Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	AI for interference threshold description
Date Submitted	**2007-07-09**
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Re:	IEEE 802.16-07/013：Task Group Review: Working Group Draft P802.16h/D2b (2007-06-19)
Abstract	AI result according to the group resolution in meeting #49.
Purpose	To consolidate the 16h draft.
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AI for interference threshold description

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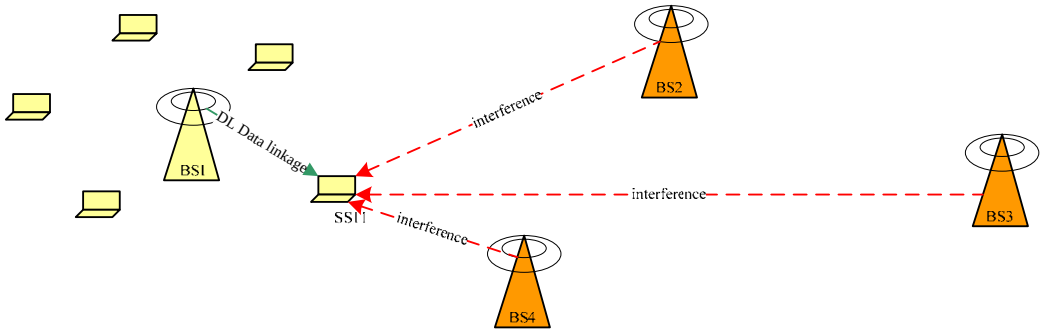
Overview

After the AI assigned in meeting 48 *[1]*, contribution C80216h-07_053 *[6]* was presented in meeting 49. After discussion, since there is no specific text change in that contribution, an AI for Xuyong was assigned in meeting 49, to work on with this topic and check the usage and the needs for different interference thresholds. This contribution is a following work with C80216h-07_053.

Discussion

In order to see where and when to use the interference thresholds, let's think about the case when interference impact on data transmission, and when such impact should be identified for better coexistence.



To shorten the language, let assume a 16 system No.1 is operating, the BS in system No.1 is called BS1, while one of its SS is called SS11, and some systems nearby with BS respectively called BS2/BS3/BS4, making different level of interference to SS11. So we have conclusion here:

1) When other BSs transmits, it DO cause interference to simultaneous link from BS1 to SS11;
2) Although such interferences exist, we don't know whether this interference will cause bad impact on this link. Since the SINR and RSSI of the receiver (SS11) normally have margins for tolerance of minor interference:
   a) Some interference may cause no impact on this link;
   b) Some interference may cause the link to choose slower modulation/coding;
   c) Some interference may cause the link fail.

E.g. assume the DL link between BS1 is with -75 dBm signal strength with a 16 dB SINR, and SS11 receiving strength from other BSs is -85dBm(BS2)/-97dBm(BS3)/-78dBm(BS4) respectively, the SINR of the link will drop to 9dBm/15dBm/3dBm respectively according to the impact of these interference sources. So BS2/BS3/BS4 may cause different impact above to this link.

Modulation Coding	Sensitivity(dBm)	Receiver SNR(dB)	Bits / sub carrier in 1 symbol
QPSK 1/2	-86	5	1
QPSK 3/4	-84	8	1.5
16-QAM 1/2	-79	10.5	2
16-QAM 3/4	-77	14	3
64-QAM 2/3	-72	18	4
64-QAM 3/4	-71	20	4.5

If we do not want to build up any relationship between BS1 and other BSs, we do not necessary to have any threshold to tell apart the interference levels (since in such case nothing can be done after we decided which interference is above certain threshold).

However, we have collaborative mechanisms in current project to make enhancement on the coexistence performance. So we should tell apart the different interference source once collaborative mechanism was implemented. Here is one potential strategy:

1) For the interference source which will not have throughput impact on current link (called ***acceptable interference***), the SS will ignore its existence even if the SS have detect such interference;

2) For the interference source which will force the link to choose slower modulation/coding method (called ***harmful interference***), the SS should detect the interference source and identify it, and report it to the its serving BS;

3) For the interference source which will cause the link to be fail (called ***destructive interference***), the SS must detect the interference source and identify it, and report it to its serving BS as long as the linkage still exist.

Reference:

[1] *IEEE 802.16-07/016r7: Letter Ballot Recirc #24a Comment Database (2007-06-12)*

[2] *IEEE P802.16h/D2b: 802.16h draft for Task Group Review (2007-05-18)*

[3] *IEEE 802.16-07/013：Task Group Review: Working Group Draft P802.16h/D2b (2007-06-19)*

[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] C80216h-07_053*: Figure and updating for interference threshold description (Wu Xuyong; 2007-05-04)*

Proposed Changes accordingly:

(the following text is in current draft and under review according to the concept above, should be revised when necessary accordingly during the meeting.)

15.1 General (P55 L11)

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}.

15.1.1 Components and Relationships (P56L25)

System: the BS and its associated SSs form a system. A WirelessMAN-CX system comprises at least one base station and one subscriber station and supports a bidirectional link.

Neighbor Relationship: it is a relationship between two systems, when the BS in at least one of these two systems creates interference higher than the *light interference threshold* 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 higher than the *light interference threshold* to the BS in another system.

It is assumed that SS to SS interference and BS to BS interference are resolved apriori 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 is beyond the capability of any automatic policy or procedure to resolve.

Figure h shows some examples of neighbor relationship formed by bidirectional 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.

Neighbor: A system is called a neighbor of system A, when it has a neighbor relationship with system A.

Interference Victim: A system is an Interference Victim, when there is at least one BS or one SS in the system which is interfered by a system's neighbor. The Interference Victim could be an Interference Source to its neighbors at the same time (e.g. system A/B/C/D in *Figure h*), or only a victim of its neighbors (e.g. system F in *Figure h*).

Interference Source: A system is an Interference Source, when there is at least one BS or one SS in the system which interferes with its neighbors. The Interference Source could be an Interference Victim of its neighbors at the same time (e.g. system A/B/C/D in *Figure h*), or only an Interference Source to its neighbors (e.g. system E in *Figure h*).

Interference Victim BS/SS: a BS/SS in an interference victim system is an interference victim BS/SS when the BS/SS is interfered by at least one SS/BS in this system's neighbor system, and the interference is higher than *light interference threshold*. The interference victim system could be an interference source BS/SS to the SS/BS in its neighbor system at the same time (e.g. BS in system A/B/C and the interference victim SSs in system A/B/C/D in *Figure h*), or only an interference victim BS/SS of the interference source SS/BS in its neighbor system (e.g. interference victim BS/SS in System F in *Figure h*).

Interference Source BS/SS: a BS/SS in an interference source system is an interference source BS/SS when the BS/SS creates interference to at least one SS/BS in the system's neighbor system, and the interference is higher than the *light interference threshold*. The interference source BS/SS could be an interference victim BS/SS of the SS/BS in its neighbor system at the same time (e.g. BS in system A/B/ C and the interference source SSs in system A/B/C/D in *Figure h*), or only an interference source system of its neighbor system (e.g. Interference source BS/SS in system E in *Figure h*).

Interference Neighborhood: An Interference neighborhood relates to a specific system. A system will perceive as an interference neighbor of other systems which create/receive interference to/from it. The *Figure h* shows some examples of neighborhood.

Community: A Community is composed of those systems which coordinate to resolve their interference. These systems can be operated by the same or different operators.

15.2.2 Scanning before interference identification (P42L84)

The IBS should monitor candidate frequencies during the selection of a working frequency. If the interference level is greater than the *light interference threshold*, which is the required strength level of a received signal within the channel bandwidth, the channel is considered as an interfered channel.

15.3.2.3 Community entry for systems using a common profile

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Undetected BSD Broadcasts/Undetected Uplink SSURF messages & Sporadic Interference (P99L19)

The BSD and SSURF messages are sent at the most robust modulation rate specified for IEEE 802.16-2004 transmissions. This rate will be 1/2 rate QPSK with a nominal sensitivity of 6.4 dB SNR (see 8.3.11.1). These transmissions may be received at levels below the threshold sensitivity and will not be demodulated, hence they will be unidentifiable (but detected as interference noise). Such interference can be termed sporadic. However, because of the statistical variation in the propagation channel whose variance can exceed 6 dB, there is a finite probability that eventually such signals shall eventually exceed demodulation threshold levels and be detected. The time to achieve this may be greater than the amount of time the IBS spends undertaking its initial CMI claiming broadcasts. In such instances it is recommended that the CCD (see *15.3.2.2*) and the PSD processes (*Section 15.5.1.20*) be used to identify low level interference and channel occupancy.

15.3.2.4 Interference Messaging: Base Station Descriptor Message (BSD)

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(P102L10)

The incidence of received BSD messages from a specific Base Station can be used as a measure of the interference intensity, indicating to the affected system whether coexistence action should be taken. The number of BSD detection events per Tcxcc cycle allows such counts. Sporadic interference can be identified by such means. The threshold for detection of such interference can be set with BS_CCID_REQ messages (*6.3.2.3.72*).

15.4 Interference prevention

…… P104L1

6) Every system should be assigned a minimum access time for the use of the radio resource without interference higher than the [light] interference threshold by other systems within the coexistence community.

Table-h40 P162L31

n: The number of SSs in this system which have reported that their interference by this BS is beyond the [light] interference threshold.

P169L46 (just use this place to point out a errata)

Equipment operating in this band must implement a random channel access mechanism capable of operating across all of the frequency range. Shall prevent co- channel operation in the presence of Radar signals. The DFS detection threshold shall be based upon:

- -67 dBm for devices with EIRP greater than 1W,
- -64 dBm for devices from 200mW to 1W EIRP,
- -62 dBm for devices with EIRP less than 200mW.

3.86 Acceptable Interference: An interference signal is within this range if its impact on a given receiver operating with a given signal to noise plus interference ratio and having a given set of capabilities reduces its capacity by no more than 66% of the interference-free capacity.

3.87 Acceptable Interference Threshold: A value (in dBm) of a signal level, above which a signal is defined as being within the *Acceptable Interference* range.

3.118 Light Interference Threshold: A value (in dBm) of a signal level, above which a signal is defined as being within the *Light Interference* range.

6.3.2.3.33 Channel measurement Report Request/Response (REP-REQ/RSP) *P9L53*

[change the text in section 6.3.2.3.33 as indicated:]

If the BS, operating in bands below 11 GHz, requires RSSI and CINR channel measurement reports, or requires neighbor detection reports, it shall send the channel measurements Report Request message. The Report Request message shall additionally be used to request the results of the measurements the BS has previously scheduled. Table 62 shows the REP-REQ message.

The REP-REQ message shall contain the following TLV encoded parameters:

Report Request

The channel measurement Report Response message shall be used by the SS to respond to the channel measurements listed in the received Report Requests. Where regulation mandates detection of specific signals by the SS, the SS shall also send a REP-RSP in an unsolicited fashion upon detecting such signals on the channel it is operating in, if mandated by regulatory requirements. The SS may also send a REP-RSP containing channel measurement reports, in an unsolicited fashion, or when other interference is detected above ~~a threshold value~~CX interference criterion. In cases where specific signal detection by a SS is not mandated by regulation, the SS may indicate 'Unmeasured. Channel not measured.' (see *11.12*) in the REP-RSP message when responding to the REP-REQ message from the BS. For systems compliant with WirelessMAN-CX, if an SS detects the CXCC from a coexistence neighbor, it shall use REP-RSP to report the information to its serving BS in an unsolicited manner. Table 63 shows the REP-RSP message.

The following threshold levels will be used for the report:

For specific signals mandated by regulation: the *regulatory threshold*

For non SSU's: light interference threshold.

6.3.2.3.71 BS_CCID_RSP message

……(P19L23) Thresholds for sending BS_CCID_RSP messages in response to non-WirelessMAN-CX interference can be set in the complementary BS_CCID_REQ message.

……(P19L49)I**NT_BSD_Frq:** The frequency of interference BSD events detected per Coexistence Control Channel (Tcxcc) cycles (calculated as the number of BSD interference events per N Tcxcc cycles [1 cycle= 10 Sec]). For this specific BSD and BSID, as relayed by this BS_CCID_RSP message, this value can be set by the home base station to make the SS less responsive to interference detection (such as highly sporadic and transient events). This value is a threshold value determining when a BS_CCID_RSP needs to be sent by the interfered with SS. Only when this value has been exceeded will the BS_CCID_REQ message be sent.

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P21L5

(3) TBD threshold/response adjustment variables (TBD)

P21L31

TBD Threshold for number of interference events per CMI Cycle)

6.3.2.3.76 CSI monitoring report message (OCSI_MNTR_REP)(P23L14)

This message is the report message from the SS to the BS for ICSI monitoring and OCSI collision detection.

For ICSI:

The SS reports the information it received from ICSI signaling;

For OCSI:

In collision detection mode, the SS uses this message to report the suspicious collision detected during the OCSI monitoring. Suspicious collision here means that during the OCSI interval which is supposed to be 0 in the CSI sequence signaling, the SS have detected the interference beyond the light interference threshold.

In collision backoff mode, the SS uses this message to report interference beyond the light interference threshold and the information from a neighboring system.(See *15.3.1.4*)

6.4.2.3.2 Dynamic Channel Selection (DCS)

……(P30L39)

Quiet periods for measurement are scheduled by the BS via the DL-MAP and the UL-MAP for the BS and SS respectively, with measurements provided, for example, by an Enhanced Channel Measurement IE (*8.4.5.3.30*). These mechanisms are supported with the REP-REQ/ REP-RSP (*6.3.2.3.33*) MAC messages to provide reports of incident interference. Once a channel is deemed unusable due to prevailing interference that has surpassed the *harmful threshold* or degraded the BER sufficiently, the BS may chose to move to a new channel. This new channel may be unmeasured or a member of a backup list of available channels previously measured by the BS or SSs. Depending on the air interface resources available for monitoring, the number of backup channels may vary. Also the 'freshness' of a channel (in terms of when the channel was last measured and how accurate the measurement is likely to be) may also depend on available resources to accomplish this task. The previously interfered channel that was vacated may be monitored for usability after some defined period. *Figure h* (subclause *6.4.2.2*), although specifically for SSUs, provides an example of how DCS can be used to provide resource management and backup operating channels.