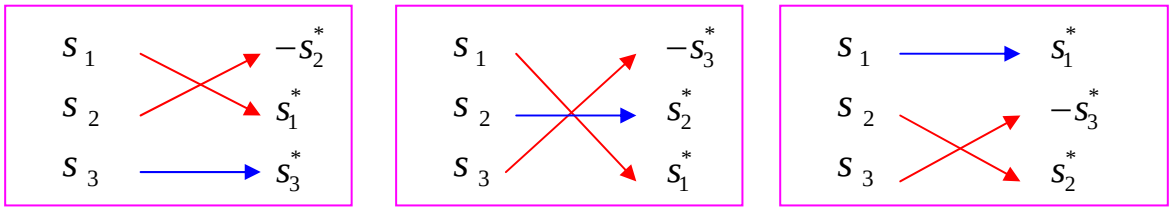
$$x_{retx} = H_{retx}\, s_{retx} + v_2$$

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:

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

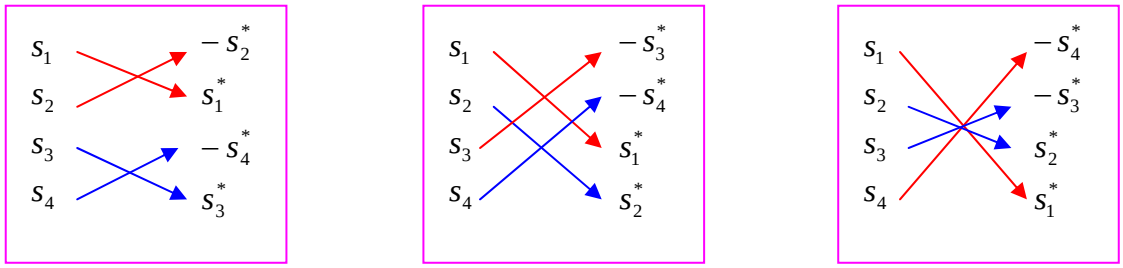
For 4 transmit antenna system, $\text{Default}: \begin{bmatrix} -s_{i+2}^* \\ s_{i+1}^* \\ -s_{i+4}^* \\ s_{i+3}^* \end{bmatrix}$, $\text{Alternative 1}: \begin{bmatrix} -s_{i+3}^* \\ -s_{i+4}^* \\ s_{i+1}^* \\ s_{i+2}^* \end{bmatrix}$, $\text{Alternative 2}: \begin{bmatrix} -s_{i+4}^* \\ -s_{i+3}^*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

For 3 transmission antennas, default retransmission sub-packet and initial transmission sub-packet consist of STTD structure with antenna 1 and antenna 2, alternative 1 and initial sub-packet form STTD structure with antenna 1 and antenna 3, and alternative 2 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) default (b) alternative 1 (c) alternative 2

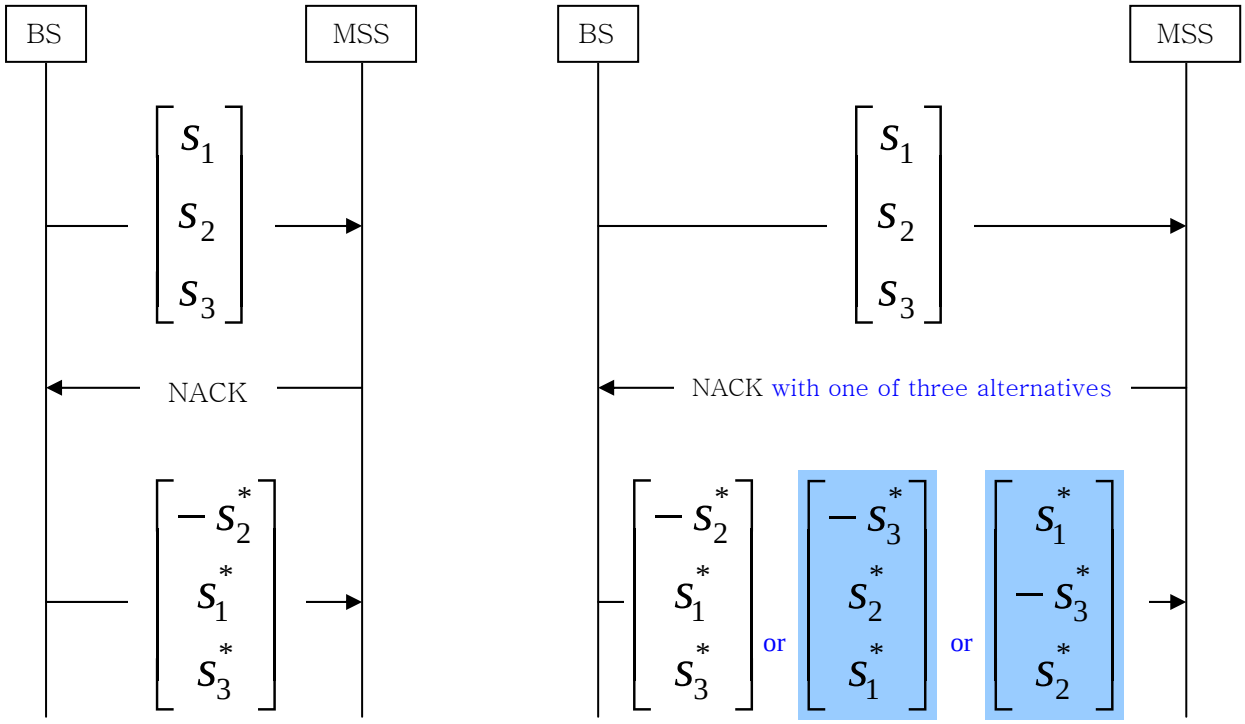
Figure 1. STTD structure in each alternative for 3 tx antennas



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

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

Receiver can select one of three alternatives and then feedback to the transmitter for retransmission scheme adaptation. There is no additional overhead to support the proposed retransmission scheme as shown in Figure 3.



(a) Current retransmission scheme (b) Proposed retransmission scheme

Figure 3. Current scheme and proposed scheme

1.2 ACK/NACK Signaling with alternatives

To send back one of alternatives with NACK signal, it is required to add the two values to current ACK/NACK values. Then there are four values indicating ACK, NACK, NACK with alternative 1 and NACK with alternative 2.

2. Proposed Text Change

[Modify Table 315m and Table 315n in section 8.4.8.9 STC subpacket combining]

Table 315m – STC subpacket combining (3–transmit antenna case)

	Initial transmission	Odd re-transmission	Even re-transmission
Space time code incremental redundancy for matrix C	$S^{(0)} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \end{bmatrix}$	$S^{(odd)} = \begin{bmatrix} -s_2^* \\ s_1^* \\ s_3^* \end{bmatrix}$ (Default) $S^{(odd)} = \begin{bmatrix} -s_3^* \\ s_2^* \\ s_1^* \end{bmatrix}$ (Alternative 1) $S^{(odd)} = \begin{bmatrix} s_1^* \\ -s_3^* \\ s_2^* \end{bmatrix}$ (Alternative 2)	$S^{(even)} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \end{bmatrix}$

Table 315n – STC subpacket combining (4 –transmit antenna case)

	Initial transmission	Odd re-transmission	Even re-transmission
Space time code incremental redundancy for matrix C	$S^{(0)} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \end{bmatrix}$	$S^{(odd)} = \begin{bmatrix} -s_2^* \\ s_1^* \\ -s_4^* \\ s_3^* \end{bmatrix}$ (Default) $S^{(odd)} = \begin{bmatrix} -s_3^* \\ -s_4^* \\ s_1^* \\ s_2^* \end{bmatrix}$ (Alternative 1) $S^{(odd)} = \begin{bmatrix} -s_4^* \\ -s_3^* \\ s_2^* \\ s_1^* \end{bmatrix}$ (Alternative 2)	$S^{(even)} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \end{bmatrix}$

[***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 (Default for H-ARQ mode=Generic)	4,7,2
NACK with alternative 1 (if H-ARQ mode=Generic)	2,3,4,
NACK with alternative 2(if H-ARQ mode=Generic)	3,6,5

3. Simulation results

In the simulation, we used convolutional code 1/2, QPSK symbols, 3 transmit and 3 receive antennas in band-AMC mode. As shown in Figure 4, the proposed scheme gives the performance gain about 1.5dB over the current STC combining scheme at BLER 10^{-2}. This gain holds when delay is 4 frames as shown in Figure 5.

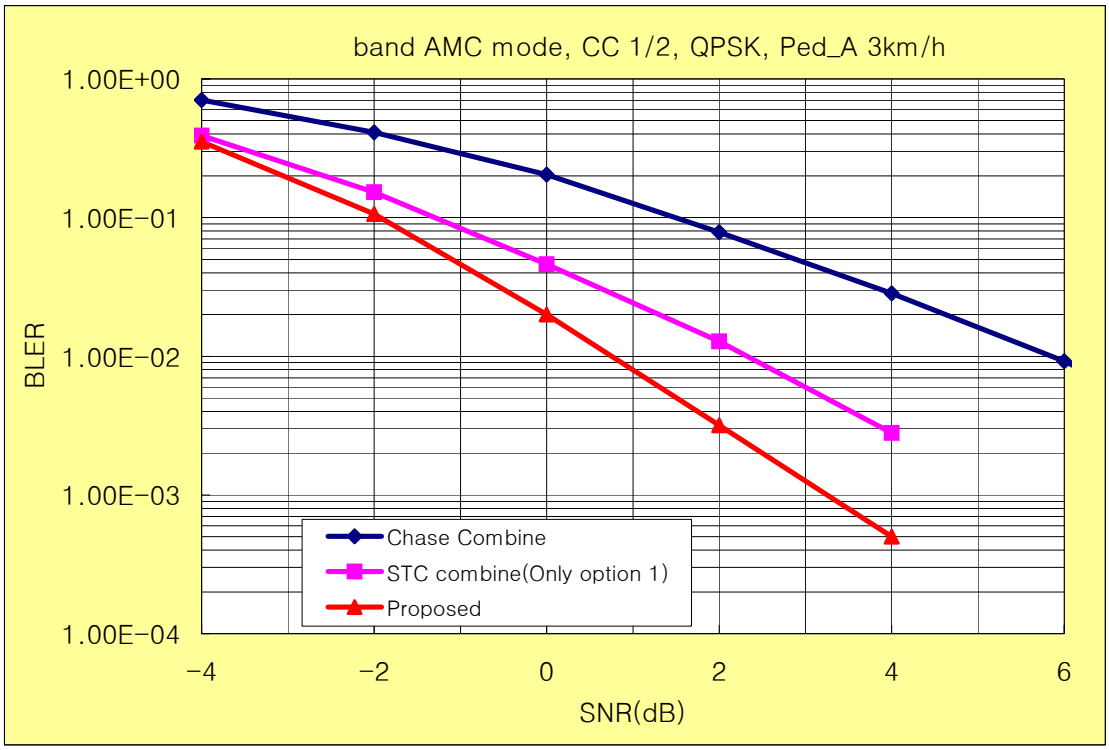


Figure 4. Performance comparison in Ped_A(3km/h) with delay=1 frames

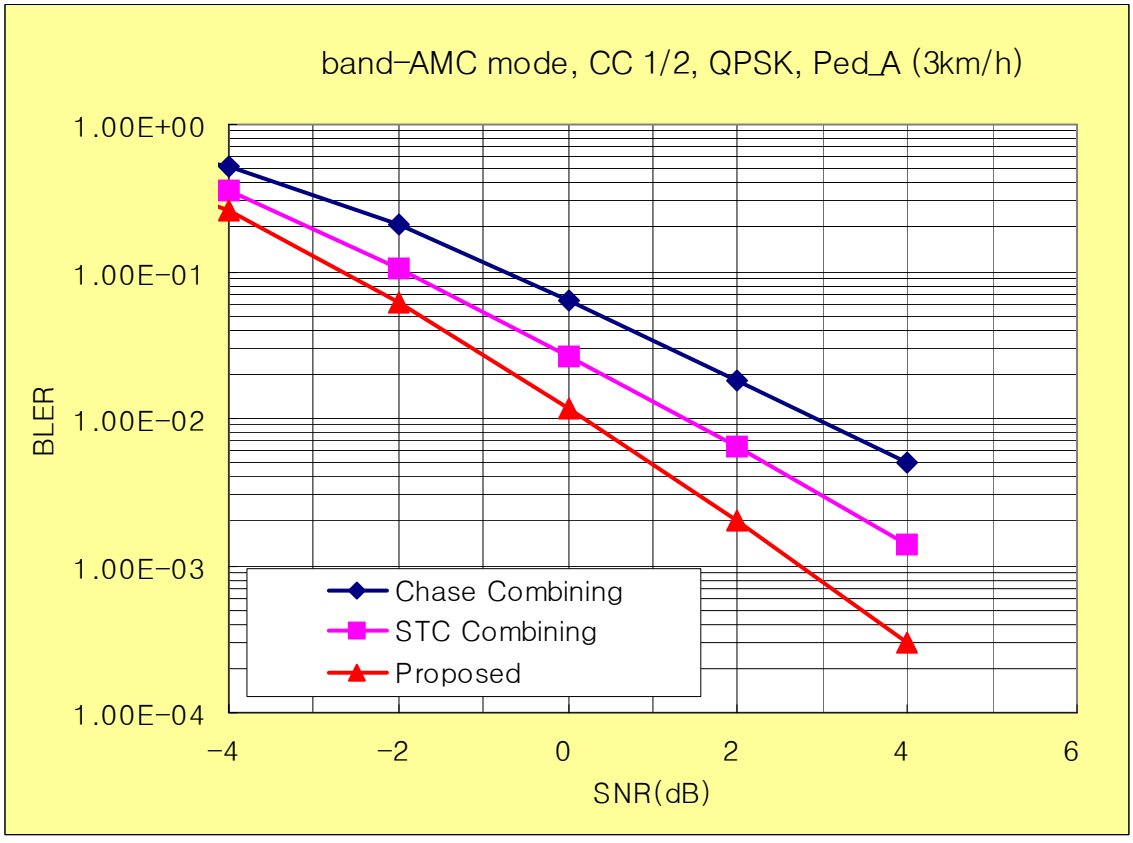


Figure 5. Performance comparison in Ped_A(3km/h) with delay=4 frames