Reply Comments to C802.16m-08/073

Document Number: 80216m-08/115

Date Submitted: Jan. 21, 2008

Source:

Hongming Zheng hongming.zheng@intel.com,

Yang-seok Choi yang-seok.choi@intel.com,

May Wu may.wu@intel.com,

Nageen Himayat nageen.himayat@intel.com

Intel Corporation

Venue:

TGm Call for comments on EVM, IEEE 802.16m-07/048, Levi FI

Base Contribution:

C80216-08/115

Purpose:

Reply comments to contribution C802.16m-08/073 and MMIB performance evaluation

Outline

- Reply to Comments in C802.16m-08/073
- MMIB Performance Evaluation

Reply to Comments 1-4 in C802.16m-08/073

- Comments 1-4 highlight discrepancies between the expected and calculated RBIR values from the tables provided for specific channel matrices.
- Observations:
  - Computation of the RBIR metric for horizontal encoding involves a numerical approximation to calculate (AVE, VAR) and the parameter ‘a’
  - RBIR has been optimized for horizontal encoding
  - Vertical encoding is an extension of horizontal encoding with the addition of parameters p1 and p2. This approximation is suboptimal.
  - The accuracy in the RBIR values can be improved by
    - Using a better numerical approximation for (AVE, VAR)
    - Determining the parameter ‘a’ with finer granularity
    - Determining p1 and p2 with finer granularity

Reply to Comments 5-7 in C802.16m-08/073

- Reply to Comment 5: Although RBIR requires calculation of parameters for a number of different code rates, this leads to improved accuracy in prediction of PER as a function of code rate. For unspecified code rates in the Tables, the parameters can be interpolated.
- Reply to Comment 6: An improved approximation is provided in contribution C80216m-08/67
- Reply to Comment 7: A simplified, but suboptimal search for parameters p1 and p2 can be used.
  - The range of k and lambda_min over which the search is performed is first quantized to a set of values
  - For a given range of k and lambda_min, pick a value of p1 and search for p2. Now use this value of p2 to determine p1. Repeat this process iteratively until the values of p1 and p2 converge. For this reason, the same numerical approximation as the horizontal encoding case may be used and the constraint p1+p2 = 1 is not necessary.
  - Repeat this process for all chosen ranges of k and lambda_min

Horizontal Encoding not Supported by MMIB

- The current formulation of the MMIB method can not be used for horizontal encoding. According to the equation below, the MI metric cannot be divided into two metrics, one for each stream. MMIB supports only vertical encoding. The current text in the EM is incomplete.

$$[\gamma(1), \gamma(2), \gamma(3)] = sort_{asc}\{\lambda_{\max} p_a + \lambda_{\min}(1 - p_a), \lambda_{\min} p_a + \lambda_{\max}(1 - p_a), \lambda_{\max}(1 - 2\sqrt{p_a(1 - p_a)}) + \lambda_{\min}(1 + 2\sqrt{p_a(1 - p_a)})\}$$

- The RBIR method supports both vertical and horizontal encoding

MMIB as a Bit Level Metric

The final MI value is an approximation that is an average of all bit level metrics per symbol in any modulation constellation.

$$QPSK: \quad I_2^{(2\times2)}(\lambda_{\min}, \lambda_{\max}, P_a) = \frac{1}{2} J\left(a\sqrt{\gamma(1)}\right) + \frac{1}{2} J\left(b\sqrt{\gamma(2)}\right), \; a = 0.85, b = 1.19$$

$$16QAM / 64QAM: \quad I_m^{(2\times2)}(\lambda_{\min}, \lambda_{\max}, p_a) = \frac{1}{3}\left[J\left(a\sqrt{\gamma(1)}\right) + J\left(b\sqrt{\gamma(2)}\right) + J\left(c\sqrt{\gamma(3)}\right)\right]$$

MMIB is therefore not a true bit-level metric

Inaccuracies in MMIB - 1

16 QAM	$1 < \kappa \le 10$	$10 < \kappa \le 100$	$\kappa > 100$
$-10dB < \lambda_{min} < 8dB$	$a = 0.48,\ b = 0.27$ $c = 0.69$	$a = 0.40,\ b = 0.21$ $c = 0.56$	$a = 0.32,\ b = 0.13$ $c = 0.37$
$\lambda_{min} > 8dB$	$a = 0.35,\ b = 0.43$ $c = 0.59$	$a = 0.37,\ b = 0.33$ $c = 100$	$a = 0.42,\ b = 0.11$ $c = 100$

64 QAM $\lambda_{min} < -10dB$	$1 < \kappa \le 10$	$10 < \kappa \le 100$	$\kappa > 100$
$-10dB < \lambda_{min} < 8dB$	$a = 0.23,\ b = 0.16$ $c = 0.59$	$a = 0.12,\ b = 0.12$ $c = 0.38$	$a = 0.08,\ b = 0.07$ $c = 0.17$ λ_{min}
$\lambda_{min} > 8dB$	$a = 0.20,\ b = 0.21$ $c = 0.62$	$a = 0.22,\ b = 0.13$ $c = 100$	$a = 0.24,\ b = 0.08$ $c = 100$

- In Tables 30 and 31, parameters a, b, c for $\lambda_{min} < -10dB$ are not specified
- For MIMO channels with 0.5 correlation, the probability of having $\lambda_{min} < -10dB$ can be as high as 30%. This can lead to significant inaccuracy.

For better accuracy, parameters a, b and c need to be specified with finer granularity.

Inaccuracies in MMIB - 2

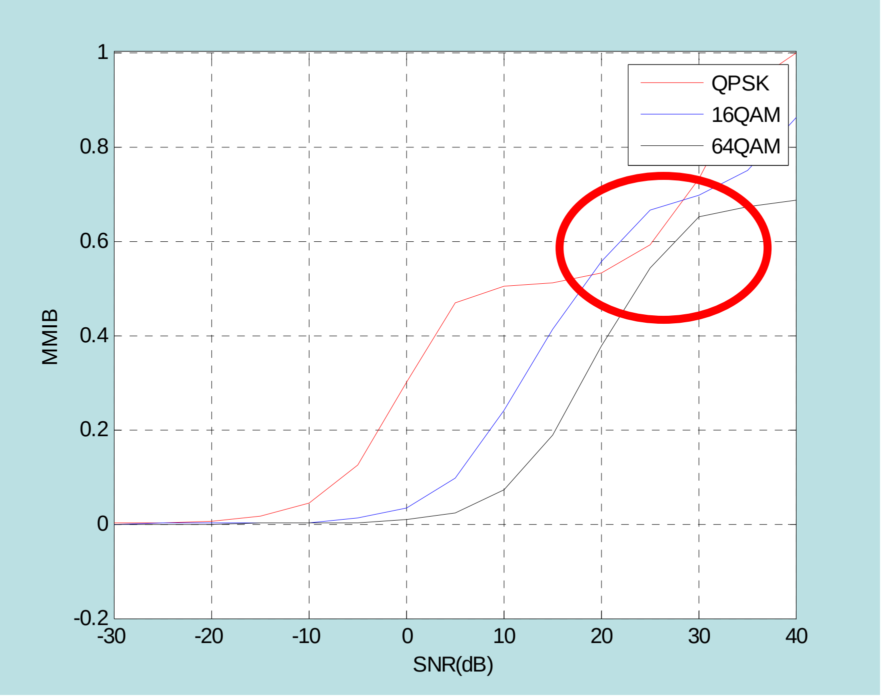
Consider the following example for the channel matrix, H
(H) = [-0.9683 + 0.0706i -0.0317 + 0.0003i;
0.1129 - 0.2085i -0.0009 - 0.0155i];

From equation (63), (64) and (65), the MMIB of the MIMO symbol is

$$[\gamma(1),\gamma(2),\gamma(3)] = sort_{asc}\{\lambda_{\max}p_a + \lambda_{\min}(1-p_a), \lambda_{\min}p_a + \lambda_{\max}(1-p_a), \lambda_{\max}(1-2\sqrt{p_a(1-p_a)}) + \lambda_{\min}(1+2\sqrt{p_a(1-p_a)})\}$$

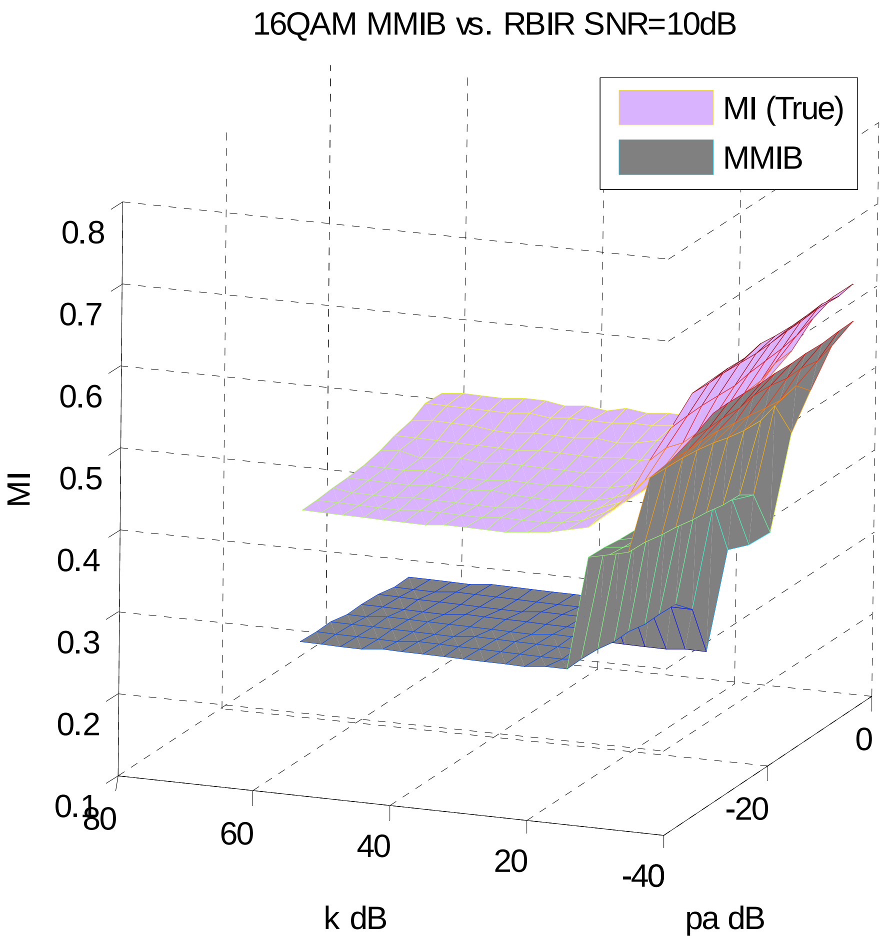
$$QPSK: \quad I_2^{(2\times2)}(\lambda_{\min},\lambda_{\max},P_a) = \frac{1}{2}J\left(a\sqrt{\gamma(1)}\right) + \frac{1}{2}J\left(b\sqrt{\gamma(2)}\right), \quad a=0.85, b=1.19$$

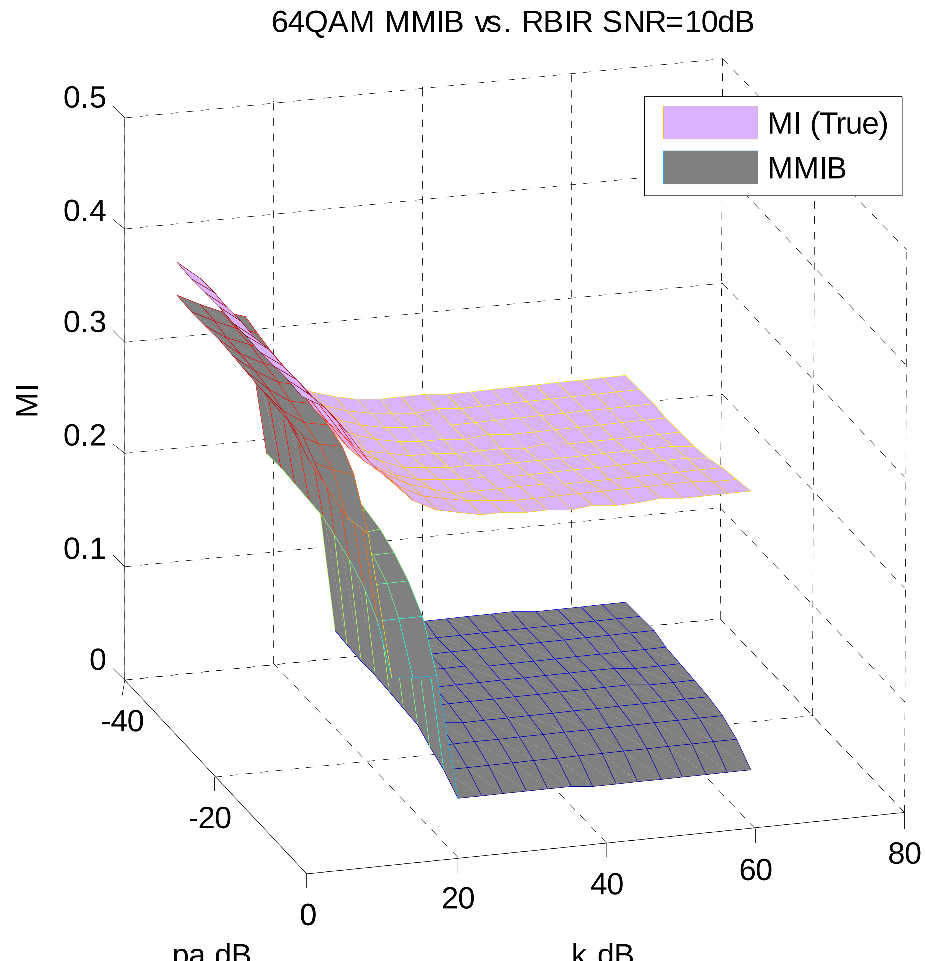
$$16QAM/64QAM: \quad I_m^{(2\times2)}(\lambda_{\min},\lambda_{\max},p_a) = \frac{1}{3}\left[J\left(a\sqrt{\gamma(1)}\right) + J\left(b\sqrt{\gamma(2)}\right) + J\left(c\sqrt{\gamma(3)}\right)\right]$$



It can be seen that MMIB does not satisfy the basic property that the bit-level information metric should decrease with increasing modulation level.

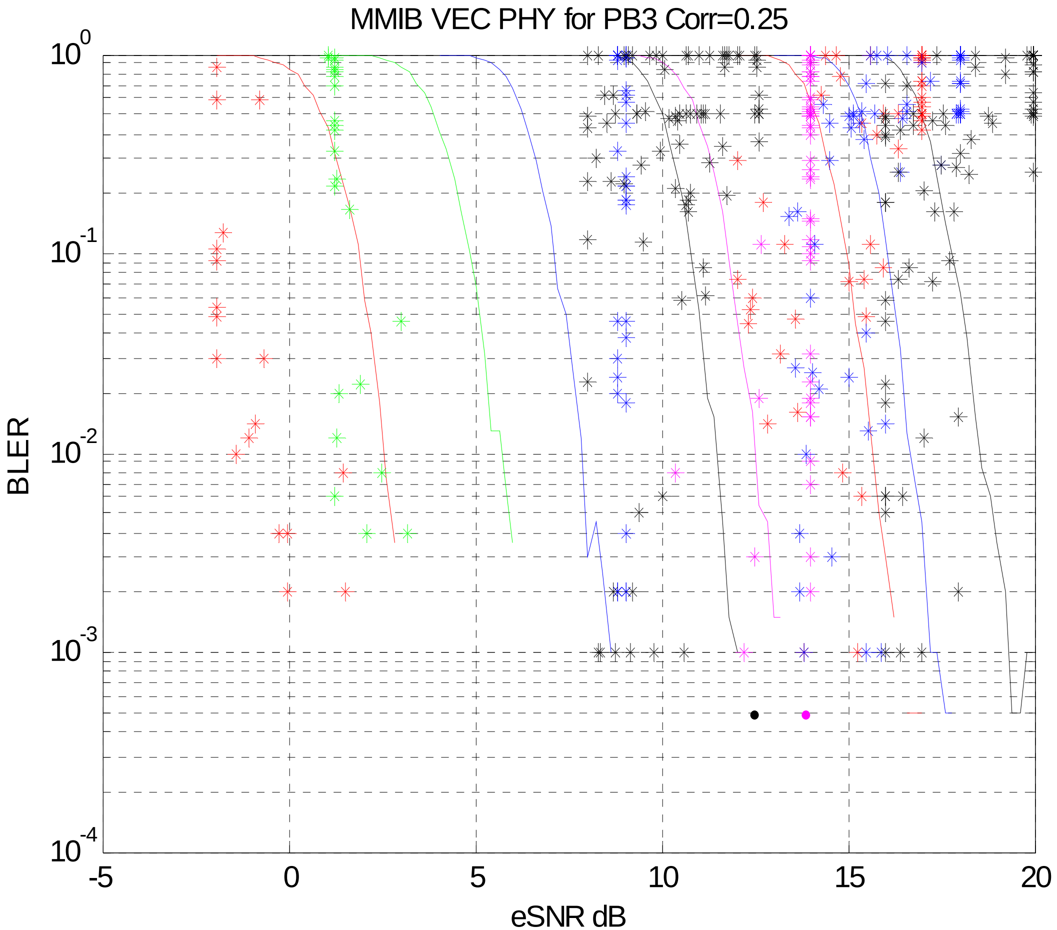
Inaccuracies Between MMIB and True MI - 3





- MMIB PHY abstraction is inaccurate
- Different offsets may be needed for different k/pa and MCS levels

Inaccuracies in MMIB - 4



- MMIB PHY abstraction is inaccurate, especially for higher MCS levels
- Each MCS may need different offset

Inaccuracies in MMIB – 5