Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Cell range extension by using differential modulations**
Date Submitted	**2004-07-07**
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Re:	IEEE 802.16e D3 Draft
Abstract	Range enhancement by using differential modulations. This is a revision 1 of the contribution; the additional texts are highlighted in green. Deleted texts are stroked out.
Purpose	To incorporate the changes here proposed into the 802.16e D4 draft.
Notice	
Release	
Patent Policy and Procedures	

Cell range extension by using differential modulation

1 Background

For the FUSC permutation, the out of coverage range MSS mapped onto specific sub-channels will not be able to perform the channel estimation and coherent demodulation, especially the SIR ratio is less than 0dB. The situation is worsening in mobility case due to the Doppler effect. However, such a MSS can still listen the FCH QPSK R=1/8 with 30% reuse, this accounts -9dB, the repetition coding can boost the data SIR but the pilot is berried into interference and noise (See Figure 1). Such scenario can happen cell border MSS during intra-system handoff or inter-system hand over.

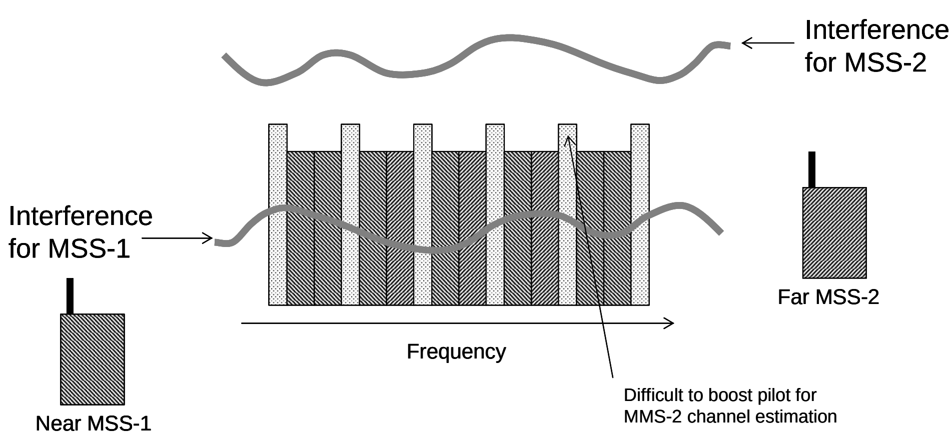

Figure 1 Range limited User Scenario

A simple fix to this is to introduce the optional differential modulation to allow low data rate transmission even the SIR is less than 0dB. For the MIMO mode the differential MIMO modulation can even increase the data rates.

2 Differential STC for non-coherent demodulation to improve the range

We propose to introduce recursive type differential modulation for both MIMO and non-MIMO modes they are applicable to QPSK constellation. The STC code based differential modulation preserve fully the space time coding gain, with only 3dB penalty compared the coherent STC code The encoding is $Z_i = \frac{1}{\sqrt{2}} Z_{i-1} S_i$ where $S_i = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix}$ and the element $s_1, s_2 \ldots$ is the input symbol. The decoding is $S_i = \frac{1}{\sqrt{2}} S_{i-1} Y_i$ where Y_i is the receiver matrix stacked from the received signal vectors, as we can see, both encoding and decoding is very simple. This is another advantage for the differential STC coding. The typical gain for differential can improve the range dramatically, even with single receive antenna for MSS.

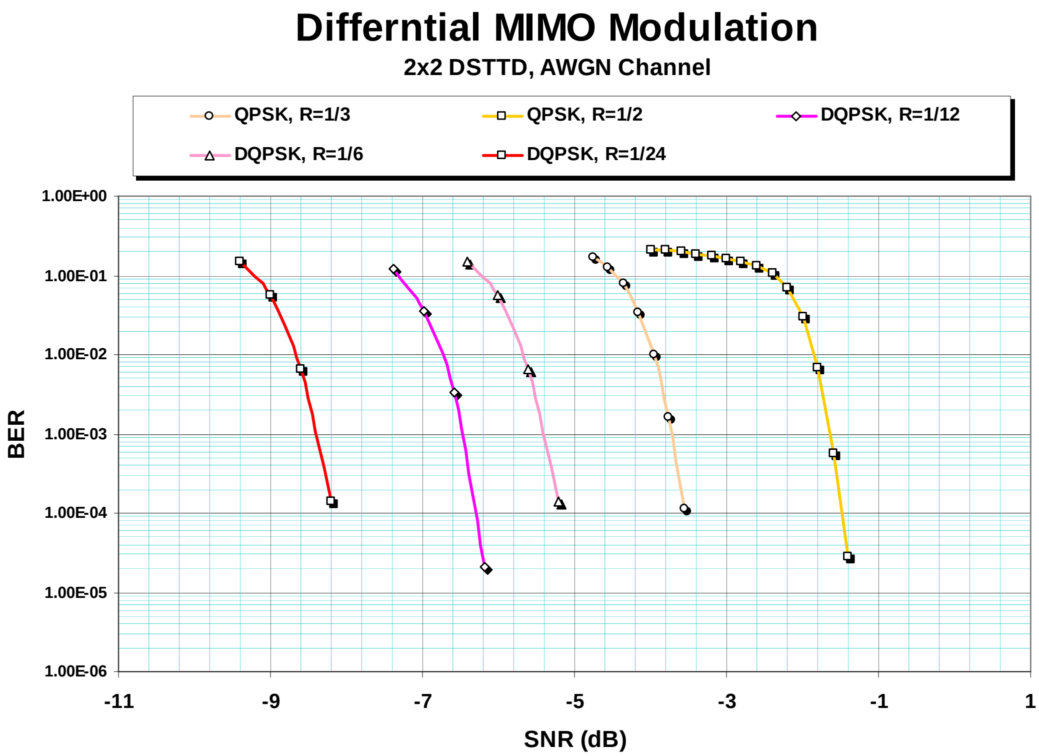

Figure 2 Performance for Differential MIMO Modulation

3 Specific text changes

[Add the following text into section 8.4.9.4.3.2]

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

Additional optional differential modulations are listed in table zzz-1

Table zzz-1 differential space time code for 1, 2 and 4 transmit antennas

Antenna Configuration	Modulation Rule	S_i
1-transmit antenna	$Z_i = \frac{1}{\sqrt{2}} Z_{i-1} S_i$	Table zzz-2
2-transmit antenna	$Z_i = \frac{1}{\sqrt{2}} Z_{i-1} S_i$	$S_i = \begin{bmatrix} s_1 & -s_2 \\ s_2 & s_1^* \end{bmatrix}$
4-transmit antenna	$Z_i = \frac{1}{\sqrt{2}} Z_{i-1} S_i$	$S_i = \begin{bmatrix} s_1 & -s_2^* & 0 & 0 \\ s_2 & s_1^* & 0 & 0 \\ 0 & 0 & s_3 & -s_4^* \\ 0 & 0 & s_4 & s_3^* \end{bmatrix}$

For single antenna transmission the input bit and symbol mapping is shown in Table zzz-2

Table zzz-2 π/4-DQPSK modulation

Codeword b_0b_1	Modulation symbol, S_i
00	1
01	j
11	-1
10	-j

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

[Modify the following text into section 11.8.3.7.2]

Type	Length	Value	Scope
151	1	Bit #0: 64 QAM Bit #1:BTC Bit #2:CTC Bit #3:STC Bit #4:AAS Diversity MAP scan Bit #5:AAS direct signalling Bit #6:H-ARQ Bit #7: ~~reserved, shall set to zero~~ Differential coding	SBC-REQ (6.3.2.3.23) SBC-RSP (6.3.2.3.24)

[Modify the following text into section 11.8.3.7.3]

Type	Length	Value	Scope
151	1	Bit #0: 64 QAM Bit #1:BTC Bit #2:CTC Bit #3:~~AAS Diversity Map Scan~~ STC Bit #4:~~AAS Direct Signaling~~ AAS Diversity Map Scan Bit #5: ~~HAR-Q~~ AAS Direct Signaling	SBC-REQ (6.3.2.3.23) SBC-RSP (6.3.2.3.24)

		Bit #6~~-7~~:~~reserved, shall be set to zero~~ H-ARQ Bit #7: Differential coding	

Modify the row in Table 355 – UCD burst profile encoding – WirelessMAN-OFDMA

FEC Code type and modulation	150	1	**~~26-255 = reserved~~** **26 = DQPSK (CC) ½** **27 = DQPSK (BTC) ½** **28 = DQPSK (CTC) ½** **29 = DQPSK (ZTCC) ½** **30…255 = reserved**

Modify the row in Table 361 – DCD burst profile encoding – WirelessMAN-OFDMA

FEC Code type	150	1	**~~26-255 = reserved~~** **26 = DQPSK (CC) ½** **27 = DQPSK (BTC) ½** **28 = DQPSK (CTC) ½** **29 = DQPSK (ZTCC) ½** **30…255 = reserved**

Insert one row DQPSK in Table 332 on page 624

Modulation/FEC rate	Normalized-C/N
Fast feedback IE	0
CDMA code	3
QPSK 1/2	6
DQPSK 1/2	9
…	…

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