Enhanced HARQ Scheme with Signal Constellation Rearrangement

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Ryohei KIMURA* Voice: +81-50-3687-6584
Christian Wengerter** E-mail: kimura.ryohei@jp.panasonic.com, yoshii.isamu@jp.panasonic.com
Isamu YOSHII*
Katsuhiko HIRAMATSU*
* Matsushita Electric (Panasonic)
** Panasonic R&D Center Germany

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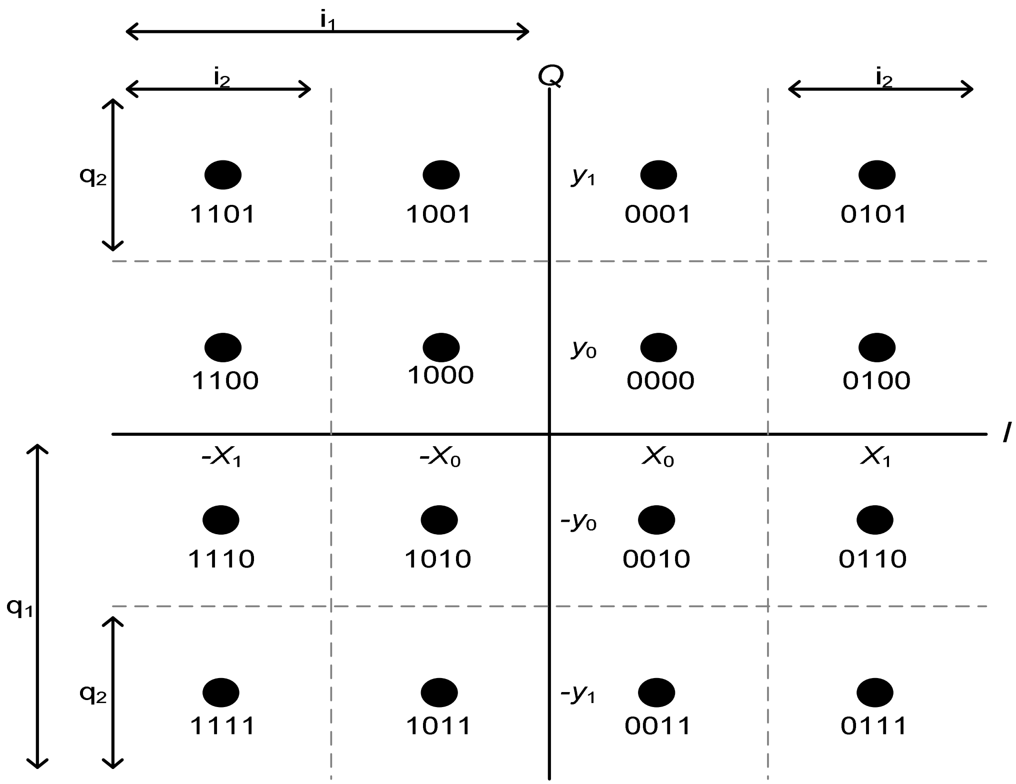
IEEE C80216m-08_771r1

Purpose:

For discussion and adoption by IEEE 802.16m group

Introduction

- Signal constellation with Gray mapping is used for Chase Combining (CC) in IEEE 802.16e



Signal constellation with Gray-mapping in 16 QAM

Symbol mapping : $i_1 i_2 q_1 q_2$
i_1 and i_2 for In-phase channel
q_1 and q_2 for Quadrature channel

i_1 and q_1 : Most Significant Bit(MSB)
- ones and zeros are mapped to half spaces (symmetry)
- Reliability is depends on the bit content of i_2 and q_2

i_2 and q_2 : Least Significant Bit(LSB)
- ones and zeros are mapped to inner/outer rows /columns
- Reliability is independent from the bit content

For 16 QAM, the reliabilities of the bits Gray−mapped onto the modulated symbol vary from the MSBs i_1 and q_1 to the LSBs i_2 and q_2.

Problem Statement and Solution

- Problem Statement
  - As the reliability variations between MSBs and LSBs increase, the error rate performance gets worse with respect to having equal bit reliabilities.
  - Since the 16e CC scheme transmits (at least partially) identical symbols with identical signal constellation/mapping for all transmissions, the variations in bit reliabilities increase over retransmissions. This is particularly true when soft-combining the received packets by maximal ratio combining (MRC) at modulation symbol level or by adding LLRs at bit level.
- Solution
  - to average out the bit reliabilities over the retransmissions by signal Constellation Rearrangement (CoRe) for retransmissions.

CoRe Rule for 16 QAM

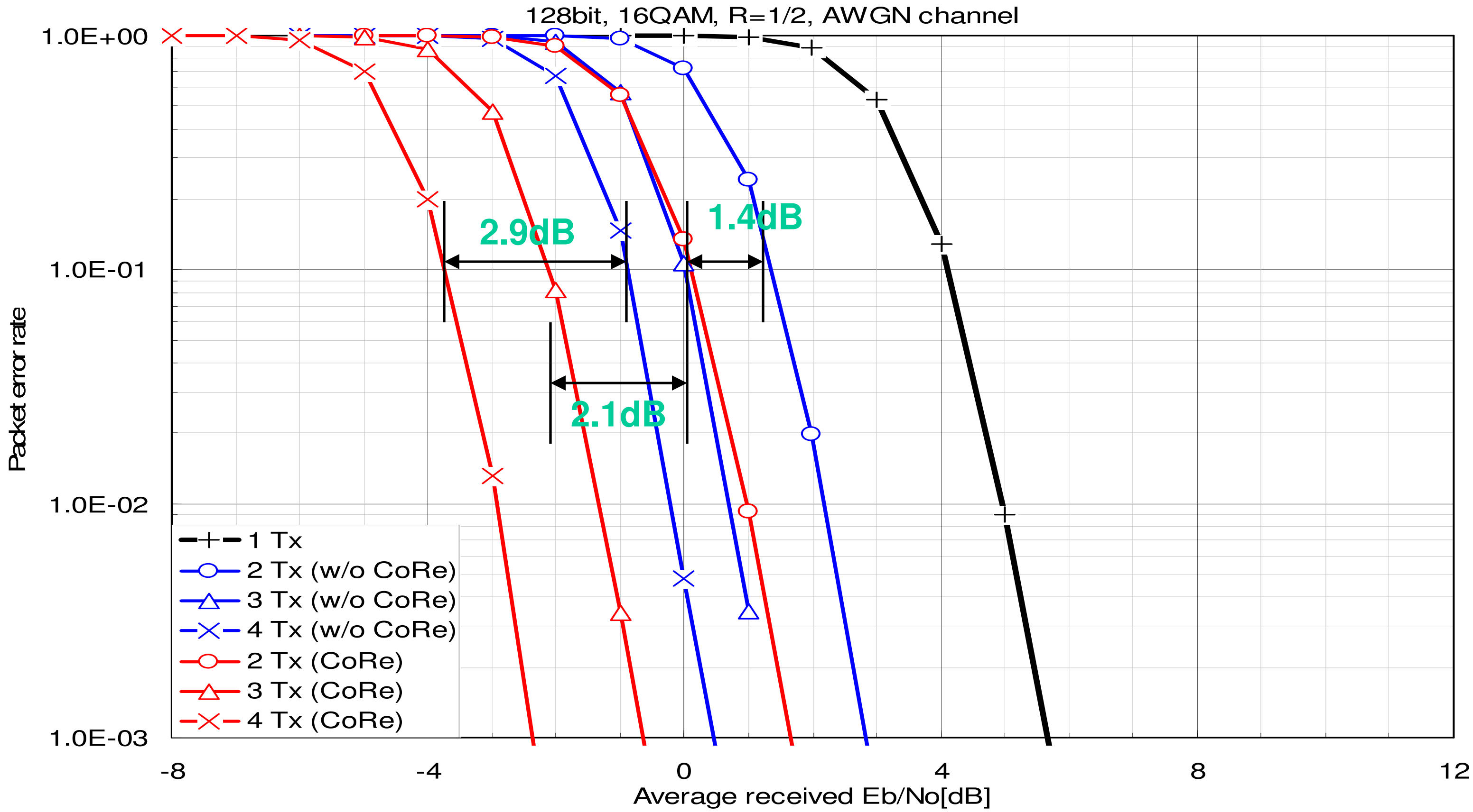
Transmission No.	Bit pattern	Explanation
1	$i_1 i_2 q_1 q_2$	- None
2	$i_2 \bar{i}_1 q_2 \bar{q}_1$	- Swapping i_1 with i_2 and q_1 with q_2 /logical inversion of i_1 and q_1
3	$i_2 i_1 q_2 q_1$	- Swapping i_1 with i_2 and q_1 with q_2
4	$i_1 \bar{i}_2 q_1 \bar{q}_2$	- Logical inversion of i_2 and q_2
Further transmission		- Repeatedly using the signal constellations form 1^{st}-4^{th} transmissions

- Simple rearrangement rule based on reordering and inversion of the logical bit values

Simulation Setting

Parameter	Value
Carrier frequency	2.5 GHz
System bandwidth	10 MHz
FFT size	1024
Sub-carrier frequency spacing(f_s)	10.94 kHz
Useful symbol interval (T_s=1/f_s)	91.4 μsec
Guard interval (T_g=T_s/8)	11.4 μsec
Number of information bits for packet	128 bits (16 QAM) / 192 bits (64 QAM)
Antenna configuration	1-by-1
Channel coding	Turbo coding (original rate = 1/3)
MCS	16 QAM/64 QAM, R = 1/2
Channel model	AWGN
Channel estimation	Ideal
Maximum number of transmissions	4 (16 QAM) / 6 (64 QAM)

Performance Comparison for 16 QAM



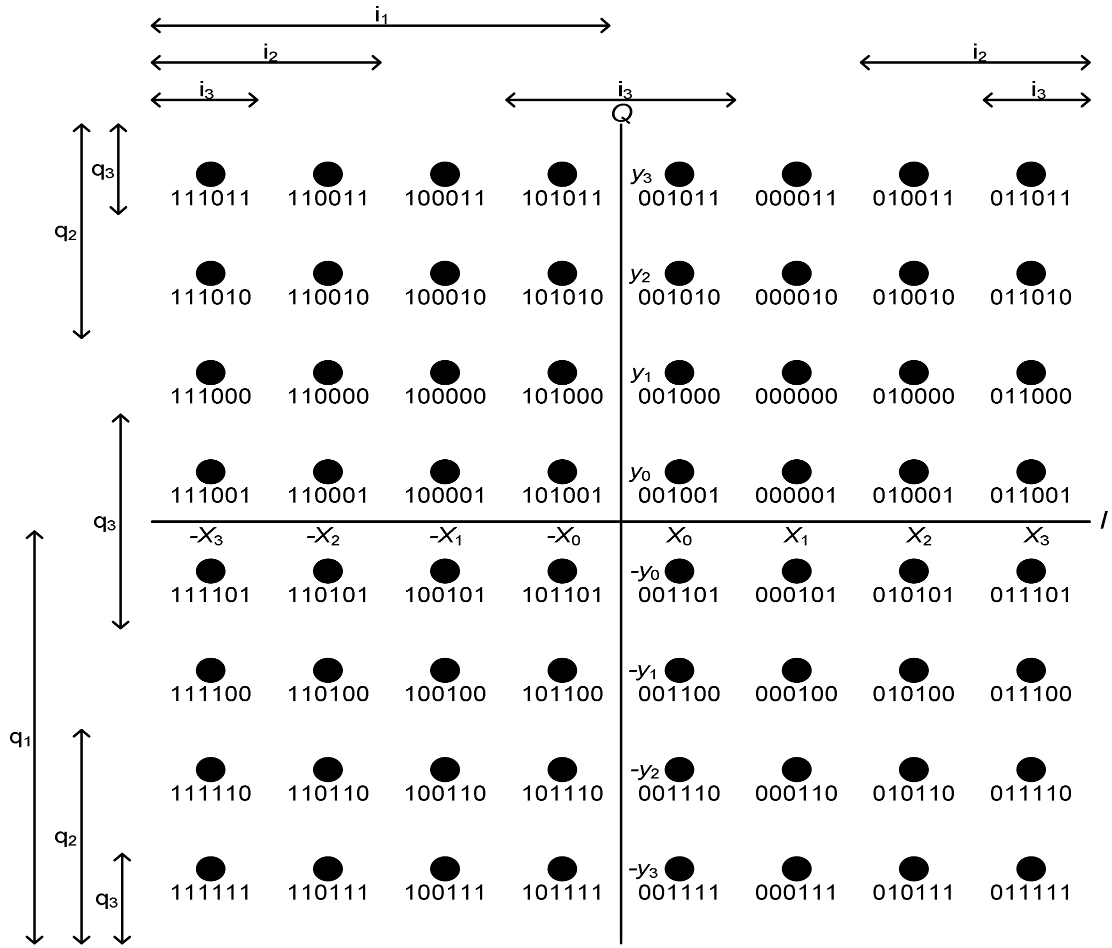
- The gain is expected to be even larger for higher code rates

Conclusion

- The proposed CC with CoRe scheme shows a significant performance gain with respect to the 16e CC without CoRe.
- CoRe should be included in the 16m SDD.
- The proposed SDD text is as shown in C80216m-08_771r1.

Appendix:
Signal Constellation Rearrangement for 64 QAM

Signal constellation with Gray-mapping in 64 QAM



Symbol mapping : $i_1i_2i_3q_1q_2q_3$
i_1, i_2 and i_3 for In-phase channel
q_1, q_2 and q_3 for Quadrature channel

i_1 and q_1 : High Reliability
- ones and zeros are mapped to half spaces (symmetry)

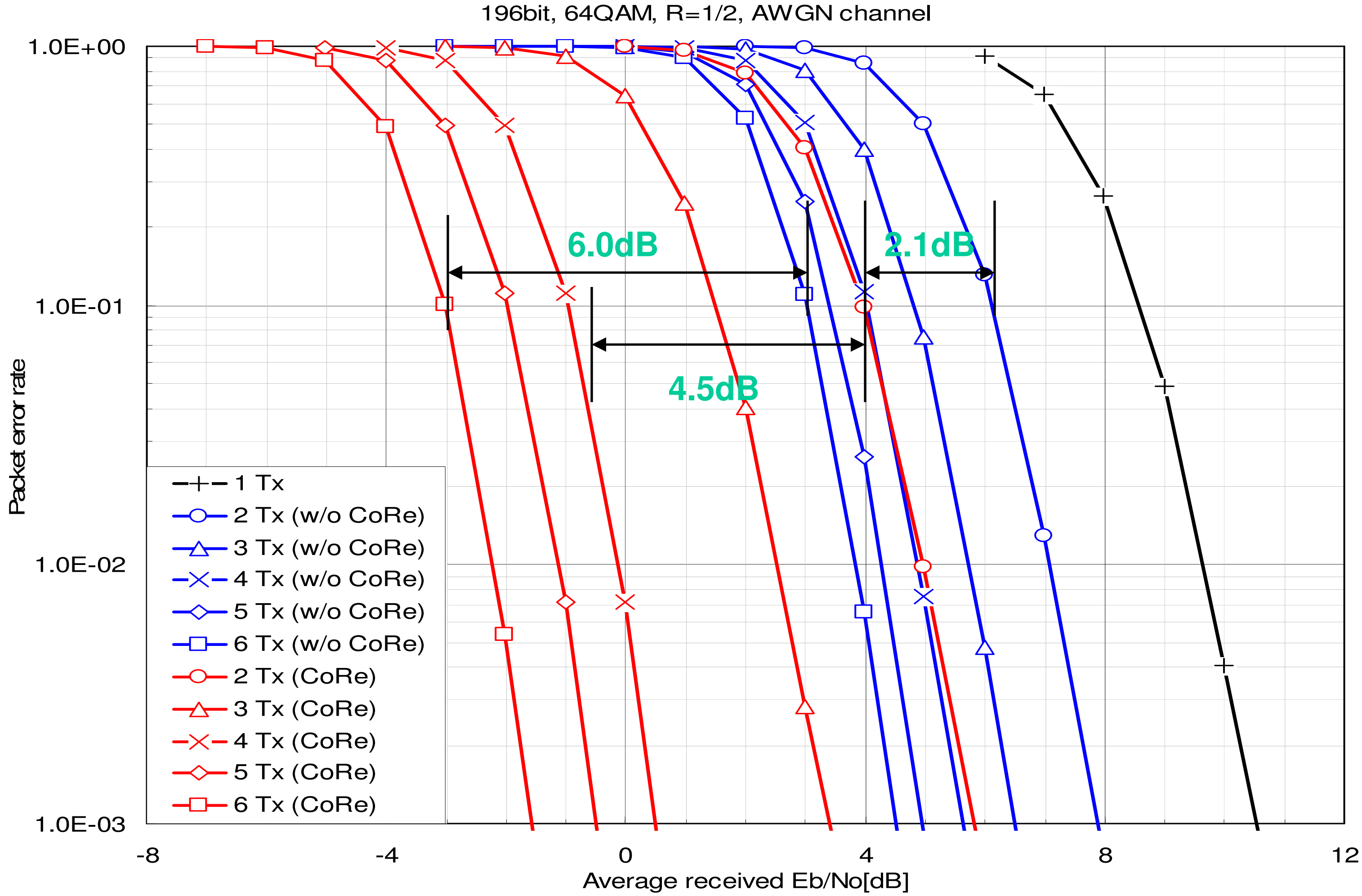
i_2 and q_2 : Medium Reliability
- ones and zeros are mapped to rows /columns 3-4-5-6(inner)/1-2-7-8(outer)

i_3 and q_3 : Low Reliability
- ones and zeros are mapped to rows /columns 1-4-5-8/2-3-6-7

Rearrangement Rule for 64 QAM

Transmission No.	Bit pattern	Explanation
1	$i_1 i_2 i_3 q_1 q_2 q_3$	- None
2	$i_2 i_3 i_1 q_2 q_3 q_1$	- 1-bit circular shift for the in-phase and orthogonal components individually
3	$i_3 i_1 i_2 q_3 q_1 q_2$	- 2-bits circular shift for the in-phase and orthogonal components individually
4	$i_1 \bar{i}_2 \bar{i}_3 q_1 \bar{q}_2 \bar{q}_3$	- Logical inversion of i_2, i_3 , q_2 and q_3
5	$i_2 \bar{i}_3 \bar{i}_1 q_2 \bar{q}_3 \bar{q}_1$	- 1-bit circular shift for the in-phase and orthogonal components individually - Logical inversion of i_1, i_3 , q_1 and q_3
6	$i_3 \bar{i}_1 \bar{i}_2 q_3 \bar{q}_1 \bar{q}_2$	- 2-bits circular shift for the in-phase and orthogonal components individually - Logical inversion of i_1, i_2 , q_1 and q_2
Further transmission		- Repeatedly using constellations form 1^{st}-6^{th} transmissions

Performance Comparison for 64 QAM



Performance Comparison for 64 QAM