Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	Using energy pulses for interference identification between 802.16 systems.
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Re:	80216h-06_021： Third Working Group Review: P802.16h Working Document (2006-08-10)
Abstract	Base in the result of 16h-Pulses ad hoc, this paper discusses the mechanism using energy pulse in interference identification. This was a first output and may initial further discussion in this topic.
Purpose	To consolidate the working document.
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Using energy pulses for interference identification between 802.16 systems

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Overview

This paper was a first output from the [16h-Pulse] ad hoc and may initial further discussion in this topic.

Following the conclusion of meeting #44 in San Diego, we are using this ad-hoc to continue discussing the issue of Energy Pulse. We are aim to find out some solution for signaling between 16 systems using the different existing PHY modes.

My proposal for the schedule is,

1)Everyone interested in this topic give the comment on before 13th Sept;

2)I will draft a contribution according to the ad-hoc opinions before 15th and ask for feedback;

3)Revise the contribution according to the feedback and upload before deadline, 17th Sept;

4)Collect reply comment from WG before the opening plenary in 25th Sept, and report to the TG in LE meeting.

Here is my comprehension on the scope of this Ad-hoc and some consensus in meeting before,

1)Not to change the existing PHY functionality;

2)Signaling between 16 LE systems using different PHY mode is the main scope;

3)Here the air signaling is only for the interference identification, not appreciated in further process;

4)This feature needs to be implemented in both initializing phase and operating phase;

5)The overhead for this feature should be less than 1 percentage of the radio resource;

6)The characteristic of the signal used in interference identification should be the same as which is used in the normal operation.

the AI for this Ad-hoc group written in C80216h-06_047r1.xls according to last meeting is shown as follows:

"Create an Ad-Hoc on how the existing PHY modes can be used to implement this feature (energy pulses) and what is exactly the PHY mode or modes, symbol duration, MAC message to be used, detection issues, deferential from the Radar signals."

Pls see the following reference for background information of this ad hoc

1) LE TG meeting minutes of 44# meeting in San Diego(802.16h-06_019)
2) AI table noted in last meeting (C80216h-06_047r1)
3) Working document for the 3rd WG review (802.16h-06_015r1)
4) Commentary database of 2rd WG review (802.16h-06_020r2)
5) Comment 1067 in 4) and contribution related in last meeting (C80216h-06_054)

Reference**:**

[1] *IEEE 802.16h-06/019: 802.16h License-Exempt Task Group Meeting Minutes (2006-08-08)*

[2] *IEEE 802.16h-06/015r1: Working Document for P802.16h (2006-08-01)*

[3] *IEEE 802.16h-06/021: Third* Working *Group Review: P802.16h Working Document (2006-08-10)*

[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)*

Question and Discussion about the ISSUES in AI

1)**Question**: How the existing PHY modes can be used to implement this feature ?

-- in another word, do we need to change the PHY mode in order to implement the feature?

Discussion: We can use the any existing PHY mode which was already there inside the standard, and just add features upon current PHY and MAC to support coexistence between systems using different PHY. **[9]** These feature has some similarity with DFS, they are both add-on features to support coexistence in an open or so called light licensing band.

Considering the spectrum characteristic, I saw no distinct difference between a short uplink PHY PDU and an energy pulse using the same PHY.

2) **Question**: what is exactly the PHY mode or modes could be used to implement this feature?

Discussion: One of the following, **WirelessMAN-SCa, WirelessMAN-OFDM, WirelessMAN-OFDMa or some kind of PHY defined by future.**

3) **Question**: How long is the symbol duration for the energy pulse?

Discussion: **There is some factor to be considered, and we see that 320us to 1ms duration may be suitable after rough calculation.**

Firstly, the spectrum characteristic should be similar to a short PHY PDU so that it won't make the PSD worse than the normal signal. Counting on different PHY mode and profile, duration no less than 100us should be ok.

Secondly, we need to count on the Eb/No to match the requirement of detecting the interference and decode the information from the energy symbol using OOK (on-off keying). These need some careful calculation and to be continue on discussion. We now have a rough calculation here:

Assumption:

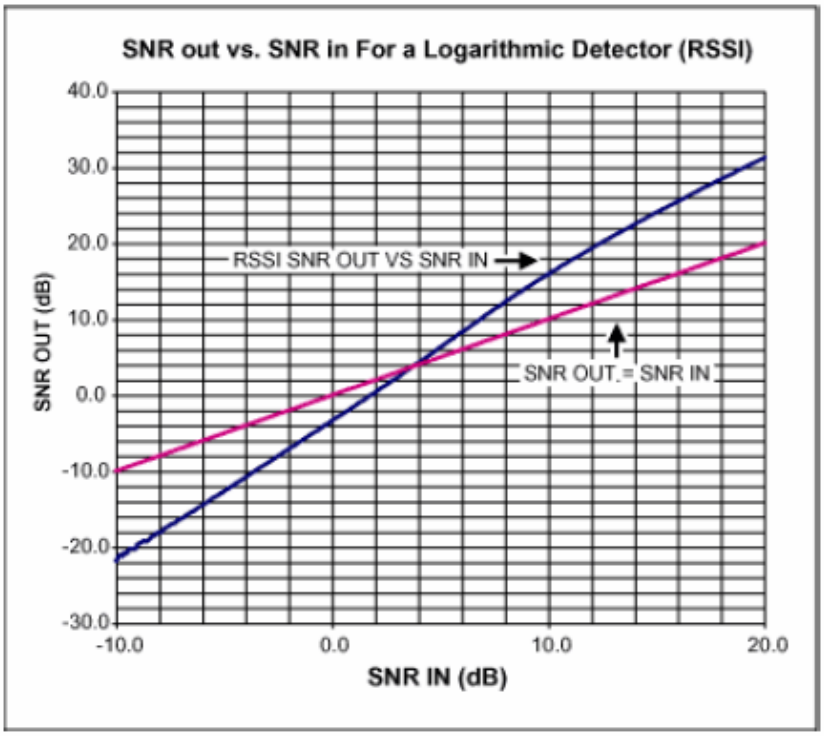
1) The interference signal (OOK signal from the neighbor system) is consider as the signal to the energy pulse detecting and decoding system. **[2] [9]**

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, when 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:

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

4) **Question:** MAC message to use?

Discussion: **<u>We have not finished defining all the message since there still doesn't have agreement in the whole mechanism for this feature.</u>**

However, some item are already defined or to be defined in WD.

-- Broadcasting message for the interference detection and identification. (BSNUR_BC in current WD)

-- Timing initialization for the slots to carry energy pulse signal (OOK). ***<u>(tbc.)</u>***

-- Report of the information decoded from the pulse in the air, SS to BS. (REP_RSP in current WD)

-- Feedback from the BS to the SS. ***<u>(tbc.)</u>***

5) **Question:** Detection issues?

Discussion:

If we follow the interference criteria in **[5]** 802.16-2004 Annex B, or **[7]**ITU-R REC F.758, we should at lest be able to detect the interference with interference-to-noise ratio -6dB.

Sensing or detecting the interference may be adequate for non-collaborative mechanism, but once we want to identify the interference source and continue on some collaborative mechanism. The interference identification shall have the ability to identify the information carried in the signaling for the neighbor that was 6dB lower than the thermal noise, which Interference-pulse-Noise power was only 1dB raised from the noise floor.

As we know, we need the SINR to be at lest 6.4 dB for BPSK demodulation in OFDM PHY, similar in OFDMa-PHY, **there is a 12.4 dB gap between the sensitivity requirement and the capability of the normal modulation**, although it's much more efficient comparing to the energy pulse method (OOK, on-off keying in some material) counting the throughput.

So normal demodulation method could only be used in the specific circumstance that the signal received from neighbor system is quite higher than the noise level, in same PHY profile of course. **It may not be able to fit in interference identification step of collaborative mechanism when there is interference received and cause SINR degradation up to more than 6dB.**

*Reference: Typical RF characteristic list **[4] [5]***

(Licensed exempt band):

Channel bandwidth= 5MHz

Noise Figure= BS: 3dB SS: 5dB

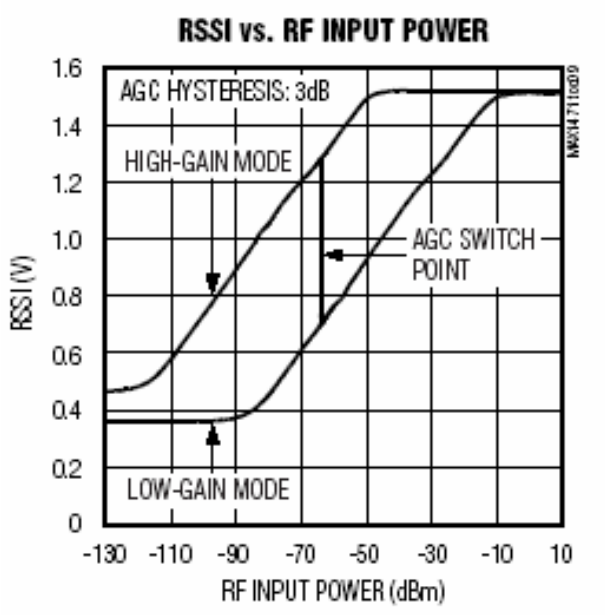
Thermal Noise Density = 174 (dBm/Hz)

Interference criteria, I/N = -6dB/-10dB

Max. tolerable interference power = BS:-104dBm SS:-102dBm

So the information in the Energy Pulse Symbol and frame may be implemented as illustrated below: **[2] [9]**

- The receiver of the Energy Pulse signal should be sensible to the energy pulse symbol, when RSSI detect two levels of interference power in one 1ms *(Assumption)* energy pulse slot, which is divided into two even parts and measured separately.
- If the 500us first part's RSSI is more than 1 dB lower than the 500us second part's RSSI, it will be considered as an <SOF> symbol. This can be implemented based on whichever the existing PHY. FYI, the following figure shows a real example of a very early RF chip, the RSSI output vs. INPUT POWER is strictly increasing monotone within the concerned range, and the slope is quite steady, so the delta error may not considerably harm the sensitivity of the RSSI keying detection. **The requirement for the sensitivity was generally feasible by RSSI detection in arithmetic calculation; however, we need further study and experiment on the feasibility for the practical performance.**



- Some level in the middle between the higher and the lower RSSI in last bullet should be recorded as the threshold of verdict and used to judge each RSSI measuring result.
- When measuring results of both parts in one slot/symbol show high, it indicates a 1 slot/symbol, if show low, it indicates a 0 slot/symbol.
- If the first part shows high and second part shows low, this symbol shall be judged as <EOF>.
- By collect all the sequential decoded results of relates symbols in one logical slow control channel, the bits between <SOF> and <EOF> should form a CRC verifiable TLV structure. The information in the structure will be extracting and reported to the BS while the structure passes the CRC verification.

6) **Question:** Deferential from the Radar signals

Discussion:

-- Radar signal characteristic ***(tbc.)***

Since this signal carries no information useful for further contact and negotiation, it fits non-collaborative mechanism naturally.

-- Energy Pulse signal characteristic

Since the Energy Pulse symbol is just some kind of normal occupied or empty interval of the PHY duration, if the duration of one symbol is more than 300us, the RF characteristic of the Energy Pulse symbol is basically the same with an UL PHY PDU.