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Title	**Comment on the Pre-coding of STC for 3&4 Transmit Antennas**
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Re:	3 and 4 antennas pre-coding contributions
Abstract	To highlight and compare the performance simulation results for 3 and 4 antenna pre-coding
Purpose	To provide the more simulation results on the rate-1 3 and 4 antenna pre-coding technique
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Comment on the Pre-coding of Space Time Code for 3&4 Transmit Antennas

1 Introduction

Several contributions proposed the pre-coding for the space-time-coding transmission for 4-Tx and 3-Tx rate-1 code. These class of the non-linear pre-coding is based on the re-mapping of the real part and imaginary part of the modulation symbols onto the space time coding constellations, namely the Matrix-A. Such a mapping or pre-coding is designed to achieve the full diversity and full rate code at space time coding level only. However, when applying this technique into the specific end-to-end coding modulation system of OFDMA PHY, the gain of the pre-coding is diminished.

1.1 Calibration at Raw Bit Error Rate

In order to perform cross comparison of different simulation results, we first verify the performance at raw BER. In Figure 1, the published data and the simulation data obtained are matched well. It shown that at the raw BER level the pre-coding scheme does demonstrate the diversity order 4 and the provided additional gain over the matrix-A.

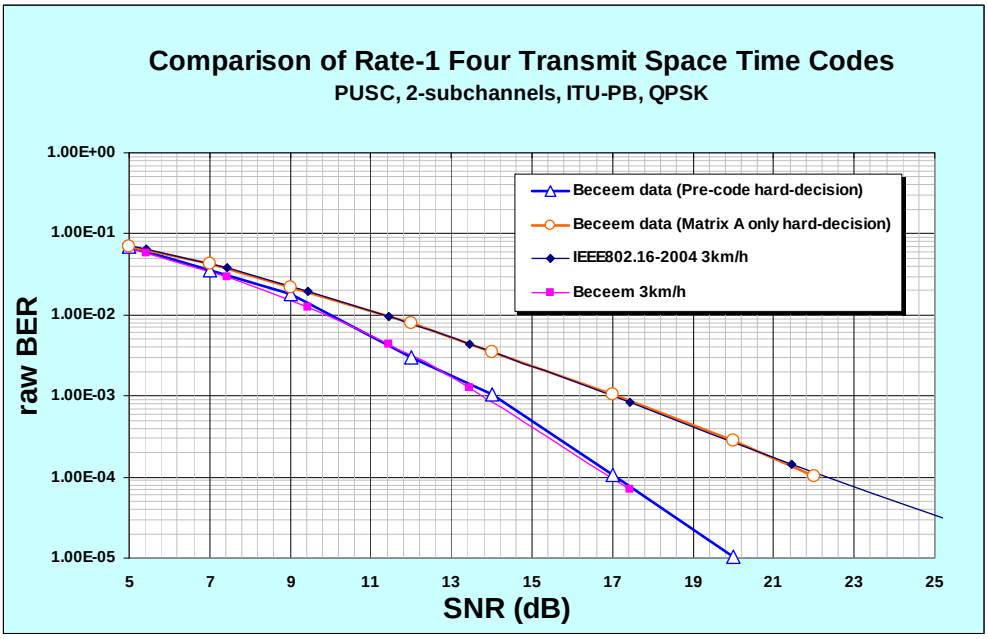

Figure 1 Raw BER Performance for the Pre-Coding

However, as we can show in the following that such diversity gain can be diminished if the performance is evaluated at the FEC decoder output, full diversity gain achieved by the pre-coding is diminished. This is due to the fact that coding and modulation chain built in the OFDMA PHY can extract the diversity via sub-channel permutation, bit-interleave and FEC decoder.

1.2 Channel Weighted Soft De-mapping

In addition to the channel bit-interleave, at the FEC decoder side, the soft de-mapping of the bit should be weighted by MIMO channel information, this has a significant impact over the diversity performance of the FEC output. (see e.g. Proakis: ”Digital Communications”).

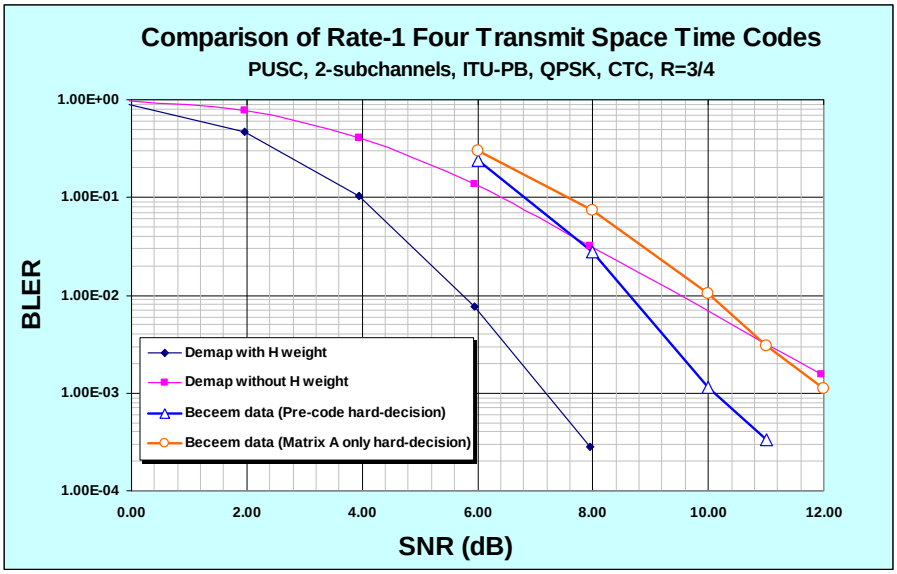

Figure 2 Channel Weighted Soft Demapping Impact on Diversity Performance

As we can see the hard decision FEC suffers the diversity loss and the simple channel weighted soft demapping should be implemented when comparing the different FEC coded STC methods.

1.3 Bit Interleave

The bit-interleave as a basic building block should also incorporated into the performance evaluation. As we can see the bit-interleave process can provide and extract the temporal diversity gain. As can be seen from Figure 3, @BLER=1%, we have the following conclusions for the 4 transmit rate-1 space time code:

1. There is about 1dB bit interleave gain for pre-coded matrix-A and
2. There is more than 1.5dB bit interleave gain for the basic matrix-A
3. The performance of pre-coded matrix-A has only 0.3dB gain over the basic matrix-A
4. For code rate lower and ¾ the gain of pre-coding is diminished

1.4 Complexity of Decoding of Pre-coded Matrix-A

In all the simulations for the pre-coding scheme in this contribution, the true MLD decoding is employed. Due to the constellation rotation at transmitter, the MLD decoder can not enjoy the simple slicing to perform the soft bit QAM demapping, the received constellation de-rotation prior to the QAM demapping is sub-optimal and suffers performance loss, therefore, the MLD decoder for the pre-coding can be only achieved by computing the Euclidean distance. This drastically increases the de-mapping complexity as compared the non-pre-coded matrix-A where the simplest bit slicing can be used for optimal QAM demapping.

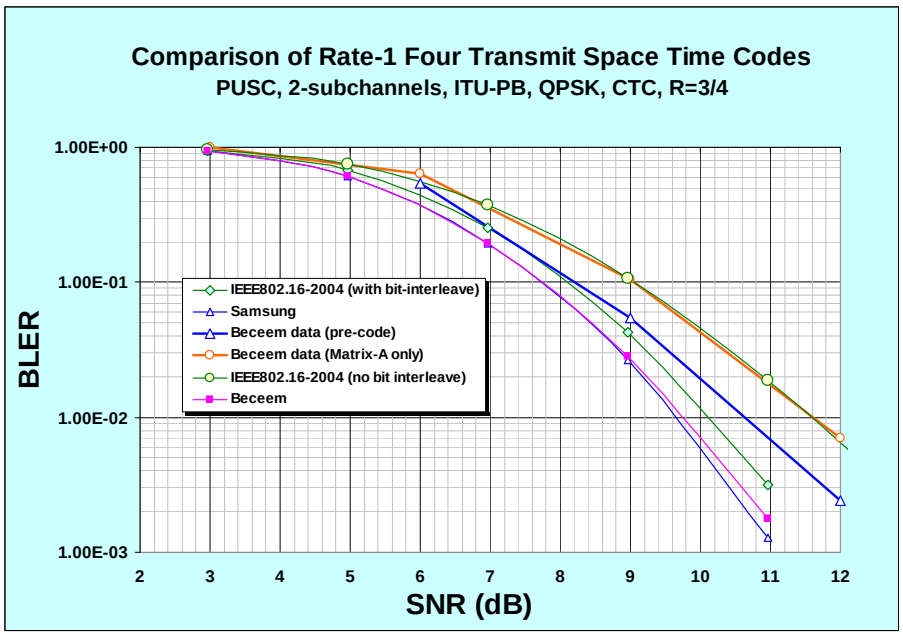

Figure 3 Performance comparison of the pre-coded and non-pre-coded matrix-A

1.5 Comparison of 2/3/4 Transmit Antenna Rate-1 STC Performance

For the rate-1 space time code matrix-A, @BLER=1%, 3-antenna matrix-A has only 0.2 dB gain over 2-transmit matrix-A, while 4-antenna matrix-A has about 1.5dB gain over 2-antenna matrix-A. See Figure 4, as we can see, there is not much room for the full-rate full diversity space time code, such as pre-coding to achieve significant performance enhancement for 3 antenna and 4 antenna case.

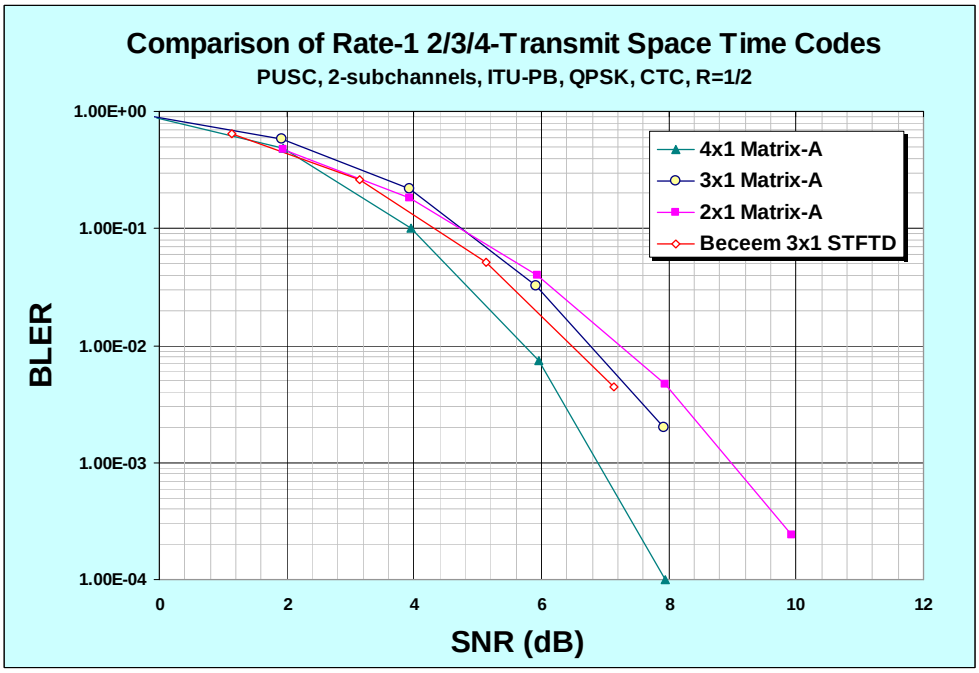

Figure 4 comparison of the rate-1 STC for 4/3/2 transmit antenna cases

2 Conclusions

The diversity gain of full-rate full-diversity rate-1 space time pre-coding diminishes when the performance is evaluated at CTC decoder output. The added complexity for the pre-coding at both encoder and decoder (in particular for the QAM demapping) is significant and does not have the merit to tradeoff with the performance benefit.