Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	Figure and updating for interference threshold description
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Re:	IEEE 802.16-07/010：IEEE 802.16 Working Group Letter Ballot Recirc #24a: Announcement (2007-02-01)
Abstract	AI result according to the group resolution in meeting #48.
Purpose	To consolidate the 16h draft.
Notice	
Release	
Patent Policy and Procedures	

Figure and updating for interference threshold description

Wu Xuyong, Avi Freedman

Overview

We have some discussion in meeting 48 about the definition for different level of interference and their threshold, according to comment 2064 by Kenneth Standwood:
Page 51, Line 23, Subclause 15.1, Document P802.16h-D2
Comment: Definitions belong in section 3
Suggested Remedy: Move interference and threshold definitions to section 3.
Reply by Wu Xuyong: May we put a figure to summerize these interference and threshold here (before "In addition to those thresholds,") and move the definitions to section3. Seems better for clarification.
Group Decision: Accept-Modified
Group Resolution:
1) Move interference definitions to section 3.
2) leave the threshold definition and add a figure.
AI taken by Xuyong to work with Avi to provide the figure for interference threshold.

However, after checking section 3, I find that the existing text in 15.1 for interference and its threshold is not definition; they are illustration under the existing definition in section 3 instead. So I reformat the paragraphs according to description item style and waiting for the resolution of the figure.

Here we will have some discussion based on the C802.16h-07/015r1 and there are some notes below.

The Margins we used within discussion:

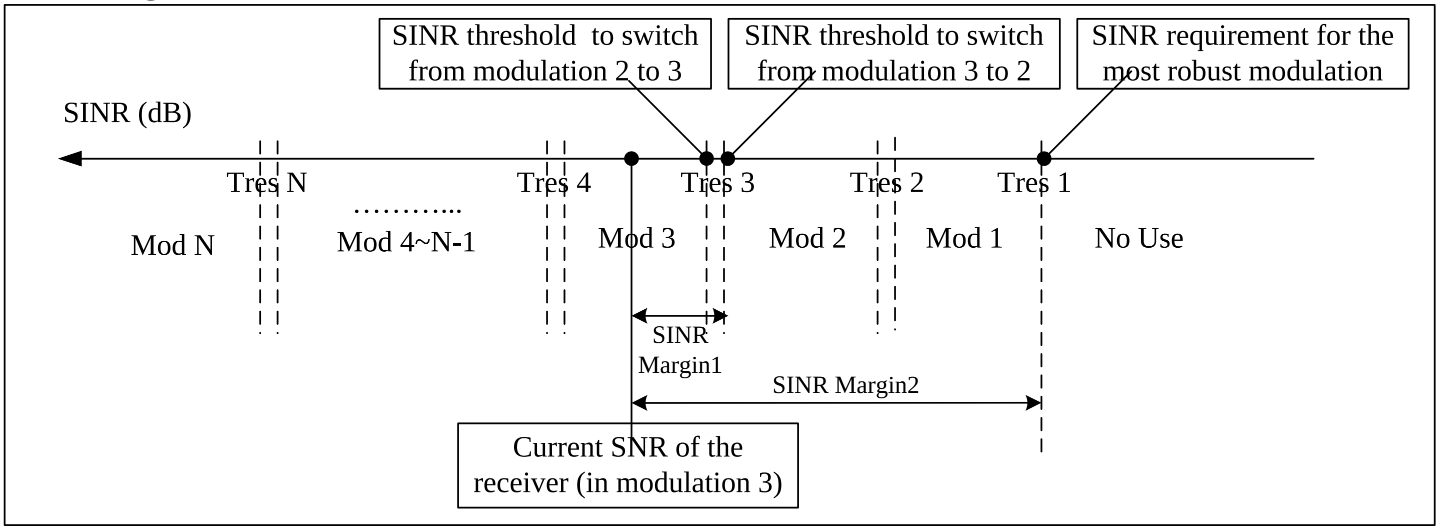


Figure 1 Margins in receiver SNR comparing to mandatory exit entry threshold for current modulation and the most robust modulation

This figure is to express the meaning of SINR Margin1 and SINR Margin2; they are both related to current SINR of the receiver which count on the signal situation without interference (SNR). The Axis in this figure is left oriented which indicate the left side have higher SINR/SNR value, while the right end area indicate very low SNR that the receiver will not capable to proceed any demodulation for data transceiver.

Assume that one 16h receiver is currently using modulation 3, it indicate that the SNR for this receiver is within the requirement of the modulation 3 and lower than the basic requirement to upgrade to modulation 4.

The SNR is always higher than the basic SINR requirement of current modulation, so the difference between them we can call it ***Margin1*** (***The margin value of current SNR of the receiver comparing the basic SINR requirement of current modulation method in this data link.***).

While Margin2 stand for the difference between current receiver SNR and basic SINR requirement in demodulation the most robust modulated data.

In Formula:

Margin1= SNR - SNIR requirement for current MC (modulation + coding profile);

Margin2= SNR - SNIR requirement for most robust MC (modulation + coding profile);

One possible question about this figure is why we have 2 dashes between different modulations. The answer is we need to have a cushion between two different modulation applications to prevent frequent switching back and forth in critical zone. So the boundary value of SINR for higher modulation to lower switching is different to the lower to higher switching. That's already materialized in primary standard (see below). The difference between H2L (mandatory exit) and L2H (minimum entry) switching boundary should be no less than 1dB, and this also ensures that acceptable interference threshold is bigger than light interference threshold.

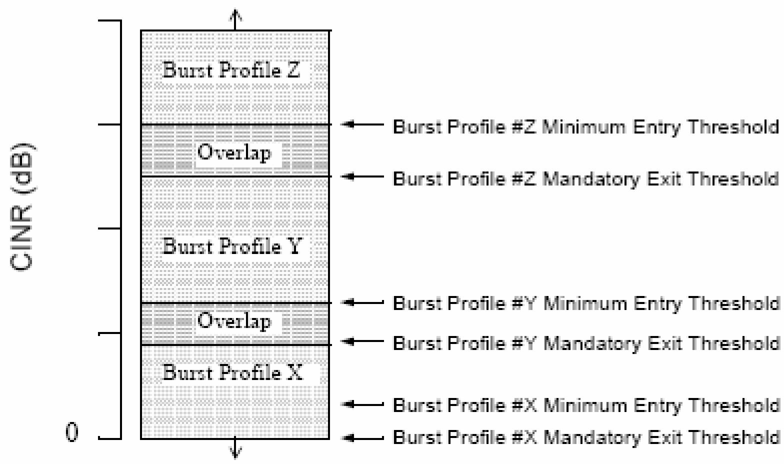


Figure 81—Burst profile threshold usage

Figure 2: 802.16-2004 figure 81

The grades of interference and the threshold terms:

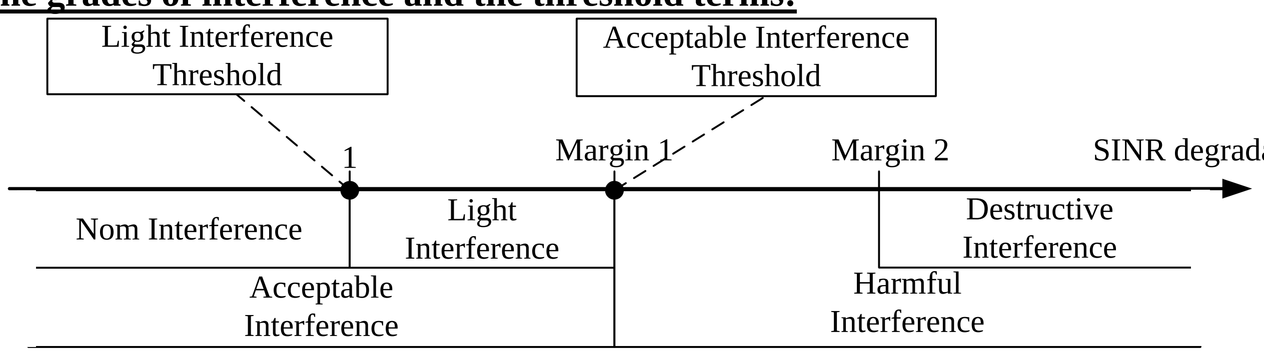


Figure 3: the interference grades and the threshold between these grades

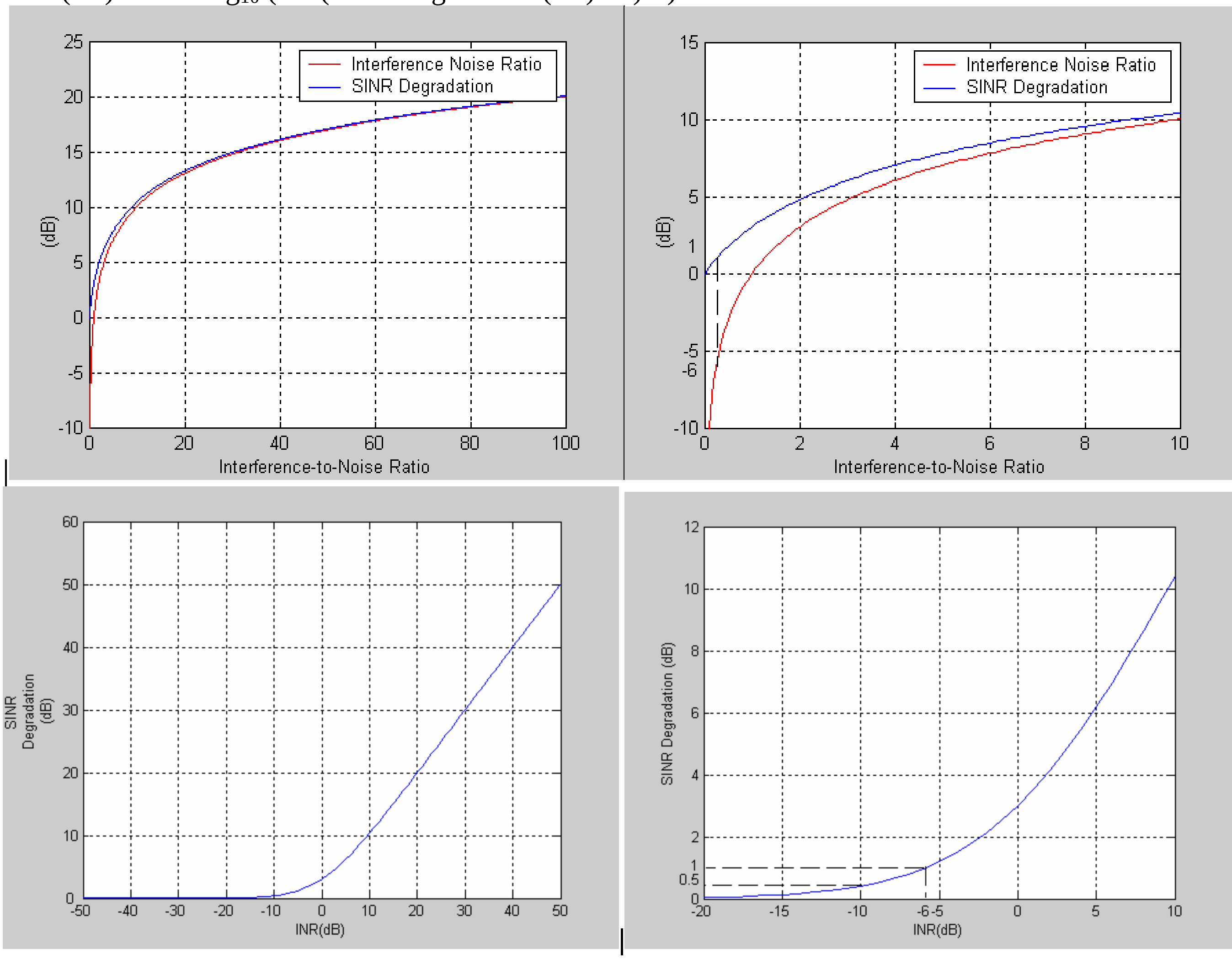
The figure above is describing the relationship between different grades of interference using the SINR degradation aspect, which indicate the impact of the interference under the instant receiver signal quality situation. While ***SINR degradation*** ((SNR–SINR) according to the occurrence of the interference) is equivalent to ***INR*** (interference-to-noise ratio) in principle, since

$$\begin{aligned}\text{SINR degradation (dB)} &= 10\log_{10}(S/N) - 10\log_{10}(S/(I+N)) \\ &= 10\log_{10}((S/N)/(S/(I+N)) \\ &= 10\log_{10}((I+N)/N) \\ &= 10\log_{10}(I/N+1)\end{aligned}$$

$$\text{INR (dB)} = 10\log_{10}(I/N)$$

$$\text{SINR degradation (dB)} = 10\log_{10}(10\text{\^{}}(\text{INR(dB)}/10)+1)$$

$$\text{INR (dB)} = 10\log_{10}(10\text{\^{}}(\text{SINR degradation(dB)}/10)-1)$$



Here by, we can either use SINR degradation or INR ratio to describe the grades of interference.

Non-Harmful: SINR degradation <1dB [8]

Light: 1dB[8]< SINR degradation < interference Margin (2dB DL/ 3dB UL) [9] <= SINR Margin1

Acceptable: SINR degradation < SINR Margin 1 (minimum 2dB DL/ 3dB UL) [9]

Harmful: SINR degradation > SINR Margin 1 > = interference Margin (2dB DL/ 3dB UL) [9]

Destructive: SINR degradation > SINR Margin 2

In another way, it may express equivalently as:

Non-Harmful: INR < -6dB [8]
Light: -6dB [8] < INR < (-2.3dB DL/ 0dB UL) [9] < INR Margin1
Acceptable: INR < INR Margin 1 (minimum -2.3dB DL/ 0dB UL) [9]
Harmful: INR > INR Margin 1 >= (-2.3dB DL/ 0dB UL) [9]
Destructive: INR > INR Margin 2

Light interference threshold is only related to the INR, so that's a constant 1 dB defined in SINR degradation, though this interference threshold will be to tight for any interference resolution, because light interference will not be harmful for any MC(modulation + coding) profile transceiver in real operation;

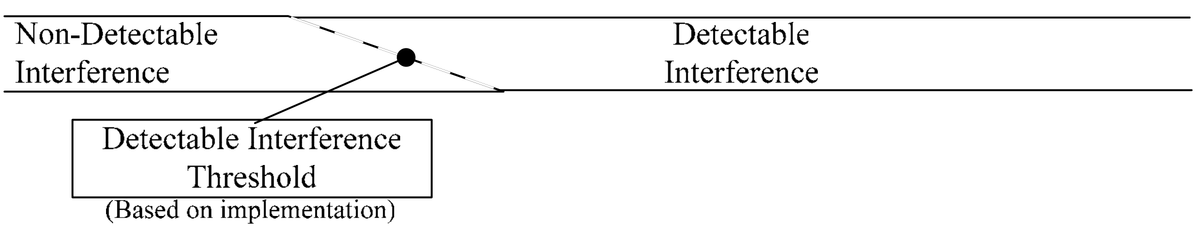
Acceptable interference threshold is related to current SNR of receiver and the mandatory exit SINR threshold current modulation, so that's a value of Margin 1. Hereby all the interference higher than the acceptable interference threshold is called harmful interference since it will force the receiver to ask for degrading MC profile. And the interference lower will not directly cause the MC degrading in transceiver.

This threshold is most useful since it relates to real impact by the interference. Interference above this threshold will be harmful, while below will be acceptable.

There is a minimum limitation for this Margin 1 in implementation and interoperation; by referencing the WiMAX Forum we choose 2dB in DL and 3dB in UL as the minimum Margin for each MC (Modulation + Coding) profile. That means 2dB DL and 3dB UL degradation in receiver SINR will be the lowest impact among any harmful interference, if we want to detect and identify all the harmful interference, we need to deal with the interference which cause 2dB DL/3dB UL SINR degradation as the worst case.

While ***detectable threshold*** is related to implementation method of interference detection, so that's leave to a implementation topic and depends on the technique choice of profile and detection method.

Detectable: Interference level > Detection threshold (implementation specific)



Reference:

[1] *IEEE 802.16-06/068r5: comment database of IEEE 802.16 LB24 (2007-04-12)*

[2] *IEEE P802.16h/D2a: (Temporary Editor's Draft) D2a for P802.16h (2007-03-28)*

[3] *IEEE 802.16-07/010：IEEE 802.16 Working Group Letter Ballot Recirc #24a: Announcement (2007-02-01)*

[4] *IEEE 802.16-2004: IEEE Standard for Local and metropolitan area networks Part 16: Air Interface for Fixed Broadband Wireless Access Systems (2004-10-01)*

[5] *IEEE 802.16e-2005: IEEE Standard for Local and metropolitan area networks Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1 (2006-02-28)*

[6] *IEEE C802.16-07/020r1: Action Items from Session #48 (Mariana Goldhamer; 2007-03-11)*

[7] *IEEE C802.16h-07/015r1: IEEE C802.16h-07/015r1 Action Item from Session #46: Definition of the interference Criteria (Avi Freedman, Xuyong Wu; 2007-01-17)*

[8] *CONSIDERATIONS IN THE DEVELOPMENT OF CRITERIA FOR SHARING BETWEEN THE TERRESTRIAL FIXED SERVICE AND OTHER SERVICES (Questions ITU-R 225/9 and ITU-R 127/9) (1992-1997-2000) Page 6*

By referencing interference to the receiver thermal noise level the problem is greatly simplified, since the permitted interference PSD so derived will be dependent solely on receiver noise figure and independent of the modulation scheme of the victim system. It may be shown that, independent of the normal received carrier level, the degradation in fade margin with interference set to a given level relative to receiver thermal noise level is as follows:

Interference level relative to receiver thermal noise (dB)	Resultant degradation in fade margin (dB)
–6	1
–10	0.5

Within the Tables, the choice of an interference to thermal noise *I/N* value of –6 dB or –10 dB is selected to match the typical requirements of individual systems. For detailed sharing analyses, the interference criteria must be derived in accordance with Annex 1, to match the individual, specific, sharing scenario under consideration, and will need to be agreed between the parties concerned.

[9] *WiMAX System Evaluation Methodology Version 1.0 (WiMAX Forum 1/30/2007)*

Proposed Changes accordingly:

The text below is just copied from the draft as a place holder, to be modified according to the concept above.

15.1 General

This clause describes high-level protocols and policies that may be used for coordinating the system operation in order to reduce the interference between WirelessMAN-CX systems, and between WirelessMAN-CX and non-WirelessMAN-CX systems.

The effect of interference on a victim receiver depends on many factors such as the power of the wanted signal received by the receiver, the receiver capabilities and its user's requirement and services. One can identify 5 ranges of interference, as its power at the receiver grows:

— *Non-harmful interference***,** which does not impact the receiver. Interference might raise the noise level by some amount (and we follow here the common practice to assume that interference affects the receiver similar to noise of the same power and hence it is additive to noise). In IEEE 802.16.2™-2004, a small noise level rise, of 1dB was considered as a threshold for limiting the interference which is commensurate with the noise rise due to any type of interference. This type of interference should be taken into account for system planning and design in licensed bands.

— *Light Interference***,** which still does not impact the receiver as it is capable to operate with the same level of performance even if interference were not present. This is due to the fact that the signal to noise plus interference (SINR) is high enough. See Annex A for a deeper description and an example. It should be noted that for modern systems, such as OFDMA, which can use sub-channelization, even a small noise rise can lead to some loss of performance.

— *Acceptable Interference***,** As the systems covered in this clause, are supposed to work in non-exclusive bands, it is expected that they will be subject to interference that affects their performance. We suggest using capacity reduction as the measure for interference, and also standardizing the acceptable capacity reduction to be up to 66% of the interference-free capacity. This value of 66% results from the fact that we envision up to 3 systems to share the same frequency channel in the same neighborhood. This number is also in accordance with the requirements on the frame size, latency requirement etc.

— *Harmful Interference***,** This is a strong interference which allows the link to communicate only by using its most robust mode of operation. In this mode, management messages can be communicated, but no traffic QoS can be assured. This is actually an interference that denies service, as understood by regulatory bodies.

— *Destructive Interference***,** This level of interference disables the victim from communicating using any capable modulation.

A threshold, in this document, is a signal or interference level (measured in dBm), at which an action, such as a report or coordination, is triggered.

Thresholds are defined as the boundaries between the levels mentioned above. The following thresholds were defined for different actions:

— *Light Interference Threshold*, is the boundary between the non-harmful interference range and the light interference range. This threshold is defined as a noise rise of 1db, which corresponds to an interference signal of interference to noise ratio I/N= -6dB. This threshold is used to recognize the existence of an interfering WirelessMAN-CX source, with which coordination can be performed.

— *Acceptable Interference Threshold*, is the boundary between the light interference and acceptable interference ranges. This value is used for recognizing a non-SSU interference source.

— In addition to those thresholds, a *Regulatory Threshold* is set according to regulatory requirements for SSU interference sources.

— Each of the above threshold levels should be transformed into a suitable *detection threshold*, which is the signal level set to determine if the interference source exists, with a given probability of detection under a given probability of false alarm.

The detection is performed within a given time frame, which is generally different from the symbol time used to determine the operation signal to noise ratio.

If not stated otherwise or required by regulation, the required probability of detection shall be 0.9, and the probability of false alarm shall be 10^{-4}.