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Title	**Comparison of Link Performance Abstraction for ML Receivers with MMIB and RBIR Metrics**
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Re:	Call for contributions for 802.16m Evaluation Methodology, IEEE 802.16m-07/048, 12/17/07
Abstract	This contribution compares link abstraction methodologies proposed for ML receivers based on MMIB metrics developed in C802.16m-07/142 and RBIR metrics in C802.16m-07/187
Purpose	For discussion and approval by 802.16 TGm
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Link Performance Abstraction Comparison for ML Receivers

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I. Introduction

This contribution provides the comparison of two link evaluation methodologies as defined in the current draft of Evaluation Methodology Document, namely the MMIB and RBIR methods, with focus on MIMO Maximum Likelihood (ML) receivers. Link performance abstraction using MMIB metrics for ML receivers was proposed for adoption in a previous contribution C802.16m-07/142 [2]. This contribution developed an approach that is based on a) defining the mutual information between each transmitted bit and its associated LLR before turbo decoding, 2) approximating the PDFs of LLR by a mixture Gaussian distributions 3) identifying dominant Gaussian distributions 4) calculating the means and variances of those dominant Gaussian PDF from the channel matrix (i.e., the Eigen values and matrix condition numbers)

Contribution C802.16m-07/187 derives RBIR metrics as symbol based mutual information normalized to bit level by dividing with the modulation order. Again for ML abstraction, this approach also uses Gaussian distribution approximation approach similar to MMIB, with means and variances derived from the channel matrix.

However, there are some key differences in how these metrics are derived that should be looked at when down-selecting and choosing one approach over the other.

Mainly we find that RBIR metrics proposed for ML receivers do not satisfy some properties that are expected/ assumed about mutual information metric in the evaluation methodology document. These mappings are developed using adjustment parameters aided by link simulations for each MCS, as opposed to numerically obtaining true value of MI by Monte-Carlo methods.

The study below is based on our best understanding of RBIR implementation and uses the functions, approximations and tables currently provided in the RBIR section 4.3.1.3 of the EVM document. Since it is expected that numerical approximations are not always completely accurate, we only focus here on aspects that are particularly important and not isolated cases, and cannot be attributed to approximation errors alone.

We suggest that these technical issues be addressed and clarified in the working group before accepting the EVM document.

II. Brief Overview of Implementation

MMIB Implementation Steps for ML

- Based on bit-level MI between transmitted bit and post processing LLR
- Compute three parameters based on Eigen-values of H and the “Eigen-spread”. Quality of each data stream fundamentally depends on the Eigen-values and the “Eigen-spread”

$$H^H H = VDV^H, D = \begin{pmatrix} \lambda_{\max} & 0 \\ 0 & \lambda_{\min} \end{pmatrix}, p_a = \min\{p, 1-p\}, \text{ where } |\mathbf{V}|.|\mathbf{V}| = \begin{pmatrix} p & 1-p \\ 1-p & p \end{pmatrix}, \; 0 \le p \le 1$$

- Obtain set of dominant Gaussian PDFs and define MIB as sum of the J(.) functions based on these PDFs

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

$$\lambda_{\max}(1-2\sqrt{p_a(1-p_a)}) + \lambda_{\min}(1+2\sqrt{p_a(1-p_a)})\}$$

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

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

- Parameter a,b,c depend on the condition number of the channel matrix and modulation order only, but not on code rate. To clarify, note that the in SISO MIB functions are expressed as a mapping from channel quality as represented by SNR to MIB. For MIMO matrix channel, it is a three-dimensional mapping from these three parameters (Eigen values and spread) to MIB. The actual three dimensional mapping is obtained by generating numerical LLR PDFs of the matrix channel and a modulation constellation and evaluating MIB with this LLR PDF. To avoid a cumbersome lookup table, the following convenient functional approximation table has been provided.

16 QAM	$1<\kappa\le10$	$10<\kappa\le100$	$\kappa>100$
$-10dB<\lambda_{\min}<8dB$	$a=0.48,\ b=0.27$ $c=0.69$	$a=0.40,\ b=0.21$ $c=0.56$	$a=0.32,\ b=0.13$ $c=0.37$
$\lambda_{\min}>8dB$	$a=0.35,\ b=0.43$ $c=0.59$	$a=0.37,\ b=0.33$ $c=100$	$a=0.42,\ b=0.11$ $c=100$

64 QAM	$1<\kappa\le10$	$10<\kappa\le100$	$\kappa>100$
$-10dB<\lambda_{\min}<8dB$	$a=0.23,\ b=0.16$ $c=0.59$	$a=0.12,\ b=0.12$ $c=0.38$	$a=0.08,\ b=0.07$ $c=0.17$
$\lambda_{\min}>8dB$	$a=0.20,\ b=0.21$ $c=0.62$	$a=0.22,\ b=0.13$ $c=100$	$a=0.24,\ b=0.08$ $c=100$

RBIR Implementation Steps for ML

- Define “symbol-level” LLR (i.e., ratio of the conditional probability of a certain symbol to the summed probability of other symols), which is approximated as a Gaussian PDFs with a mean AVE and variance VAR. Define the mutual information per symbol or SI as the mutual information between symbol and its symbol-level LLR

$$SI = \frac{1}{M}\sum_{i=1}^{M}\int_{-\infty}^{\infty} p(LLR_i)\log_2\frac{M}{1+e^{-LLR_i}}dLLR_i, \quad SI \approx \log_2 M - \frac{1}{\log_e 2}\begin{bmatrix} \frac{2}{3}f_1(AVE) \\ +\frac{f_1(AVE+\sqrt{3VAR})}{6} \\ +\frac{f_1(AVE-\sqrt{3VAR})}{6} \end{bmatrix},$$

$$f_1(x) = \log_e(1+e^{-x})$$

  - Approximation is used because there is no closed-form solution to the integration
- Two “hypothetical” data streams with the associated SNR defined by the associated column norm of H (2x2).
- Calculate AVE and VAR of SI for each “hypothetical” stream
  - The calculation of AVE and VAR of symbol-level LLR uses 3-4 nearest neighboring

constellation in an approximation, and AVE and VAR must resort to some numerical integration. Hence a look-up table based on the column norm of H is provided in the following

$$\gamma_{dB} = 10\log_{10}\left(\frac{d^2 |H_k|^2}{\sigma^2}\right), d = \begin{cases} \sqrt{2}, \ for\ QPSK \\ 2/\sqrt{10}, \ for\ 16QAM \\ 2/\sqrt{42}, \ for\ 64QAM \end{cases}$$

H_k is the k-th column vector of the channel matrix $\mathbf{H} = \left[H_1 \quad H_2\right]$, and σ^2 is the variance of noise

γ_{dB} (dB)	[-20:0.5:30]
AVE	[-0.4016 -0.4123 -0.4233 -0.4344 -0.4457 -0.4571 -0.4687 -0.4804 -0.4922 -0.5041 -0.5160 -0.5279 -0.5397 -0.5515 -0.5631 -0.5745 -0.5856 -0.5962 -0.6065 -0.6161 -0.6249 -0.6329 -0.6399 -0.6456 -0.6499 -0.6524 -0.6530 -0.6513 -0.6470 -0.6396 -0.6287 -0.6139 -0.5944 -0.5697 -0.5391 -0.5018 -0.4567 -0.4031 -0.3396 -0.2650 -0.1780 -0.0770 0.0398 0.1743 0.3286 0.5051 0.7063 0.9352 1.1949 1.4889 1.8211 2.1959 2.6179 3.0926 3.6259 4.2245 4.8961 5.6491 6.4933 7.4396 8.5006 9.6904 11.0251 12.5229 14.2045 16.0930 18.2146 20.5989 23.2784 26.2897 29.6733 33.4750 37.7458 42.5431 47.9314 53.9830 60.7788 68.4100 76.9786 86.5992 97.4004 109.5263 123.1389 138.4197 155.5725 174.8260 196.4366 220.6922 247.9159 278.4700 312.7611 351.2455 394.4351 442.9043 497.2976 558.3381 626.8372 703.7054 789.9640 886.7593 995.3772]
VAR	[0.2952 0.3003 0.3055 0.3108 0.3162 0.3218 0.3276 0.3336 0.3400 0.3468 0.3541 0.3620 0.3705 0.3800 0.3904 0.4021 0.4152 0.4301 0.4471 0.4673 0.4887 0.5143 0.5438 0.5779 0.6175 0.6633 0.7164 0.7779 0.8491 0.9316 1.0270 1.1373 1.2645 1.4112 1.5801 1.7741 1.9967 2.2516 2.5430 2.8755 3.2542 3.6849 4.1737 4.7277 5.3548 6.0636 6.8644 7.7686 8.7895 9.9429 11.2474 12.7253 14.4033 16.3140 18.4964 20.9982 23.8761 27.1982 31.0450 35.5109 40.7058 46.7560 53.8056 62.0176 71.5751 82.6815 95.5627 110.4754 127.720 147 170 197 228 263 304 352 406 470 543 627 725 838 968 1118 1292 1492 1724 1991 2300 2657 3069 3545 4095 4729 5462 6309 7287 8416 9720 11226 12965];

- Modify the AVE and VAR of the SI for each data stream, since the channel quality of actual data streams cannot be represented by the column norm of H
    - Heuristic parameters (a_1, a_2) are introduced with a provided table (MCS-dependent, also condition number dependent, derived from link simulations and optimized with AWGN reference). The scaling factor of “2” for 64QAM seems to be unexplained.
    -

$$AVE_{Stream,i} = a_i \times AVE, \quad VAR_{Stream} = VAR \quad for\ QPSK, 16QAM$$
$$AVE_{Stream,i} = a_i \times AVE, \quad VAR_{Stream} = 2 \times VAR \quad for\ 64QAM$$

Parameter a		QPSK 1/2	QPSK 3/4	16QAM 1/2	16QAM 3/4	64QAM 1/2	64QAM 2/3	64QAM 3/4	64QAM 5/6
$k < 10$ $\lambda_{\min} dB \le -10$	1^{st} Stream	0.9000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	2^{nd} Stream	0.9000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
$k < 10$ $-10 < \lambda_{\min} dB \le 8$	1^{st} Stream	2.8372	1.4444	0.4343	1.5737	0.7872	1.0000	1.0000	1.0000
	2^{nd} Stream	1.4801	1.4859	0.6389	1.1526	1.1000	1.0000	1.1000	1.0000

$k<10$ $\lambda_{\min} dB > 8$	1st Stream	1.2000	1.0000	0.6000	0.9889	0.4695	1.5889	1.5000	0.9222
	2nd Stream	1.2000	1.2000	0.6000	1.3632	0.3111	2.0667	1.0667	0.9333
$10 \le k < 100$ $\lambda_{\min} dB \le -10$	1st Stream	1.9264	1.1731	1.0000	1.0000	2.0000	1.0000	1.0000	1.0000
	2nd Stream	1.6172	1.3444	1.0000	1.0000	2.0000	1.0000	1.0000	1.0000
$10 \le k < 100$ $-10 < \lambda_{\min} dB \le 8$	1st Stream	0.8833	1.1900	0.5000	1.1246	0.6611	0.8556	1.0111	1.0000
	2nd Stream	0.8857	1.3000	0.5000	0.8532	0.6500	0.8333	1.1556	1.0111
$10 \le k < 100$ $\lambda_{\min} dB > 8$	1st Stream	1.1000	1.0000	0.5500	1.0000	0.7310	1.0778	1.1111	0.8333
	2nd Stream	1.1000	1.1000	0.5500	1.0000	0.9111	1.0778	1.1667	0.8333
$k \ge 100$ $\lambda_{\min} dB \le -10$	1st Stream	0.8000	0.9737	0.4000	1.0000	1.0000	1.0000	1.0000	0.6889
	2nd Stream	0.8111	1.2456	0.4000	0.7479	1.0000	1.0000	1.0000	1.0000
$k \ge 100$ $-10 < \lambda_{\min} dB \le 8$	1st Stream	0.9736	0.9573	1.7303	0.8532	1.4895	0.8889	0.8889	0.7556
	2nd Stream	2.6241	1.0222	0.4667	0.8310	0.6444	0.9445	1.0555	0.8445
$k \ge 100$ $\lambda_{\min} dB > 8$	1st Stream	0.9000	1.0000	0.4500	1.0000	0.9000	0.9000	0.8889	0.7556
	2nd Stream	0.9000	1.0000	0.4500	1.0000	0.9000	1.0000	1.0000	0.7667

- For vertical MIMO, combining SI of both stream is necessary
    - Another set of heuristic parameters (p_1, p_2) are introduced with a provided table (again MCS-dependent, also condition number dependent, derived from link simulations and optimized with AWGN reference).

$$SI = p_1 \cdot SI_{stream1} + p_2 \cdot SI_{stream2}$$

		QPSK 1/2	**16QAM 1/2**	**64QAM 1/2**
$k<10$ $\lambda_{\min} dB \le -10$	p_1	0.5000	0.5000	0.5000
	p_2	0.5000	0.5000	0.5000
$k<10$ $-10 < \lambda_{\min} dB \le 8$	p_1	0.5445	0.6667	1.0000
	p_2	0.6556	0.4444	0.3333
$k<10$ $\lambda_{\min} dB > 8$	p_1	0.5000	0.5000	0.5667
	p_2	0.5000	0.5000	0.5223
$10 \le k < 100$ $\lambda_{\min} dB \le -10$	p_1	1.0000	0.5000	0.5000
	p_2	0.1111	0.5000	0.5000
$10 \le k < 100$ $-10 < \lambda_{\min} dB \le 8$	p_1	0.6667	0.1111	0.5333
	p_2	0.3333	0.8889	0.5111
$10 \le k < 100$ $\lambda_{\min} dB > 8$	p_1	0.5000	0.5000	0.8889
	p_2	0.5000	0.5000	0.1111
$k \ge 100$ $\lambda_{\min} dB \le -10$	p_1	0.2222	0.0000	0.5000
	p_2	0.7778	0.5556	0.5000
$k \ge 100$ $-10 < \lambda_{\min} dB \le 8$	p_1	0.6667	0.4778	0.0000
	p_2	0.0000	0.6556	1.0000
$k \ge 100$ $\lambda_{\min} dB > 8$	p_1	0.5000	0.5000	0.5000
	p_2	0.5000	0.5000	0.5000

III. RBIR for Some Typical Channels

In this section, a few simple channel cases are used for the purpose of sanity check, in an effort to analyzing the behavior of the two methods.

Comment 1: RBIR for diagonal channels

$$H = \begin{bmatrix} x & 0 \\ 0 & x \end{bmatrix}$$

where x is any value. (assuming $\sigma^2 = 1$ in all the examples for simplicity.)

The above channel must give approximately same value of MI for both streams. However, since RBIR tables have different values of ‘a’ for each stream, the above results in difference values of RBIR for the two streams

***Specific example*:**

$$H = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

RBIR for QPSK-1/2 for the above channel is 0.627 for stream1 and 0.4322 for stream2. In the domain of effective SNR, such a different in RBIR maps to a large difference (***2.8 dB vs 0.25 dB***) in post-ML quality of the two stream, but we know that actually the post-ML quality of the two stream should be same.

Comment 2: RBIR Symmetry

Consider two channels $\mathbf{H}_1 = \begin{bmatrix} a & b \\ c & d \end{bmatrix}, \mathbf{H}_2 = \begin{bmatrix} b & a \\ d & c \end{bmatrix}$, which are just column permutations of each other. The performance of both the above channels is expected to be same with vertical encoding

For almost all channels tested it is found that a channel and its column permutation give different values of RBIR for vertical encoding.

Specific Example:

$$H = \begin{bmatrix} 0.5955 + 2.0955i & -1.8932 + 0.4440i \\ -1.1083 + 4.5946i & -0.8652 - 0.5163i \end{bmatrix}$$

The RBIR (for 16QAM R-1/2) of the above randomly generated channel and its permutation are given by 0.61 and 0.58 respectively.

Note that the SI of both hypothetical streams are the same because of the same column norms. Given that the actual SI is the result of weighted sum of the two Sis, the only way that will results in same RBIR after column permutation is by setting $p_1 = p_2$, which is not the case in the provided table. A wild guess is that index 1 and 2 are tied to any properties of the matrix, but currently this is not clear at all.

Comment 3: RBIR Properties

a) $H = \begin{bmatrix} 5 & 0 \\ 0 & 5 \end{bmatrix}$**,** *RBIR(16QAM-R1/2) =**0.64,** RBIR(64QAM-R1/2)=**0.71***

$H =$[2.4458 + 1.5065i   0.4224 + 1.8827i

   0.9998 + 2.5964i -3.0534 - 2.3936i]   , *RBIR (16QAM-R1/2)=0.65, RBIR(64QAM R1/2) = 0.73*

RBIR does not satisfy the basic property of for any bit-level information metric that it should ***decrease with increase in modulation level*** (Note: This is satisfied for SISO RBIR/MMIB and ML MMIB functions)

b) $H = \begin{bmatrix} 10 & 0 \\ 0 & 10 \end{bmatrix}$**,** *RBIR_ML (H,64QAM-R1/2) = **0.55**, RBIR_SISO(h=10, 64QAM) **= 0.94***

As shown above or the above diagonal channel it is expected that RBIR metric for ML is 'approximately' same as that of the SISO, since a diagonal channel is essentially two parallel SISO channels. However, the above result shows that they are very different.

c) Note also in the above example, the channel in b) has higher SNR than that in a), and but the former gives a *smaller* RBIR metric for 64QAM-R1/2. It is not correct intuitively.

d) Note further that the parameters p1 and p2 do not add up to one, which results in an RBIR value of greater than one in certain cases.

Comment 4: Negative Values of SI and RBIR for high SNR

$$H = \begin{bmatrix} 25 & 5 \\ 5 & 25 \end{bmatrix}$$

For the above channel RBIR(stream 1) **= 0.166**, RBIR(stream2) = **-0.212** for 64QAM R-1/2
RBIR for vertical encoding is **-0.0166,** which is too small and negative, and RBIR for stream 2 is also negative. An information metric cannot be negative and it is also expected that bit-information rate must be much larger at these SNRs.

Note that the SNR for the above channel (defined by column norm is around 28 dB). This behavior is observed for typical channels at high SNRs.
One way to explain this is by looking at the approximation in Eq (43) of the EVM document. The second term in SI expression is dominated by f1(AVE-sqrt(VAR)), which is large for large values of VAR, values which are obtained well within operating SNR regions. We have also noted that substituting the approximation with the actual numerical integration results in the similar inconsistency.

Comment 5: RBIR for different code rates – Applicability to IR/HARQ

According to the current development of RBIR for ML receivers, different values of RBIR are obtained for different code rates, for the same modulation (due to code-rate dependent heuristic adjustment parameters sets).

This is different from 'RBIR/MMIB for SISO and MMIB for ML receivers', which have a unique value for a given modulation, i.e., code rate independent. Hence, the development for IR in section 4.6.3 Eqs 92-95, which is based on this assumption for a MI metric no longer applies to RBIR as defined for ML.

Since RBIR is dependent on code rate (similar to effective SNR in EESM), new RBIR tables would be required to cover the new possible code rates with IR.

Comment 6: Approximation used in RBIR integral

The approximation in (43) is suggested for avoiding computation of RBIR function in real-time. We have seen that this approximation works approximately well when AVE/sqrt(VAR)<0.5 (empirical observation)

1) AVE = 5, VAR = 40 (Obtained for H = diag[5 5], 16QAM-R ½)
   Num. Integral = 0.69, Num. Approx = 0.64
2) AVE = 5, VAR = 20
   Num. Integral = 0.86, Num. Approx = 0.83

From the Tables 25 and 26, it can be verified that situations in case (a) arise often. It would be good to clarify under what conditions this approximation is good, and if there are alternate approximations that can be used in general.

Comment 7: Search for Optimal Adjustment Parameters for RBIR

In the current version of EVM, Appendix Q provides an approach to derive adjustment parameters for each MCS. There are a total of 18 ‘a’ parameters and 18 ‘p’ parameters (defined for each stream and partition) to be obtained for *each MCS*.
How is the optimization in Q2 Step 3 performed? Does it involve a simultaneous search over 9 parameters and does expression in Q.3 Step 4 require a search over 18 dimensions simultaneously to minimize the expression?

The current text says ‘***for all H which belongs to a particular range of k and lambda***’. So, if this implies obtaining parameters (a,p) for a partition by selecting H in that partition, what does H mean here? It does not make sense, since the data here is effective SNRs which are computed for a given fading channel realization (described by many different H on different subcarriers, which can belong to multiple partitions).

Further detail needs to be provided in this section.

IV. Comparison Table

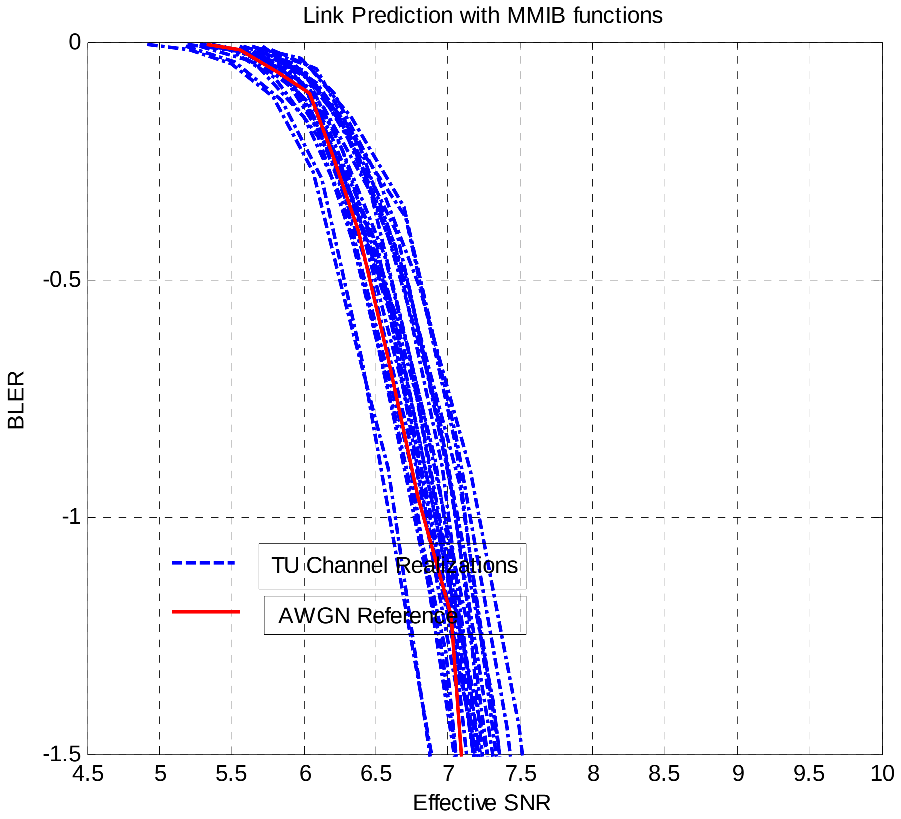
	MMIB	RBIR	Comment
1) SISO Systems and MIMO Systems with Linear Receivers	A simple SNR to MMIB mapping is used which is defined by a function unique to each modulation (or a lookup table can also be used)	A simple SNR to RBIR mapping is used which is defined by a lookup table unique to each modulation	These SNR to MMIB/RBIR mapping are found to be close and hence no difference is expected in these simulations. *The rest of the comparison deals with ML receivers*
2) Physical Interpretation and HARQ	MMIB functions correspond to the true observed bit mutual information of the matrix channel. They satisfy the properties of bit mutual information a) Fall in the range [0.0 1.0] b) Decreasing with increase in modulation order	It was seen that RBIR does not meet these constraints. See Sections above.	It cannot be claimed that the RBIR metrics can be combined across modulations etc., since RBIR metric generated does not meet the requirements of mutual information. In that sense, does not conform to the definitions used in previous studies and the remaining sections of EVM.
3) Channel Dependency	MMIB functions are generated by a) Numerically obtaining (by *Monte-Carlo simulation and numerical integration of LLR PDFs obtained from a Gaussian matrix channel and a constellation mapping model*), the theoretical true bit-level MI of a matrix channel b) Approximating this function with numerical approximations c) NO AWGN or link simulations are used at any point, as these functions are independent of the underlying system (Note: Compare to SISO MI functions, which are defined for a SISO Gaussian channel defined by an SNR)	RBIR functions are obtained by a) Performing Link Simulations b) Optimizing parameters a_i and p_i for each MCS c) A different value of RBIR is obtained for each code rate, even though the modulation is fixed. Does not conform to the definition of information metric	For RBIR, the parameter tables must be optimized with link simulations and synchronized between companies. The primary objective of using MI metrics is to avoid parameter tables which must be updated with link simulations
3) Heuristic Adjustment for codes	MMIB functions are independent of system parameters, code rates etc.,	Same as above	Same as above

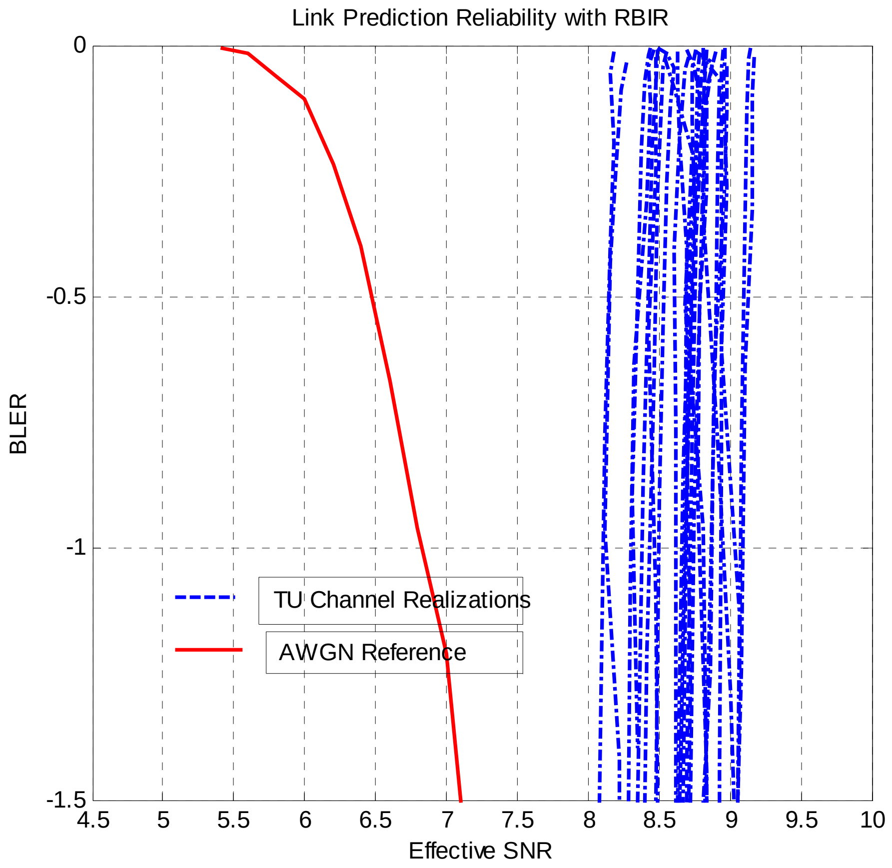
	For characterizing performance with new binary codes or additional code rates, only AWGN simulations are required to generate AWGN reference curve		

V. Numerical Results

The numerical results are generated to check the reliability of performance prediction. 25 different channel realizations are simulated. For each realization, mean SNR is swept so that the entire BLER range is obtained. PB3, IID MIMO channel model is used. MCS used is 16QAM Rate ½ with PUSC.

The red curve in the figure represents AWGN reference, where x-axis is the AWGN SNR and the y-axis is the BLER in AWGN simulation condition. The blue curves are obtained from a fading simulation. For each BLER point, the MI of the corresponding channel realization is computed. This MI is mapped to an effective SNR using the SISO MI to SNR relationship of the corresponding modulation. Same set of data from link results are used in both figures below.





VI. Conclusions

RBIR modeling for ML requires four “fudge” parameters (a1,a2,p1,p2) by link simulations for each MCS level. Our numerical results with RBIR for ML do not show good prediction reliability. Multiple simple examples also suggest that the RBIR approach as defined cannot pass even simple sanity check or basic properties as expected from a mutual information metric. Furthermore, due to dependency on heuristic adjustment required for different MCS levels, it is not clear that this method can be applied to model post-IR performance since IR can be deemed as generating an additional code rates after combing.

On the other hand, MMIB functions for ML are capacity measures defined for the underlying bit channel induced by a modulation constellation and the matrix channel. Because the framework for MMIB is well-grounded based on information theory, much like their SISO counterparts (both MMIB, which is defined as bit channel capacity for SISO for and RBIR defined as normalized symbol capacity for SISO), MMIB method does not require any heuristic parameters that depends on MCS and is also independent of the actual code, system parameters etc. In addition they satisfy all the properties of a bit-level mutual information metric like the SISO MI metrics and not surprisingly show good prediction for ML.

Based on this study, it is suggested to adopt the MMIB as the baseline link to system mapping methodology, especially for ML-MIMO receiver modeling.

References

[1] Krishna Sayana, Jeff Zhuang, Ken Stewart, IEEE C80216m-07/097, "Link Performance Abstraction based on Mean Mutual Information per Bit (MMIB) of the LLR Channel", IEEE 802.16 TGm contribution, May 04, 2007.

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