Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Interference Knowledge Impact on Link-to-System Mapping**
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Re:	IEEE 802.16m-07/031– Call for Comments on Draft 802.16m Evaluation Methodology Document
Abstract	This contribution discusses the knowledge of interference impacts on the receiver, and proposes a method to model this is in the PHY abstraction. In addition, baseline assumptions for the knowledge of interference statistics are also proposed.
Purpose	To incorporate the proposed text changes into the Draft 802.16m Evaluation Methodology Document (IEEE C802.16m-07/080r3)
Notice	
Release	
Patent Policy	

Interference Knowledge Impact on Link-to-System Mapping

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1. Introduction

This contribution describes the impact of the knowledge of interference statistics at the receiver on decoding performance, and how this impact can be modeled in the link-to-system mapping procedure. Link level and system level results are presented demonstrate the impact, and performance of the proposed solution. Baseline assumptions for the knowledge of interference are also suggested.

The discussion and proposed solution presented in this contribution is independent of the PHY abstraction method used.

2. Background and Motivation

System level simulations make use of link level simulation results in an additive white Gaussain noise (AWGN) channel to determine a transmission predicted block error rate (BLER) from a given signal-to-noise and interference ratio (SNIR). If different symbols of the same code block are received with different channel conditions, and than a PHY abstraction method (e.g. EESM, MIESM, etc.) must be used to properly map system level SNIRs to link level curves that are generated in AWGN environments. The PHY abstraction method determines a predicted BLER from component SNIRs of the code block.

In its basic form, the component SNIRs used as inputs to the PHY abstraction method are associated with inherent assumptions of the channel condition knowledge at the receiver. From example, consider the case of transmission over a frequency selective channel with only AWGN. Using component SNIRs that include the per-subcarrier channel gains of the receiver as the inputs to the PHY abstraction method will result in BLER performance consistent with the assumptions of known per-subcarrier channel gains at the receiver.

In general in system level simulations with inter-cell interference, the interference is not simply AWGN. The interference is random process with different powers on each subcarrier for each realization, due to frequnecy selective channel gains from interfering signals, different transmit power levels for different subchannels, etc. If per-subcarrier SNIRs calculated with per-subcarrier interference powers (as according to equation (25) of [1]) are used as input to the PHY abstraction, the resulting BLER performance can be shown to be consistent with a system with per subcarrier interference knowledge at the receiver.

As per subcarrier interference knowledge at the receiver is unlikely for physical systems, the PHY abstraction procedure should be changed to give performance consistent with the assumptions of interference statistics knowledge at the receiver.

3. Discussion of Proposed Method

In this contribution, link level and system level results are used to show to demonstrate the impact of interference knowledge, and suggested procedure for PHY abstraction to be consistent which interference knowledge assumptions. In particular, the proposed method is to calculate per subcarrier SNIRs using the average value of the interference over the subcarriers. For example, if the interference power is reliably known over a set of N subcarriers, then the average interference over the set of N subcarriers should be used in calculating the N per subcarrier SNIRs prior to imputing to the PHY abstraction. In general, the simulations show this proposed method results in predicted BLER performance consistent with the interference knowledge assumptions.

This contribution considers two cases of interference knowledge:

Case A. Knowledge of average interference power across all subcarriers of the transmission, for each frame, at receiver decoder.

Case B. Knowledge of per-subcarrier interference power, for each frame, at receiver decoder.

3.1. Link Level Simulations

The link simulations simulate turbo decoding of the received signal with the appropriate interference assumptions at the MAP decoder. The simulations consider a signal transmitted through a frequency selective channel with one interfering signal. The received signal on the ith subcarrier at a given time instant is given by:

$$y_i = h_i x_i + g_i d_i + n_i \qquad (1)$$

Where h_i is the channel gain, x_i is the data modulation symbol of desired signal, g_i is the channel gain of the interferer, and d_i is data modulation of interferer for the i^{th} subcarrier. The thermal noise for the i^{th} subcarrier given by n_i, is ignored in this study.

At the receiver, the log likelihood ratio (LLR) makes use of the conditional probabilities for the k^{th} bit, b_k, given by [2]

$$P(y_i \mid b_k = 1) = e^{-\frac{\left(\sum_{j=1}^{m} y_i - h_i c_j^{b_k=1}\right)^2}{\sigma_i^2}} \qquad (2)$$

$$P(y_i \mid b_k = 0) = e^{-\frac{\left(\sum_{j=1}^{m} y_i - h_i c_j^{b_k=0}\right)^2}{\sigma_i^2}} \qquad (3)$$

Where c_j is j^{th} point of the modulation constellation and σ_i^2 is the noise variance of the i^{th} subcarrier.

From (2) and (3), they will clearly be a performance difference in decoding if the noise variance is known per subcarrier, or only known across a set (or all) subcarriers.

The procedure differences for the two cases for link level simulations are:

Case A. Find average interference across all subcarriers, $\sigma_i^2 = \frac{1}{N}\sum_{n=0}^{N-1}\left|g_i d_i\right|^2$, and use the average value in MAP decoding at receiver.

Case B. Find per-subcarrier interference powers, $\sigma_i^2 = \left|g_i d_i\right|^2$ and input to MAP decoder.

3.2. System Level Simulations

In order to simulate the two cases in system level simulations, the SNIR inputs to the PHY abstraction are made to be consistent with the respective assumptions of interference knowledge at the receiver. Modeling for each case is described below.

Case A. System level simulations for which only the average interference at the receiver is known can be effectively modeled by (Figure 1)

1. Finding the average interference across the subcarriers

$$\sigma_i^2 = \frac{1}{N}\sum_{n=0}^{N-1}\left|g_i d_i\right|^2$$

2. Calculating the per-subcarrier signal-to-noise + average interference ratios (SNAIRs), and inputting to PHY abstraction

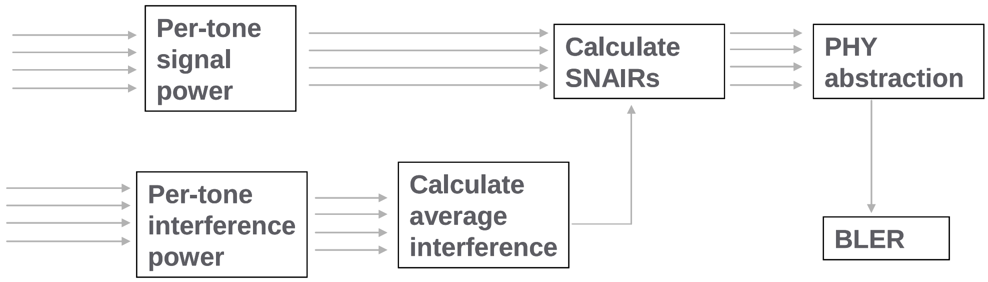

Figure 1. PHY abstraction simulation procedure for average interference knowledge.

Case B. System level simulations for which the per subcarrier interference at the receiver is known is modeled by calculating the per-subcarrier SNIRs, $\sigma_i^2 = \left|g_i d_i\right|^2$, and inputting to per subcarrier SNIRs to the PHY abstraction.

3.3. Simulation Details and Results

Link level and system level simulations were completed for cases A and B as described in the previous sections. Some key simulation parameters are listed in Table 1.

Table 1. Simulation parameters.

Packet	1024-bit rate ½ turbo coded
Decoder	Max-log-map
Channel	ITU Pedestrian B (both desired signal and interferer) Quasi-static fading
Bandwidth	10 MHz

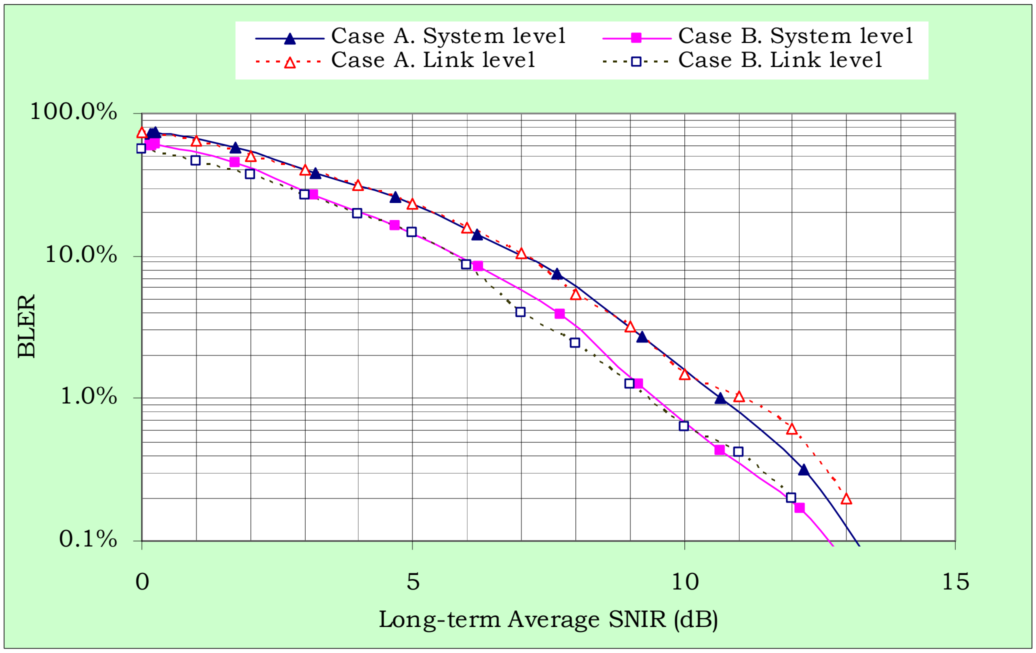

Figure 2. Link and system performance for the two cases.

Link level and system level simulation results are show in Figure 2. The results indicate that using per subcarrier interference knowledge for SNIR inputs to the PHY abstraction is consistent with link level performance assuming knowledge of per subcarrier interference at the receiver. Similarly, using average interference knowledge across subcarriers and using SNAIR inputs to the PHY abstraction is consistent with link level performance knowledge of average interference across all subcarriers at the receiver.

4. Conclusions

In order to properly model knowledge of interference statistics at the receiver the PHY abstraction inputs should be modified. Calculating the average interference across the set of subcarrier over which it is known, and then calculating per subcarrier SNAIRs for input to the PHY abstraction appears to be a method that is consistent with link level findings. We suggest this method be adopted in the 802.16m Evaluation Methodology Document.

In addition, this contribution suggests adopting baseline interference knowledge assumptions for the simulations. . For a distributed subchannel, the interference used for post-processing SNIR computation is the average interference across the tones within the distributed subchannel; for an AMC subchannel, the interference used for post-processing SNIR computation is the average interference across the tones within the AMC subchannel. A proponent can assume further granularity in interference knowledge, but must provide justification for their assumption.

5. References

[1] R. Srinivasan, J. Zhuang, L. Jalloul, R. Novak, J. Park, *Draft IEEE 802.16m Evaluation Methodology Document*, IEEE C80216m-07-080r3, August 28, 2007.

[2] B. Vucetic, J. Yuan, *Turbo Codes: Principles and Applications*, Kluwer Academic Publishers, Norwell, Mass., 2000.

6. Proposed Text

We suggest five modifications to the text of IEEE C802.16m-07/080r3:

1. Unbracket text, and modify page 68, line 27 as follows:

"[In the above we assume that ideal knowledge of interference statistics per sub-carrier is available for post-processing SINR computation. In case that that per-sub-carrier interference is not known, the per-tone SINR should be modified. One option is to by replaceing the per-tone interference power with its average across the set of sub-carriers. Equation (25) becomes:

$$SNIR^{(0)}(n) = \frac{P_{tx}^{(0)} P_{loss}^{(0)} \left|H^{(0)}(n)\right|^2}{\sigma^2 + \frac{1}{N_A} \sum_{n_A=0}^{N_A} \sum_{j=1}^{N_I} P_{tx}^{(j)} P_{loss}^{(j)} \left|H^{(j)}(n_A)\right|^2}$$

where N_A is set of subcarriers over which the interference statistics are known. Refer to section 4.5.5 for the description of interference statistics that shall be used for post-processing SINR computation in system level simulation. This model requires further study.] "

2. Page 72, modify line 17 as follows:

" .. the interference statistics.]Refer to section 4.5.5 for the description of interference statistics that shall be used for post-processing SINR computation in system level simulation."

3. Page 72, modify the paragraph on lines 19-20 as follows:

"For baseline evaluation, the default assumption is the average interference across a subchannel is known at the receiver. For a distributed subchannel, the interference used for post-processing SINR computation is the average interference across the tones within the distributed subchannel. For an AMC subchannel, the interference used for post-processing SINR computation is the average interference across the tones within the AMC subchannel. Other assumptions on interference statistics may be used, In such case, pProponents shouldshall provide justification of the knowledge of interference statistics at the receiver. assumptions related to knowledge of interference statistics used in system level simulations. "

4. Page 21, Table 1, 10th row on page, 3rd column: clarify the default interference modeling assumptions. Modify the text as follows:

"Frequency selective interference model for PUSC, no interference awareness at receiver. Use default interference assumptions, i.e. for a distributed subchannel, the interference used for post-processing SINR computation is the average interference across the tones within the distributed subchannel; for an AMC subchannel, the interference used for post-processing SINR computation is the average interference across the tones within the AMC subchannel. "

5. Page 23, Table 2, 5th row on page, 3rd column: clarify the default interference modeling assumptions. Modify the text as follows:

"Frequency selective interference model for PUSC, no interference awareness at receiver. Use default interference assumptions, i.e. for a distributed subchannel, the interference used for post-processing SINR computation is the average interference across the tones within the distributed subchannel; for an AMC subchannel, the interference used for post-processing SINR computation is the average interference across the tones within the AMC subchannel. "