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IEEE 802 Plenary Portland, Oregon

Base Document:

IEEE C802,16e-04/208r2

Purpose:

Introduce changes according to IEEE C802.16e-04/208r2 adding a 3Tx antenna mode to 802.16e/D4

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# Space-Time Codes for 3 Transmit antennas for the OFDMA PHY

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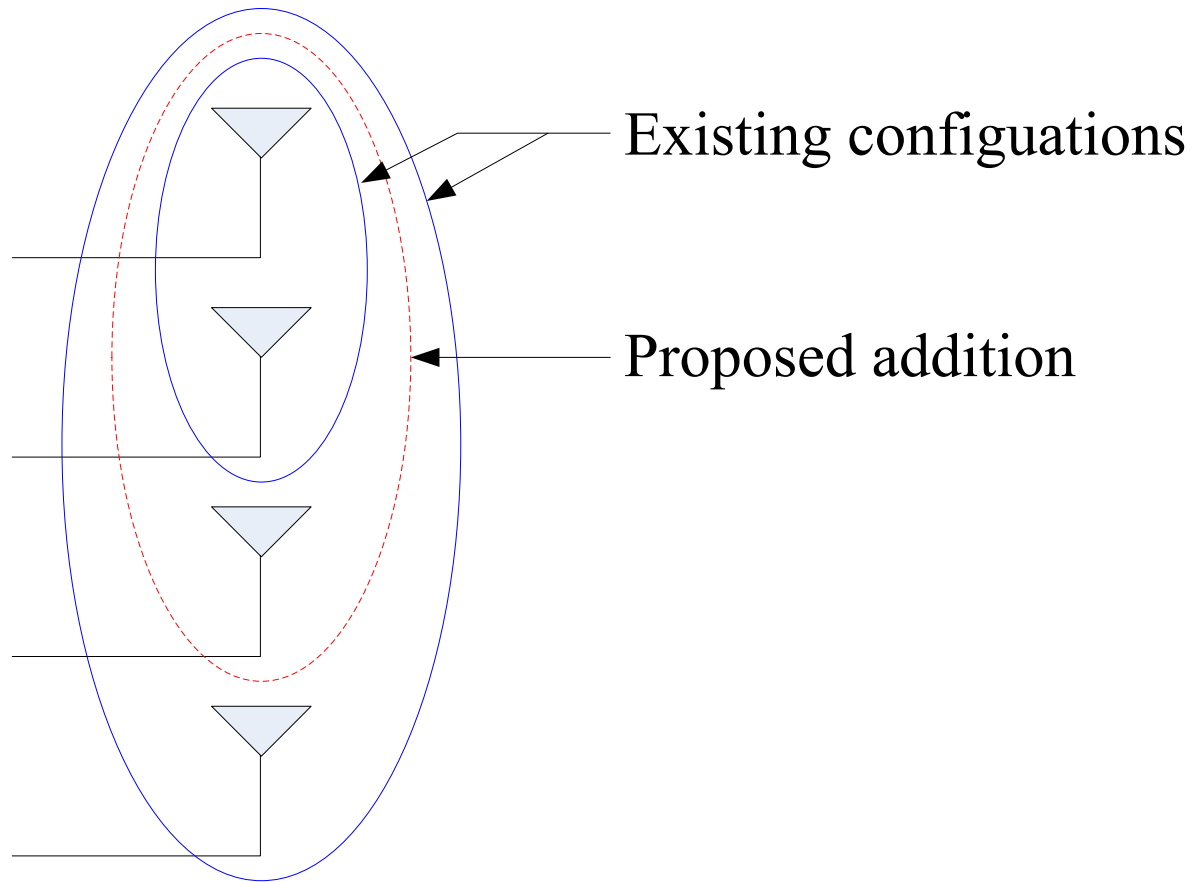
**July 14 2004**

# Problem statement

- Space-time codes are only defined for 2 and 4 BS antennas
- A 4 antenna option may not be feasible in certain deployment scenarios due to
  - Zoning regulations that restrict number of antennas
  - Structural constraints (wind, snow, etc.)
  - Cost constraints (antennas, PAs, cables, etc.)
- A 3 transmit antenna option will offer better performance than 2 transmit antennas and still be more deployment friendly than 4 antennas

Need 3 Tx antenna option

# Proposed Antenna Options



Add 3 Tx antenna MIMO option

# Properties of Proposed Scheme

- Fits cleanly into existing 4 antenna MIMO mode.
- Rate 1 and 2 codes:
  - Full transmit diversity
  - Low complexity receivers - Single symbol detection
- Rate 3 code:
  - Regular spatial multiplexing

# 3 Tx, Rate 1 STF-code

Subcarrier

$f_1$

$f_2$

$$A = \begin{bmatrix} \tilde{s}_1 & -\tilde{s}_2^* & 0 & 0 \\ \tilde{s}_2 & \tilde{s}_1^* & \tilde{s}_3 & -\tilde{s}_4^* \\ 0 & 0 & \tilde{s}_4 & \tilde{s}_3^* \end{bmatrix}$$

1
2
1
2

OFDM symbol

$$\tilde{s}_1 = s_{1I} + js_{3Q}$$

$$\tilde{s}_2 = s_{2I} + js_{4Q}$$

$$\tilde{s}_3 = s_{3I} + js_{1Q}$$

$$\tilde{s}_4 = s_{4I} + js_{2Q}$$

Here,

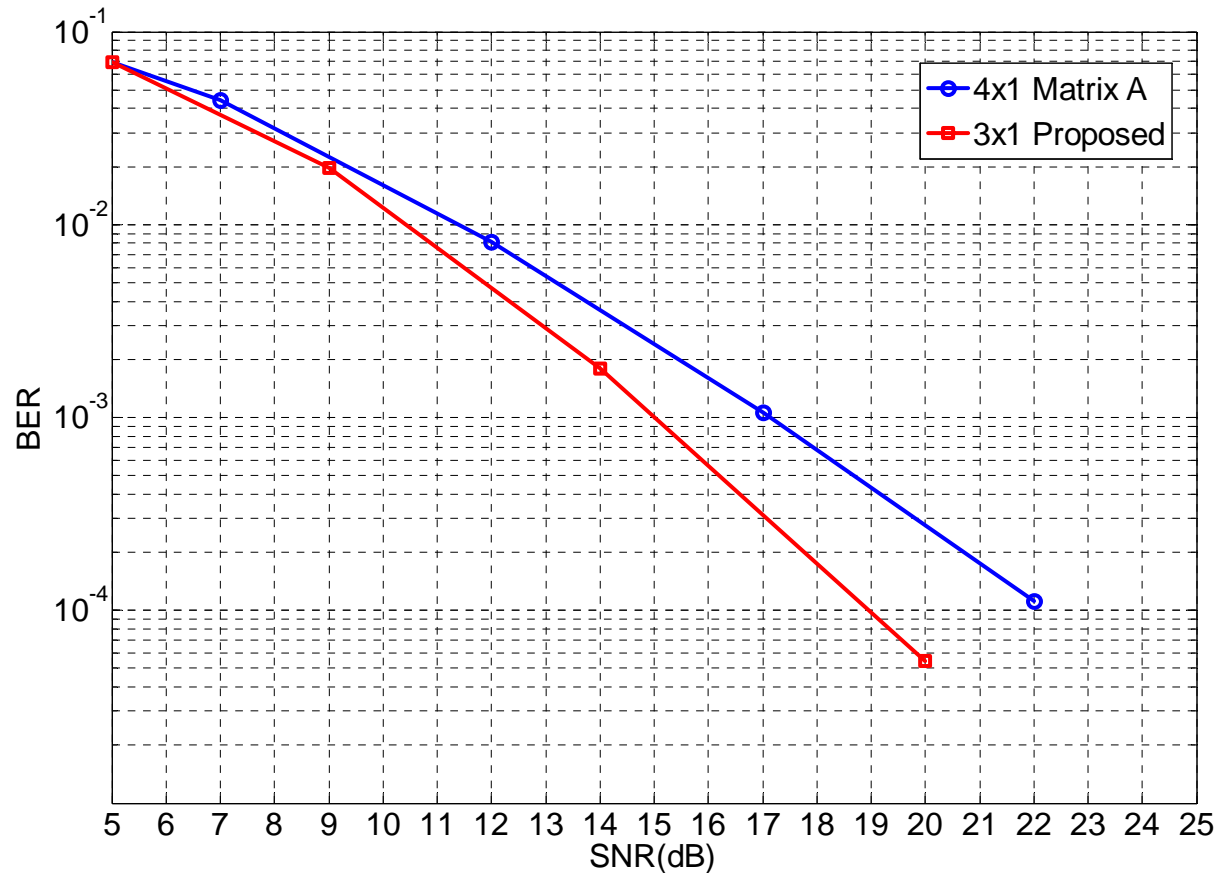
$x_i$  are the QAM symbols,

$$s_i = x_i e^{j\theta}, i = 1, \dots, 8$$

$$= s_{iI} + js_{iQ}$$

$$\theta = \frac{1}{2} \tan^{-1} 2$$

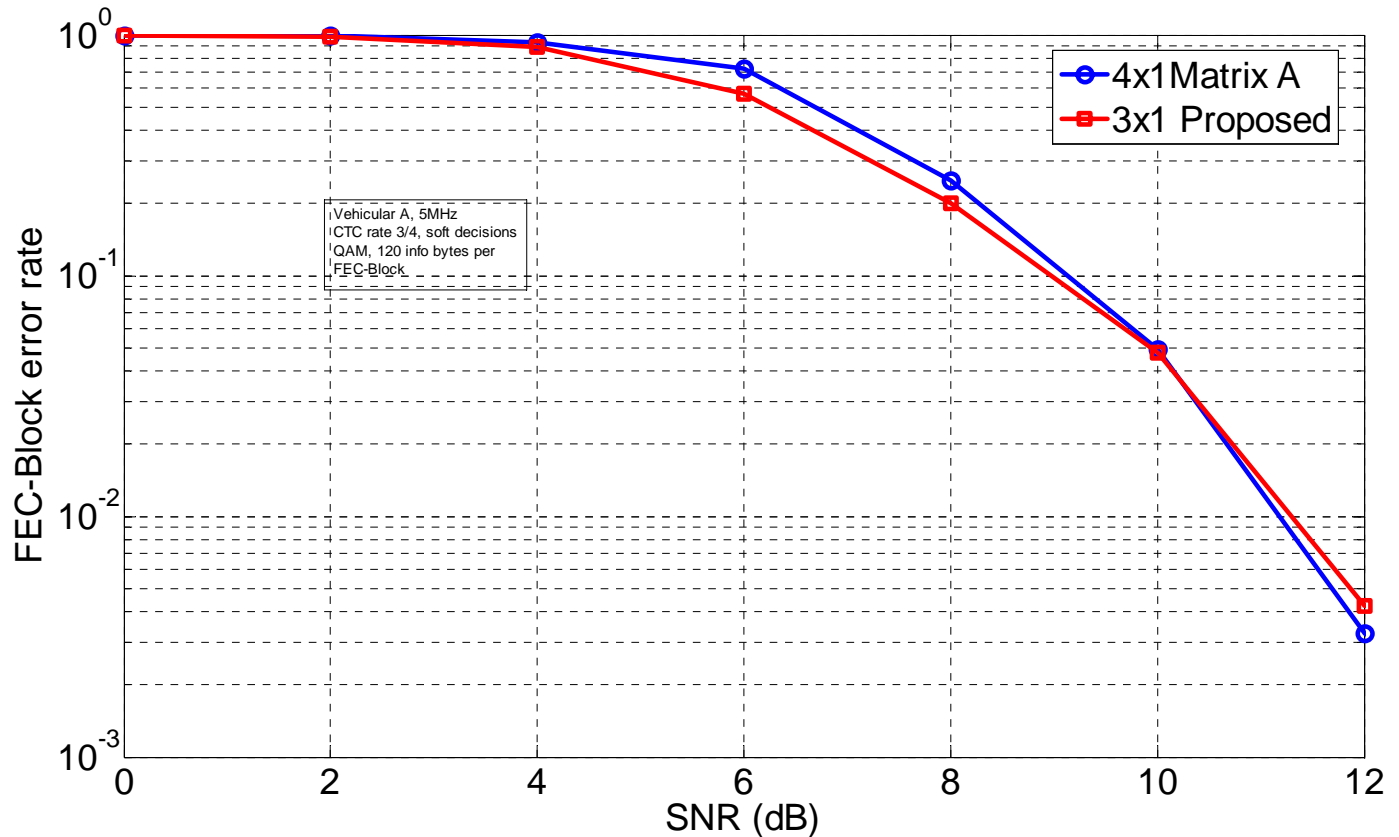
# 3 Tx, Rate 1 Uncoded Performance



Outperforms existing 4 antenna code by 2.8 dB at a BER of  $10^{-4}$  (uncoded).

# 3 Tx, Rate 1 CTC Encoded Performance

Vehicular A, 5MHz  
CTC rate  $\frac{3}{4}$ , soft,  
120 bytes per  
FEC-block, QPSK



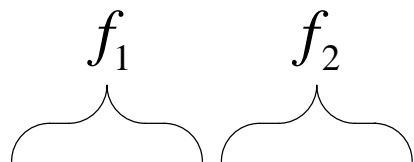
Same performance as existing 4 antenna code

**SAVES ONE  
TX ANTENNA!**



# 3 Tx, Rate 2 STF-code

Subcarrier



$$B = \begin{bmatrix} \tilde{s}_1 & -\tilde{s}_2^* & \tilde{s}_5 & -\tilde{s}_6^* \\ \tilde{s}_2 & \tilde{s}_1^* & \tilde{s}_6 & \tilde{s}_5^* \\ \tilde{s}_7 & \tilde{s}_8 & \tilde{s}_3 & \tilde{s}_4 \end{bmatrix}$$

1    2    1    2

OFDM symbol

$$\tilde{s}_1 = s_{1I} + js_{3Q}, \quad \tilde{s}_2 = s_{2I} + js_{4Q}$$

$$\tilde{s}_3 = s_{3I} + js_{1Q}, \quad \tilde{s}_4 = s_{4I} + js_{2Q}$$

$$\tilde{s}_5 = s_{5I} + js_{7Q}, \quad \tilde{s}_6 = s_{6I} + js_{8Q}$$

$$\tilde{s}_7 = s_{7I} + js_{5Q}, \quad \tilde{s}_8 = s_{8I} + js_{6Q}$$

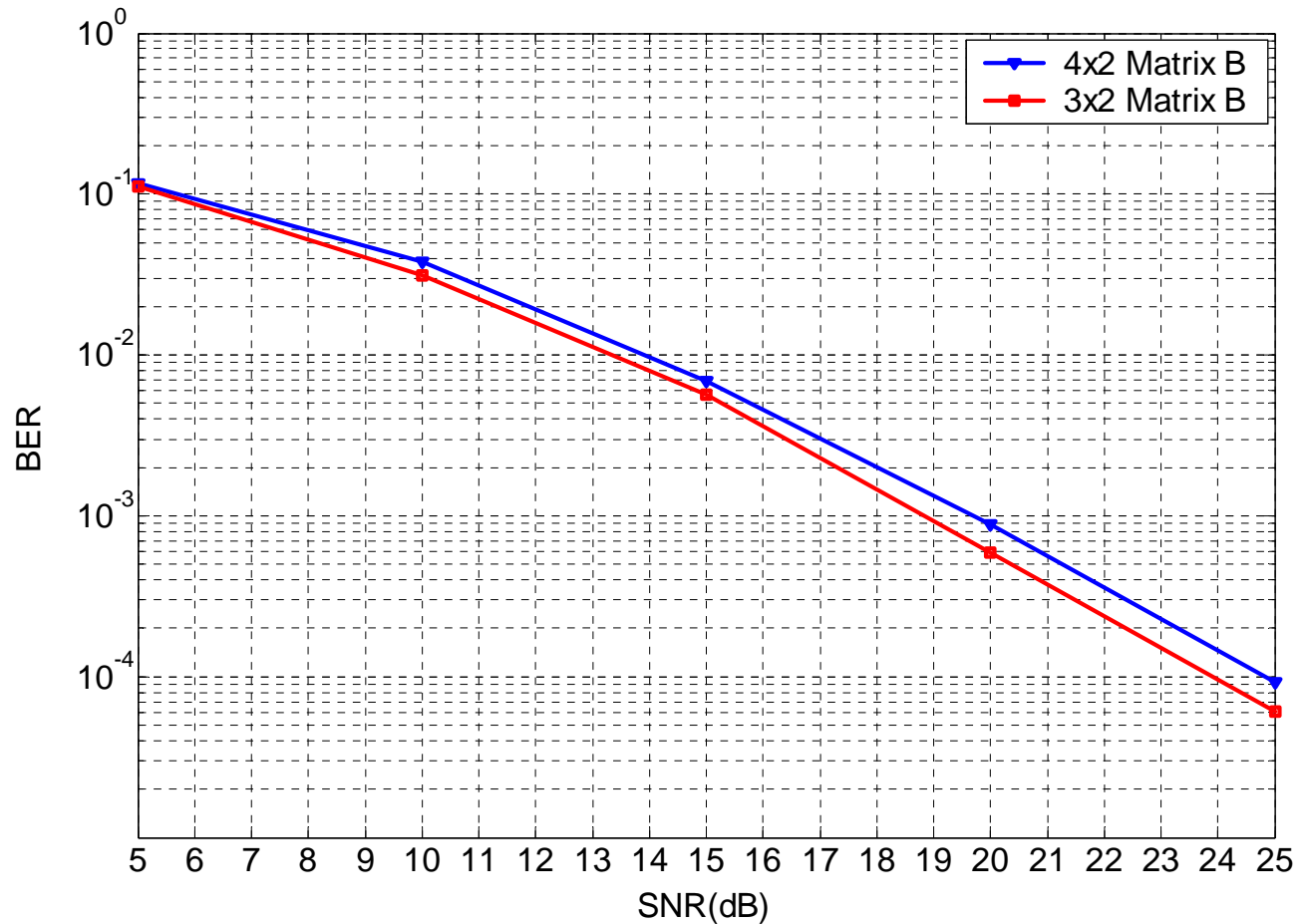
Here  $x_i$  are the QAM symbols,

$$s_i = x_i e^{j\theta}, i = 1, \dots, 8$$

$$= s_{iI} + js_{iQ}$$

$$\theta = \frac{1}{2} \tan^{-1} 2$$

# 3 Tx, Rate 2 Uncoded Performance



Outperforms existing 4 antenna code by 1 dB at a BER of  $10^{-4}$  (uncoded).

## 3 Tx, Rate 3 Code

$$\begin{bmatrix} s_1 \\ s_2 \\ s_3 \end{bmatrix}$$

Regular spatial multiplexing

# Proposed Text Changes

**Add and change text according to contribution C80216e-04/208r2 or, if 'r2' not available on server, add and change text according to contribution C80216e-04/208r1 and:**

- **In STC\_Zone\_IE (Table 277a):**
  - **Change 'STC' interpretation for 00,01,10 to 2,3, and 4 antennas.**
  - **Remove fields 'Midamble presence' and 'STC using 3 antennas'**
- **In MIMO\_Basic\_DL\_IE (Table 281a) and MIMO\_Enhanced\_DL\_IE (Table 282a):**
  - **Add specification of 00=Matrix A, 01 =Matrix B and 10=Matrix C for the 'Matrix Indicator' for STC=10.**
- **Change new section 11.8.3.7.6 in page 687 of IEEE 802.16e/D3, 11.8.3.7.6 OFDMA MSS demodulator for MIMO support:**
  - **Change TLV values for bits to be from bit #0 to bit nr #7 to 2 BS Tx Matrix A, 2 BS Tx Matrix B, 3 BS Tx Matrix A, 3BS Tx Matrix B, 3BS Tx Matrix C, 4 BS Tx Matrix A, 4 BS Tx Matrix B and 4 BS Tx Matrix C.**

**Thank You!**