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Purpose	
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Signaling using the energy keying in the frequency domain

Mariana Goldhamer (Alvarion)

Introduction

The Working document defines signaling methods using energy bins and proposes to find messages which have the required spectral power density appearance. Further studies have demonstrated that this approach is not feasible due to the fact that the bit interleaver whitens the spectral appearance of the OFDM/OFDMA signals.
This contribution proposes another approach of sending energy in the frequency domain, using the OFDM preambles used in sub-channelization. This contribution defines the relation between the preamble and the energy bin coding. The detection of the energy bins is similar with the detection of the OFDM preambles for different sub-channels.

15.5.1 Modifications to the existing textSignaling to other systems

~~[Note: the cognitive signaling may have effect on the power amplifier and on the PAPR. Call for contribution to investigate if there are such effects.]~~

15.5.1.1 Ad-hoc systems - operating principles using Cognitive Radio signaling

In order to reduce the interference situations, in deployments in which may exist a combination of 802.16 systems using a Coexistence Protocol and 802.16 ad-hoc systems, the 802.16 ad-hoc systems will apply the Adaptive Channel Selection procedures and use cognitive radio signaling procedures to interact with systems using a Coexistence Protocol. The ad-hoc systems obtain a temporary Community registration status, that has to be renewed from time to time.

15.5.1.2 Registration

The 802.16h pro-active cognitive radio approach defines signals and procedures for the reservation of the activity intervals and registration of ad-hoc systems. The operational procedures are described below:

- 802.16h Community registered systems, using a Coexistence Protocol, will reserve the MAC frame Tx/Rx intervals by using, during the MAC Frame N, starting at the absolute time AT1, cognitive signals to indicate the MAC Tx_start, MAC Tx_end, MAC Rx_start, MAC Rx_end. These signals are transmitted by Base Stations and Repeaters. ~~The specific MAC frame N is indicated in the BS data-base and these~~ These procedures will repeat after ~~N_{cogn} MAC frames~~T_cogn seconds; the values of these parameters are specified in chap. 10.5.
- During the MAC frame ~~N+1~~ starting at the absolute time AT2, cognitive signals will indicate the beginning and the end of Master sub-frames, by transmitting signals indicating by their transmission start the Tx_start, Tx_end, Rx_start, Rx_end for the specific sub-frame; these signals are transmitted by Base Stations, Repeaters and those SSs which experiences interference, at intervals equal with N_{cog} MAC Frames;
- During the MAC frame starting at the absolute time AT2~~N+2~~, will be indicated the position of the time-slots, in each Master sub-frame, to be used ~~starting with~~during the MAC Frame starting at the absolute time AT3~~N+3~~ for registration using cognitive signaling. The start of the "Rx_slot" signal will indicate the start of the time-slot.

- The ~~start of the~~ MAC frame starting at the absolute time AT4~~N+4~~ is the ~~start~~ beginning of a registration interval using the cognitive signaling; the registration interval has the duration of Tcr_reg seconds; The ad-hoc transmitters shall use during the MAC frame starting at the absolute time AT4~~N+4~~, the marked slot for sending their radio signature. The radio signature will be used for the evaluation of the potential interference during the Master slot, to systems which use the sub-frame as Master systems. The next transmission opportunities for sending the radio signatures use time-slots having the duration as indicated previously and repeating every Tcr_rep sec during the Tcr_reg interval.
    - An ad-hoc radio unit (BS, Repeater or SS) will send this signal using a random access mode for Tcr_reg~~1~~ seconds, using the sub-frame intended for their regular transmission (BSs and SSs use different sub-frames for transmission).
    - The ad-hoc transmitters will have to use the registration procedures every Tad_reg seconds.
- Registration replay
    - The radio units using the Master sub-frame will send a NACK signal, to be sent in a random mode during the next Tcr_reg_ack seconds, if they appreciate that the ad-hoc transmitter will cause interference. Typically, to a registration signal sent during a DL sub-frame, the NAK will be sent by one or more SSs, while to a registration signal sent during UL sub-frame, the NACK signal will be sent by a Base Station. The radio units using the Master sub-frame will send their response in random mode.
    - The NACK signal indicates that the requesting ad-hoc device cannot use the specific sub-frame, while using the requesting radio signature
    - Same device may try again, if using a different radio signature (for example, lower power).
    - Lack of response, for Tcr_reg_ack seconds, indicates that the registration is accepted for transmission during the specific sub-frame.

15.5.1.3 Selection of suitable reception sub-frames

An ad-hoc unit will find his suitable reception sub-frames, by using the ACS and Registration process in a repetitive way, searching for a suitable operation frequency. The practical interference situations, with synchronized MAC Frames are BS-SS and SS-BS interference. Assuming similar transmit powers, the above mentioned process will have as result finding Master sub-frames in which the path attenuation between interfering units is maximal.

15.5.1.4 Signaling procedures ~~for Cognitive Radio applications~~using frequency-keyed energy pulses

The signaling and message exchange between an ad-hoc system and systems ~~using a Coexistence Protocol is done as detailed below:~~which are members of a Community use frequency-keyed pulses.

- ~~Split the narrowest channel to be used (as defined in 802.16 Profiles) into 32 energy bins, as follows:~~
    - ~~For 256FFT, to 8 sub-carriers/bin~~
    - ~~For 512 FFT, to 16 sub-carriers/bin~~
    - ~~For 1024FFT, to 32 sub-carriers/bin~~
    - ~~For 2048FFT, to 64 sub-carriers/bin.~~
- ~~Send an 802.16h MAC message, at a suitable rate, such that the MAC header will use 1 symbol and the MAC PDU will use another symbol; the MAC header and the data field will be built in such a~~

~~way that the power distribution for different bins will be with at least 5dB higher for a bin marked in Tablex with "H" than for bin marked with "L".~~

~~The data field for both transmit and receive operations, taking into account possible FFT sizes, channel widths and the defined PHY modes, is defined in chap. t.b.d.~~

The frequency-keyed energy pulses use for every single sub-channel the preambles defined for sub-channelization in the chapter 8.3.3.5.3. Every energy bin is mapped to a OFDM sub-channel (see Table 211 – OFDM symbols parameters), as shown in the Table h5. The channels using sub-carriers at band edge or in the center are avoided.

The following figures show the desired spectral density for cognitive signaling. Independent of the actual channel width, the preambles are sent using the narrowest channel possible in the band. In the following example, in which channels of 5, 10 and 20MHz may be used, the narrowest channel is 5MHz and any other system will be able to detect the preambles, which are not attenuated by any radio filter.. ~~and the possible outcome of the MAC PDU approach, introducing some distortions in time or frequency domain, but still detectable by non-802.16 systems.~~ The narrowest channel will be centered in the frequency domain around the actually used channel center.

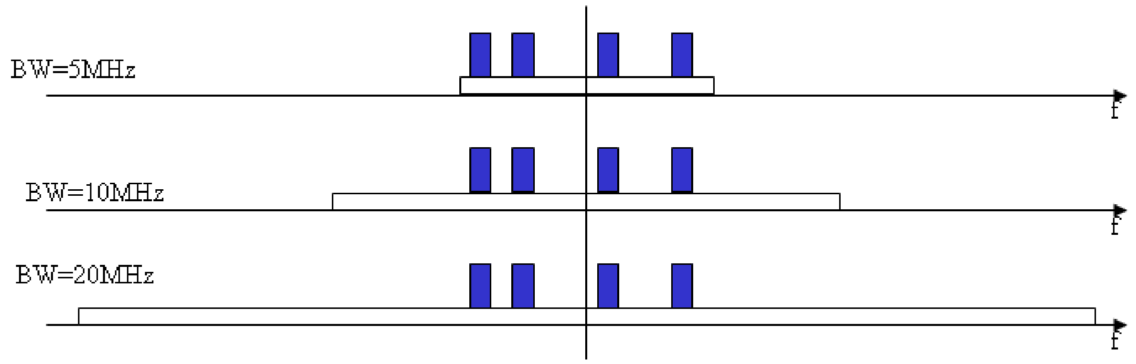
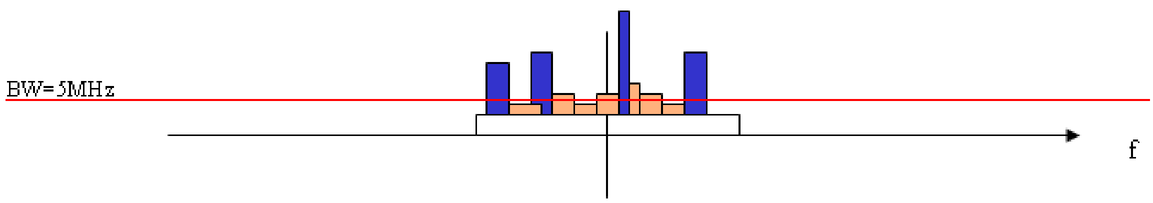


Figure h1. Desired spectral densities for different channel BWs



~~Figure h2.Obtainable spectral densities with MAC PDU approach~~

~~Due to the FFT guard sub-carriers, not all the bins are usable; we will use in continuation, from the bins numbered 0…31, where the bin#0 corresponds to the lowest frequency, only the bins 6…26. The MAC PDUs, having the spectral characteristics defined in the Table x, are defined in Chap. t.b.d for each of the 3 802.16 PHY modes.~~

In Table x were defined a number of cognitive signals, having low inter-correlation properties. ~~The energy on the not-used bins can take any value, but not more than the energy on a bin marked with "H". This tolerance will allow finding adequate data mapping for each PHY mode. Obviously, if the energy on not-used bins will be minimal, the detection process will be easier.~~

~~Table h1.~~ Table h5 Cognitive signal definition

Bin number /Signal number	**6**	**8**	**10**	**12**	**14**	**18**	**20**	**22**	**24**	**26**
Sub-channel number (1..31)	**7**	**9**	**11**	**13**	**15**	**17**	**25**	**27**	**29**	**31**
1 (802.16h Cognitive MAC Header)	H	L	L	H	H	L	L	L	H	L
2 (Tx_start)	L	H	L	L	H	H	L	L	L	H
3 (Rx_start or Rx_slot)	H	L	H	L	L	H	H	L	L	L
4 (Tx_end)	L	H	L	H	L	L	H	H	L	L
5 (Rx_end)	L	L	H	L	H	L	L	H	H	L
6 (NACK)	L	L	L	H	L	H	L	L	H	H
7 (CTS_Start)	H	L	L	L	H	L	H	L	L	H
8 (CTS_Continuation)	L	H	H	L	L	H	L	H	L	L
9	L	L	H	H	L	L	H	L	H	L

~~*[Note: 15.5.1.5 is provisional, taken from C80216h-05_032r1 and call for comments and further contribution]*~~

15.5.1.5 Using the coexistence slot for transmitting the BS IP identifier

The cognitive radio signaling described ~~above~~ in the 15.5.1.4 may be also used for the transmission of the BS IP identifier, when there is no installed Base Station Identification Server.

The transmission is done in consecutive coexistence time slots, spaced by ~~every NIptx~~ Tiptx ~~MAC frames~~seconds. The first CTS in the series starts with CTS start signal, the last CTS contains the Tx_end signal, the continuation in sequential ~~MAC frames~~CTS slots starts with the CTS_Continuation, as defined in Table ~~x~~h5. Between these signals is transmitted the IP identifier of the BS and a 8bit CRC, the L.S.B (least significant bit) for each field being transmitted first. The transmission of the above information uses only the ~~bins~~ preambles for the sub-channels 6,8,10,12,14,18,20,22,24,26 (10bits / symbol), the L.S.B. corresponding to the lowest ~~frequency.~~sub-channel number.
The transmission of a IPV4 address will request 1+ (32+8)/10 + 1 = 6 symbols and the transmission of a IPv6 address will request 1+ceil((128+8)/10) +1 = 16 symbols.

Insert at Chapt.10: Parameters and constants

10.5 Coexistence specific values

10.5.1 Cognitive signaling

The absolute time runs on a periodic base of 1800 sec. (30 minutes). For cases when one or more seconds are added/subtracted at the mid-night, the absolute time is supposed to follow those changes. All the values below are repeating based on the relation:

Time = (Absolute time) mod 1800.

The time is expressed as sec: ms, according to the decimal format xxxx:yyy.

To Editor attention: the numbering was done according to Corr-2005

Absolute time reference	Chapter	Reference	Value
AT1	Cognitive radio signaling (insert reference)	Start of the first MAC Frame (no. N) including cognitive radio signaling	0010:000
AT2	Cognitive radio signaling (insert reference)	Start of the 2nd MAC Frame including cognitive radio signaling	0010:020
AT3	Cognitive radio signaling (insert reference)	Start of the 3d MAC Frame including cognitive radio signaling	0010:040
AT4	Cognitive radio signaling (insert reference)	Start of the 4th MAC Frame including cognitive radio signaling	0010:060

Timer	Chapter	Reference	Value
T_cogn	Cognitive radio signaling (insert reference)	Repetition period of the cognitive signaling	20s
Tcr_reg	Cognitive radio signaling (insert reference)	Duration of the registration interval for ad-hoc transmitters	2s
Tcr_rep	Cognitive radio signaling (insert reference)	Time interval between the start of consecutive time-slots for registration	100ms
Tcr_reg_ack	Cognitive radio signaling (insert reference)	Time interval which starts immediately after a time-slot for registration and last as specified	20ms
Tad_reg	Cognitive radio signaling (insert reference)	Maximum time-interval in which an ad-hoc unit has to repeat the registration	1800s
T_iptx	Cognitive radio signaling (insert reference)	Time interval between the start of consecutive CTSslots for the transmission of the IP address using frequency-keyed energy pulses	20ms