Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	Interference Criteria for WirelessMAN-CX systems
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Re:	80216h-06_059：IEEE 802.16 Working Group Working Group Letter Ballot #24 (2006-10-11)
Abstract	Base in the result of 16h-Interference Criteria ad hoc, this paper discusses for defining the interference criteria and a transmission method complying with the 802.16 PHY and using RSSI detection for inter-system communication.
Purpose	To consolidate the working document.
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Interference Criteria for WirelessMAN-CX systems

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Overview

Interference Criteria (I/N):

1) Necessity for criteria defining:

We need criteria to judge if the interference is harmful or not. By using unified criteria, the detector of interference will be standardized in implementation. The harm of interference is caused by SINR degradation. Certain SINR degradation in real situation will considerably impact the normal communication in a system, based on the SINR margin of each system during the receiving when choosing the profile.
Generally, we can normally consider 1dB degradation for SINR is to be detected in licensed band, we can define similar criteria in licensed exempt case, and it may be also variable in different regulatory domains.

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So we need to define a relevant parameter for the configuration of such systems, and such parameter should meet the following aspect so that 16h can solve all the harmful interference by the interference identification and resolution mechanism within the standard.

- Minimum [I+N] increasing ratio for ***harmful interference***
- Minimum interference criteria for the interference identification ***mechanism sensitivity***
- Tolerable ***SINR degradation threshold*** of ***Receiver SNR requirement assumptions*** each modulation method in data transmition. (according to ***DIUC minimum entry threshold*** *and* ***DIUC mandatory exit threshold*** *configuration scheme*)

The magnitude of such criteria is also very important, since it's sensitive by the parameter of interference identification, for example, the necessary duration of the CSI symbol varies from **25us** to **316us** between the interference criteria of **1dB** and **3dB** on [I+N] increasing ratio.*(see ANNEX of this contribution.)*
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2) How to measure

SINR degradation measurement may be complicated, hard to unified and depending on base band implementation. Alternatively, RSSI measurement will be much easier and related most on the RF/IF chipset. If we consider the Signal Strength a Constant, the [I+N] RSSI increase ratio will be equal to the SINR degradation. So measurement difference on the RSSI difference between the period with and without specific interference will work out the [I+N] increase ratio. Such ratio is cause by the interference and can be easily converted into interference-to-noise ratio, for simplifying the expression.
For example, 1dB SINR degradation by interference, which means 1dB [I+N] RSSI increasing, is relevant to -6dB interference-to-noise ratio. While 3dB [I+N] RSSI increasing ratio is equivalent to 0dB interference-to-noise ratio.
*: As we know, one possible method to measure the [I+N] RSSI increasing ratio is to use the output of the RF chipset. Normally there will be analog or digital output from the RF chipset reacting linear to the RSSI dBm of the receiving signal, once we know the exact period containing [I+N] (e.g. symbol 1 by energy pulse or low part of SOF) and the period containing only [N] (e.g. symbol 0 by energy pulse or high part of SOF), the difference between the mean RSSI output of these two period will be counted.

3) Use interference signal to communicate between systems

In case the interference signal from the neighbor system is carrying the information, the interference signal is now transform to signal to be received, and the interference-noise-ratio is hereby transform to SNR during this receiving mechanism. Therefore, the threshold in interference criteria becomes the requirement of the sensitivity of receiver system.

The more rigorous criteria for interference detection and identification will result in the less impact on normal data transmition and we may ignore the lower inference, counting on margin of CINR requirement of each DIUC minimum entry and mandatory exit threshold. But it will increase the difficulty to decode the message inside the interference signal.

The looser criteria will make the communication between systems easier, but the interference lower than the criteria will make more impact on SINR of normal data transmition, which may be not able to be covered by the margin of CINR threshold for each profile, and lead to lower data transmition rate or lose communication between some device in some kind of situation.

So we need to make a tradeoff and be very careful of the interference criteria when we need to use the interference between systems to forward message.

According to the calculation in C80216h-06_082, we can detect and identify the interference with has1dB SINR impact (-6dB INR) by pulse signaling method. While the messaging method requires 6.4dB SNR (INR), so it may only detect and identify the interference leading to 7.3dB SINR impact, which is not acceptable counting on the margin of CINR configuration.

Reference**:**

[1] *IEEE C802.16h-06/082: Using energy pulses for interference identification between 802.16 systems.| (2006-08-08)*

[2] *IEEE P802.16h/D1: Working Document for P802.16h (2006-08-01)*

[3] *80216h-06_059：IEEE 802.16 Working Group Working Group Letter Ballot #24 (2006-10-11)*

[4] *IEEE C802.16-05/012: IEEE 802.16-2004 and IEEE 802.16e RF Characteristics (2005-04-29)*

[5] *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)*

[6] *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)*

[7] *ITU-R REC F.758 CONSIDERATIONS IN THE DEVELOPMENT OF CRITERIA FOR SHARING BETWEEN THE TERRESTRIAL FIXED SERVICE AND OTHER SERVICES (1992-1997-2000)*

[8] *Calculating the Sensitivity of an ASK Receiver (2003-11-05)*

[9] *IEEE C802.16h-06/054 Discussion on implementing the energy pulse (2006-07-10)*

Proposed Changes:

Definition

Insert the definition in subclause 3.

3.xxx. CX interference criteria: *the criteria threshold on whether the interference is harmful, defined in interference-plus-noise increasing ratio by the interference which is equivalent to the SINR degradation ratio impacting on receiver sensitivity.*

3.xxx. Harmful interference: *the interference which has SINR degradation impact more than the CX interference criteria. So as to, the ratio of interference-plus-noise to the noise is larger than the CX interference criteria.*

BS2SS message

11.4.1 DCD channel encodings

Insert the following entries into Table 358:

Name	Type (1 byte)	Length	Value (variable length)	PHY scope
CX interference criteria	61	1	Minimum interference-plus-noise increasing ratio by the harmful interference (in unit of half dB) (default value 2, for 1 dB)	All

Description modification accordingly:

Change all the equivalent expression into the expression using "CX interference criteria". Such as:

- ***"a certain threshold",***
- ***"a threshold value",***
- ***"threshold values",***
- ***"RSSI power threshold"***
- ***"predetermined threshold"***
- ***"the threshold"***
- ***"detection threshold"***
- ***"the threshold sensitivity"***

Here is some examples:

15.1.1 Components and Relationships

Change the third paragraphs as indication:

Neighbor Relationship: it is a relationship between two systems, when the BS in at least one of these two systems creates interference impact higher than ~~a certain threshold~~ the CX interference criteria to at least one SS in another system, or at least one of the SSs in at least one of these two systems creates interference impact higher than ~~a certain threshold~~ the CX interference criteria to the BS in another system.

It is assumed that SS to SS interference and BS to BS interference are resolved a priori by frequency separation (in case of FDD systems) or transmission frame synchronization (in case of TDD). It should also be noted that some deployments and installations

may cause interference that are beyond the capability of any automatic policy or procedure to resolve.

Figure h shows some examples of neighbor relationship formed by ~~bidirectional~~bi-directional interference. In *Figure h* , system A has neighbor relationships with system B, system C and system D, vice versa, system B has neighbor relationship with system A, so do system C and system D.

Figure h is an example of neighbor relationship formed by unidirectional interference. System E and system F have neighbor relationships with each other, although all the interference between the two systems is caused by system E.

15.3.1.1.2 CSI Frame Structure

Change the forth paragraphs as indication:

The SS should keep monitoring the RSSI to detect <SOF> in the CSI interval. <SOF> flag can be detected according to the power value against time, When the power in first half of the symbol window is significantly lower than the second part, which means the difference of the RSSI between the first part and second part is bigger than the CX interference criteria (see 11.4.1), one <SOF> is expected to have been received, and the SS will pick a value in the middle of the two value as a threshold for the following symbols. If a following symbol shows lower power in the first part than the threshold and in the second part a higher power than the threshold, which meet the CX interference criteria as well, it will consider as a successful in detection of another <SOF>. A CSI frame considered to start here. When two consecutive <EOF> are detected at the end using a similar method as the <SOF> detection, and all the symbols in the frame are received and verified correctly by the CRC, the whole signaling frame is received correctly and the information inside will be extracted and reported.

15.3.1.1.3 Energy keying in time domain

Change the last paragraphs as indication:

The receiving SS shall follow up the CSI timing (see 8.2.1.9.2.8, 8.3.6.2.10, 8.4.5.3.30） and decode each symbol continuously in every symbol space, so that it can acquire the information transmitted by the source system. The SSs shall verify the symbol by this aspect of RSSI meeting CX interference criteria (see 11.4.1, 15.3.1.1.2) and time.

PRINCIPLE to be discussed

1) All the so called harmful interference within the data transmission to WirelessMAN-CX system shall be resolved by at lease one of the mandatory or conditional mandatory features.

2) CX interference criteria should meet the following aspect so that 16h can solve all the harmful interference by the interference identification and resolution mechanism within the standard.

- Minimum [I+N] increasing ratio for ***harmful interference***
- Minimum interference criteria for the interference identification ***mechanism sensitivity***
- Tolerable ***SINR degradation threshold*** of ***Receiver SNR requirement assumptions*** each modulation method in data transmition. (according to ***DIUC minimum entry threshold*** *and* ***DIUC mandatory exit threshold*** *configuration scheme*)

The magnitude of such criteria is also very important, since it's sensitive by the parameter of interference identification, for example, the necessary duration of the CSI symbol varies from **25us** to **316us** between the interference criteria of **1dB** and **3dB** on [I+N] increasing ratio.*(see ANNEX of this contribution.)*

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ANNEX:

Counting on symbol duration with different interference criteria assumption

[Based on the algorithm in C802.16h-06/082[1]]

Assumption set 1(CX interference criteria =1dB SINR degradation):

1) The interference signal (OOK signal from the neighbor system) is consider as the signal to the energy pulse detecting and decoding system. **[2] [9]**

2) The interference tolerance is 6dB below the noise, which means that we need to detect and decode the signaling from the neighbor system which exceed the interference criteria ***-6dB*** I/N, while the interference make 1 dB SINR degradation to the victim system; **[4] [5] [7]**

3) Noise Figure for OOK receiver is 7dB; **[8]**

4) Degrades for input SNR of the OOK signal is shown as following figure, -6dB SNRin lead to -14dB SNRout, according to the effect of the RSSI logarithmic arithmetic. **[8]**

5) An 11 dB Eb/No, corresponding to a 10-3 BER for ASK is used in this calculation. **[8]**

Calculation on set 1:

1> $SNR_{OOK\_RCV} = SNR_{OUT} - NF_{OOK} = -14dB-7dB = -21dB$

2> $SNR_{OOK\_RCV} \geqslant (Eb/No)_{REQ} * (Rate/BBW)$ =>

$$Rate \leqslant SNR_{OOK\_RCV}/(Eb/No)_{REQ} * BBW = 10^{(-21-11)/10} * 5*10^{6}\ Hz = 10^{(-21-11)/10+0.7+6}\ Hz = 10^{3.5}\ Hz \approx 3.16k\ Hz$$

3> $Tb \approx 1/Rate \geqslant 1/3.16kHz \approx 316us$

Assumption set 1(CX interference criteria =3dB SINR degradation):

1) Same;

2) The interference tolerance is the same as the noise, which means that we need to detect and decode the signaling from the neighbor system which exceed the interference criteria 0***dB*** I/N, while the interference make 3 dB SINR degradation to the victim system; **[4] [5] [7]**

3) Same;

4) Degrades for input SNR of the OOK signal is shown as following figure, 0dB SNRin lead to -3dB SNRout, according to the effect of the RSSI logarithmic arithmetic. **[8]**

5) Same

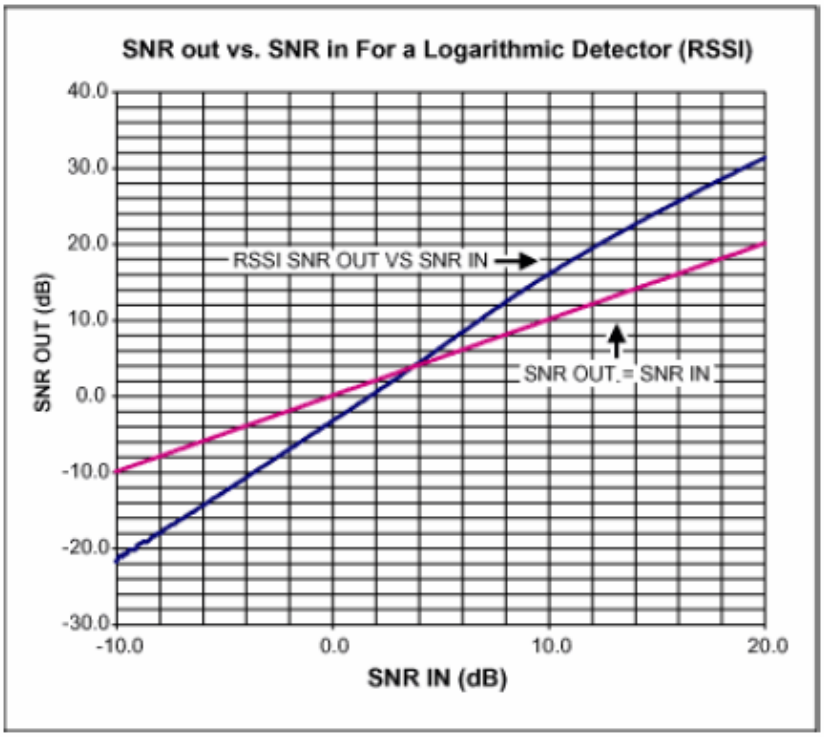
Calculation set 2:

1> $SNR_{OOK\_RCV} = SNR_{OUT} - NF_{OOK} = -3dB-7dB = -10dB$

2> $SNR_{OOK\_RCV} \geqslant (Eb/No)_{REQ} * (Rate/BBW)$ =>

$$Rate \leqslant SNR_{OOK\_RCV}/(Eb/No)_{REQ} * BBW = 10^{(-10-11)/10} * 5*10^{6}\ Hz = 10^{(-10-11)/10+0.7+6}\ Hz = 10^{4.6}\ Hz \approx 40k\ Hz$$

3> $Tb \approx 1/Rate \geqslant 1/40kHz \approx 25us$


SNR out vs. SNR in For a Logarithmic Detector (RSSI)
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
SNR OUT (dB)
RSSI SNR OUT VS SNR IN
SNR OUT = SNR IN
-10.0
0.0
10.0
20.0
SNR IN (dB)