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Re:	IEEE 802.16m-07/23 "Call for Comments on Draft 802.16m Evaluation Methodology Document"
Abstract	This contribution proposes a PHY abstraction based on EESM for non-linear receiver for 802.16m Evaluation Methodology
Purpose	Discuss and adopt proposed text in 802.16m Evaluation Methodology document
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A Proposal for EESM Method for Non-linear MIMO Receiver

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1. Introduction

The dynamic PHY abstraction methodology based on EESM (Exponential ESM) has already been adopted as part of the draft 802.16m evaluation methodology document (C802.16m-07/080r1). With this method, in order to get the effective SINR of a FEC block, the per-tone post-processing SINR is needed firstly. However, for MIMO system, when a non-linear receiver, such as Maximum Likelihood receiver, is used, the per-tone post-processing SINR cannot be calculated through explicit equation. To evaluate the system performance when using the non-linear receiver, the corresponding method of PHY abstraction should be proposed. We propose the use of the method defined and validated by Hao Liu et al [1] in order to obtain the effective SINR for the non-linear receiver based on the per-tone post-processing SINR as calculated for a linear receiver.

2. Suggested Method

In the following description of the method, we use the Maximum Likelihood receiver as representative of a non-linear receiver.

2.1 Phy Abstraction

In our suggested method, the key point is to get the value of per-tone post-processing SINR g_k ($k=1,...N$) and the tuning factor b_{ML} (b for ML $SINR_{AWGN}(BLER)$ curve detector). So the following steps are used to get the SINR and b_{ML}:

(1) Through link simulation, we obtain the $SINR_{AWGN}$ vs. $BLER$ curve for AWGN channel with the ML receiver for a given MCS (Modulation and Code Scheme).

(2) The BLER achieved for the ML receiver, $BLER_{ML}$, over the MIMO channel for the same MCS as in Step 1 is obtained via link simulation

(3) The per-tone post-processing SINR, g_k, for each tone, k, is calculated based on equations derived for the linear MMSE detector (see Ref [1])

(4) Using the per-tone SINRs, g_k, obtained in Step 3, the effective post detector SINR corresponding to the value of $BLER_{ML}$ measured in Step 2, becomes a function of the tuning factor, $ß_{ML}$, via the EESM equation (1):

$$SINR_{eff\_ML} = -b_{ML} \ln\left[\frac{1}{N}\sum_{k=1}^{N} e^{-\frac{g_k}{b_{ML}}}\right] \quad (1)$$

(5) Steps 2 to 4 are repeated with different SINRs at the transmitter in order to obtain different effective post-detector SINR, $SINR_{eff\_ML}$, corresponding to different $BLER_{ML}$

(6) Finally, we find the value of $ß_{ML}$ that calculates the effective post-detection SINR, $SINR_{eff\_ML}$, for the ML receiver that matches as close as possible to the SINR, $SINR_{AWGN}$, of the receiver in an AWGN channel at the same BLER by finding the value of $ß_{ML}$ that satisfies equation (2) across all $BLER_{ML}$ data points:

$$\min \sum \left[SINR_{eff\_ML}(b_{ML}) - SINR_{AWGN}(BLER_{ML}) \right]^2 \quad (2)$$

After the above steps, we get the value of b_{ML} and the SINR vs. BLER curve for a given MCS. The steps 1 through 6 above are repeated to obtain results for different MCS.

2.2 Application to System Simulation

During system simulation, with the parameter b_{ML} and the $SINR_{AWGN}(BLER)$ curve, we can obtain the BLER when ML receiver is used as follows:

(1) Calculate the per-tone post-processing SINR g_k based on MMSE receiver

(2) Applying the results of step 1 to equation (1), calculate the effective SINR $SINR_{eff\_ML}$ based on ML receiver

(3) Using $SINR_{eff\_ML}$, the BLER for the ML receiver is obtained by looking up the value of BLER that corresponds to $SINR_{eff\_ML}$ (which is equivalent to $SINR_{AWGN}$, from the $SINR_{AWGN}(BLER)$ curve.

3. Proposed Text Changes

Add a new subsection 4.3.3.1 in section 4.3.3 after the line 11 in page 61:

4.3.3.1 EESM for Non-linear MIMO Receiver

When non-linear MIMO receiver (e.g Maximum Likelihood) is used in system simulation for a MIMO system, the EESM abstraction procedure is modified as follows:

1. Determine the tuning factors b_{nl} for non-linear receiver.
   (1) Obtain a $SINR_{AWGN}(BLER)$ curve at AWGN channel with a non-linear receiver for a given MCS (Modulation and Code Scheme) via link-level simulation.
   (2) Find b_{nl} for MIMO channel with non-linear receiver for a given MCS (Modulation and Code Scheme)
      a) g_k is the kth tone post-processing SINR, which is calculated with explicit linear detector equation (e.g MMSE etc) [1].
      b) $BLER_{nl}$ is the BLER with non-linear MIMO receiver being used. The value of $BLER_{nl}$ that corresponds to a particular effective post detector SINR, $SINR_{eff\_nl}$, is obtained via link-level simulation.
      c) The effective post detector SINR, $SINR_{eff\_nl}$, for non-linear receiver with g_k corresponding to $BLER_{nl}$ is specified as a function of b_{nl} via application of the EESM relationship:

$$SINR_{eff\_nl} = -b_{nl} \ln\left[\frac{1}{N}\sum_{k=1}^{N} e^{-\frac{g_k}{b_{nl}}}\right] \quad (1)$$

      d) In order to get different $BLER_{nl}$ for different effective post detector SINR, the steps (a) through (c) are repeated several times with different SINR at transmitter.
      e) Finally we compare $SINR_{eff\_nl}$ with AWGN SINR at the same BLER and find the optimal tuning factor b_{nl} to satisfy:

$$\min \sum\left[SINR_{eff\_nl}(b_{nl}) - SINR_{AWGN}(BLER_{nl})\right]^2 \quad (2)$$

2. In the system simulation, the per-tone post-processing SINRs g_k are computed based on the applicable equations for a linear reciver (note that the linear receiver must be consistent with the one used in the link simulation)
3. According to the tuning factor b_{nl} and the per-tone post processing SINR g_k ,use the equation (1) to compute the effective SINR, $SINR_{eff\_nl}$, with non-linear MIMO receiver being used. And then use the $SINR_{eff\_nl}$ to look up $SINR_{AWGN}(BLER)$ curve and finally get the corresponding BLER.

4. References

1. Hao Liu, Liyu Cai, Hongwei Yang, and Dong Li: "EESM based link error prediction for adaptive MIMO OFDM system" 2007. IEEE VTC2007-Spring. IEEE 65th April 2007 Page(s):559 - 563.
2. IEEE C802.16m-07_080 r2:Draft IEEE 802.16m Evaluation Methodology Document.