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Re:	LE TG Call for Contributions
Abstract	More details for CXCC
Purpose	Approval
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Consolidation of Coexistence Control Channel

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Introduction

This contribution enhances the 802.16h Coexistence Control Channel. It is proposed that the detailed description of CXCC will be the first sub-chapter in 15.3.
The 15.3 chapter structure should be:

15.3.1 CXCC Structure
15.3.2 Signaling procedures
15.3.2.1 Signaling using Energy Keying
15.3.2.2 Signaling using Frequency Keying
15.3.3 Same Profile Messaging procedures during CXCC.

In order to use in CXCC sub-channel 3 the signaling to Ad-Hoc systems, four additional CXCC cycles are needed. This has conducted to the definition of a CXCC multi-frame.

Specific changes

Changes to 15.1.5.3 Coexistence Control Channel

Move the existing text from 15.1.5.3 to 15.3.1
Insert the following text at 15.1.5.3

The Coexistence Control Channel is based on a series of synchronized time-slots used in a coordinated mode and allowing the following basic functionality:

- Secondary synchronization
- Detection of specific spectrum users
- Detection of bursty spectrum users
- Evaluation of cumulated interference during Master sub-frames
- Inter-system communication using same-PHY profile
- Inter-system communication using frequency-keying
- Inter-system communication using energy-keying.
- Registration of backhaul-less systems.

Insert 15.3.1. Coexistence Control Channel description

15.3.1.1 Basic principles

The CXCC allocation usage will follow the following rules:

— The CXCC allocations are mapped to Master and Shared sub-frames.

— During the CXCC allocations, no Slave or Shared activity is allowed; however, depending of context, the Master sub-frames may be used for transmitting regular data. The common sub-frame preceding a Slave within a CXCC allocation will not be transmitted.

— The timing of the CXCC allocation, relative to the MAC Frame, is given in clause 10.5.2.

— The timing of the CSI allocation is given in 10.5.3

— CX_MAC Frame numbering is binary having the length of 10bits; the CX_MAC_Frame = 0 is synchronized
with the absolute time 00:00:00.

— The repetition period of CXCC for 5ms MAC Frames is 5.12s (1024 MAC Frames). Four CXCC cycles constitute a CXCC Multi-Frame.

— A sub-channel is formed from eight CXCC allocations, mapped within Master and Shared sub-frames, four for the DL and four for the UL.

— The CXCC four sub-channels are scheduled in consecutive order.

- The duration of a CXCC sub-channel is:
  - o 1024 / 4 = 256 MAC frames (1280 ms)
  - o The CXCC allocations appear in average every 256/8 = 32 MAC Frames (160ms).

— The CXCC allocations during a CXCC sub-channel are:
  - o Master 1 sub-frame DL: CX_MAC_NO mod 256 = 0
  - o Master 1 sub-frame UL: CX_MAC_NO mod 256 = 32
  - o Master 2 sub-frame DL: CX_MAC_NO mod 256 = 64+1
  - o Master 2 sub-frame UL: CX_MAC_NO mod 256 = 96+1
  - o Master 3 sub-frame DL: CX_MAC_NO mod 256 = 128+2
  - o Master 3 sub-frame UL: CX_MAC_NO mod 256 = 160+2
  - o Shared sub-frame DL: CX_MAC_NO mod 256 = 192+3
  - o Shared sub-frame UL: CX_MAC_NO mod 256 = 224+3.

15.3.1.2 CXCC sub-channel allocation

15.3.1.2.1 Sub-channel 1

The sub-channel 1 is used for synchronization followed by an interval during which the 802.16 systems will remain quiet. This silence interval will allow the identification of bursty systems or of specific spectrum users.

Every DL and UL allocation in the sub-channel 1 starts by transmitting the ~~secondary~~ synchronization signals, followed by a total silent interval for all systems till the end of the UL or DL MAC Frame. ~~The silent interval will be used to determine the specific spectrum users or the spectrum users not compliant with WirelessMANCX coordinated approach.~~

The CXCC sub-channel 1 uses the defined MAC Frames within the MAC Frame numbers 0…255.

The synchronization signals may be transmitted only by systems using the GPS synchronization in their Base Stations.
The signals to be transmitted at the beginning of the designed CXCC slots are defined below:

(delete clause 15.2.1.5 because most of the text is used below)

15.3.1.2.2 Sub-channel 2

Sub-channel 2 will be used for data transmission between systems using a same PHY profile and their specific Master sub-frames. Sub-channel CXCC allocations, corresponding to specific Master sub-frames, will be claimed by the systems and used to transmit randomly chosen but periodic BSD and SSURF messages. Only the system claiming a specific CXCC allocation will transmit, while all other systems will remain silent.
The Shared sub-frames will only be used to transmit BSD and SSURF for purposes of interferer identification.

The CXCC sub-channel 2 uses the defined MAC Frames within the MAC Frame numbers 256…511.

15.3.1.2.3 Sub-channel 3

Sub-channel 3 will be used for Secondary sync / Freq keying (NURBC transmission with freq keying) and signaling to backhaul less ~~other~~ (Ad-hoc) systems.

The CXCC sub-channel 3 uses the defined MAC Frames within the MAC Frame numbers 512…767. The sub-channel 3 uses the first 5 CXCC cycles within the CXCC Multi-Frame.

The sub-channel 3 is extended in a multi-frame, such to provide the needed functionality at the expense of higher delays.

Secondary sync
The secondary synchronization signals will be transmitted at the start of every CXCC Multi-frame, using the signals described in Table h2.

Transmission of the NURBC message using the frequency keying
For the transmission of the NURBC message are used the CXCC allocations which are included in the first CXCC Frame.

(move here 15.3.1.2.2 Using the coexistence slot for transmitting the BS IP identifier and use the text as modified below)

The radio signaling described in section ***15.3.1.3*** ~~may be also~~will be used for the transmission of the BS_NURBC message (see 15.3.1.5), when there is no active Base Station Identification Server.
The transmission is done in consecutive symbols, using the default guard interval between symbols. The transmission of BS_NURBC is preceded by the CSI_start signal, as defined Table h 4. The BS_NURBC message is followed by a 32bit CRC and the Tx_end signal. The L.S.B (least significant bit) for each field is transmitted first. The transmission of the above information uses the preambles for the sub-channels (16bits / symbol), the L.S.B. corresponding to the lowest sub-channel index.

The length of the BC_NURBC message is given in Table h3. The transmission of BC_NURBC (IPV4) will require 1+ (96+32)/16 + 1 = 10 symbols and the transmission of BC_NURBC (IPV6) will require 1+(192+32)/16 +1 = 16 symbols.

Signaling to backhaul-less systems

The procedures for signaling to backhaul-less systems are defined in continuation.

(move 15.4.3 here and use the text as modified below)

~~**15.4.3 Interference prevention from backhaul-less systems**~~

~~15.4.3.1~~ Operating principles

There could be deployments in which there is a combination of systems forming a community via an IP network and thus using the Coexistence Protocol, and other systems, deployed in the same area and frequency band, but are not connected via the IP network. These systems will be called here 802.16 backhaul-less systems. It should be clarified that those backhaul-less systems are still considered to comply with WirelessMAN-CX. The 802.16 backhaul-less systems will apply the Adaptive Channel Selection procedures and use radio signaling procedures to interact with systems using a Coexistence Protocol. The backhaul-less systems obtain a temporary Community registration status, which has to be renewed from time to time.

~~15.4.3.2~~ Registration

~~The WirelessMAN-CX defines signals and procedures for the reservation of the activity intervals and registration of backhaul-less systems. The operational procedures are described below:~~

~~— WirelessMAN-CX 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, radio 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. These procedures will repeat after T_cogn seconds; the values of these parameters are specified in section *10.5*; No regular data transmission should take place 20 ms from the start of AT1 (the maximum IEEE802.16 MAC frame duration).~~

~~— During the MAC frame starting at the absolute time AT2, coexistence 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 experience interference, at intervals equal with Ncog MAC Frames; no regular data transmission should take place 20 ms from the start of AT2 (the maximum IEEE802.16 MAC frame duration).~~

Registration request

~~—~~The ~~MAC frame starting at the absolute time AT3~~CXCC allocations during the sub-channel 3 and starting with the second CXCC cycle in the Multi-frame is the beginning of a registration interval using the coexistence signaling~~; the registration interval has the duration of Tcr_reg seconds;~~ The ~~ad-hoc~~backhaul-less ~~transmitters~~ systems shall use the CXCC allocations for sending their cumulated radio signatures during one of the allocations corresponding to a Master sub-frame, both in DL and UL. ~~during the MAC frame starting at the absolute time AT3, the marked master sub-frames 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 legacy Master systems will not transmit data during CXCC allocations for sub-channel 3.

~~o~~The radio signature will consist of a preamble and a MAC header, sent on the working channel and using the same power and sub-carrier allocation, as used in the regular data transmission mode;

~~oThe sub-frame starting at Tx_start is slotted, each slot having the duration of 100us. The transmission of a radio signature will start at a slot boundary, as perceived by backhaul-less systems. No ranging assumptions were taken in the assessment of the slot duration.~~

~~oAn ad-hoc radio unit (BS, Repeater or SS) will send this signal using a random access mode for Tcr_reg seconds, using the sub-frame intended for their regular transmission (BSs and SSs use different sub-frames for transmission).~~

~~o~~The ad-hoc transmitters will have to use the registration procedures every Tad_reg seconds (see 10.5.1).

~~oNo regular data transmission should take place 20 ms from the start of AT3 (the maximum IEEE802.16 MAC frame duration).~~

~~—~~Registration reply

~~o~~The radio units using the Master sub-frame will send a NACK (see *Radio signal* definition ~~*Table h 4*~~) signal, during the ~~MAC Frame starting at the absolute time AT4~~next CXCC cycle, and using the same sub-frame as used by the un-acceptable transmitter, if they appreciate that the ad-hoc transmitter will cause interference. Typically, to a registration signal sent during a DL sub-frame, the NACK 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.

~~o~~The NACK signal indicates that the requesting ad-hoc device cannot use the specific sub-frame, while using the requesting radio signature

~~o~~Same device may try again, if using a different radio signature (for example, lower power).

~~o~~Lack of response indicates that the registration is accepted for transmission during the specific sub-frame.

~~oNo regular data transmission should take place 20 ms from the start of AT4 (the maximum IEEE802.16 MAC frame duration).~~

~~15.4.3.3~~ Selection of suitable reception sub-frames

An ad-hoc unit will identify suitable reception sub-frames, by using the ACS and Registration processes repetitively, 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 processed will find, as result, Master sub-frames in which the path attenuations between interfering units are maximized.

15.3.1.2.4 Sub-channel 4

Sub-channel 4 will be used for interference assessment for WirelessMAN_CX compliant systems.
The data or Radio Signature will be transmitted using the max. power during the corresponding Master sub-frames. If regular data transmission is used, it has to be scheduled in such a way to represent the power density characteristics of cumulated radio signatures.
Every system using a specific Master sub-frame will use the CXCC allocation mapped into that Master sub-frame for letting a new system to assess the maximum interference in a Master sub-frame and frequency channel.
The CXCC sub-channel 4 uses the defined MAC Frames within the MAC Frame numbers 768 - 1023.

15.3.1.2.5 CSI Allocations

The CSI allocations will be transmitted, if supported, in the last 100us of the Master sub-frame w allocations. No other transmissions are allowed during these intervals.
The detailed structure is presented in (insert paragraph).

- Master 1 sub-frame DL: CX_MAC_NO mod OCSI_cycle = 0
- Master 2 sub-frame DL: CX_MAC_NO mod OCSI_cycle = 1

- Master 3 sub-frame DL: CX_MAC_NO mod OCSI_cycle = 2
- Shared sub-frame DL: CX_MAC_NO mod OCSI_cycle = 3

end

15.3.1.3 Signaling using frequency-keyed energy pulses

Move here the content of 15.4.3.4

Modify this text as follows:

~~The signaling and message exchange between an backhaul-less system and systems which are members of a Community use frequency-keyed pulses~~. 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 an OFDM sub-channel (see Table 213-OFDM symbols parameters), as shown in the *Radio signal* definition ~~*Table h 4*~~. ~~The channels using sub-carriers at band edge or in the center are avoided.~~

The following figures show the desired spectral density for radio 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. The narrowest channel will be centered in the frequency domain around the actually used channel center.

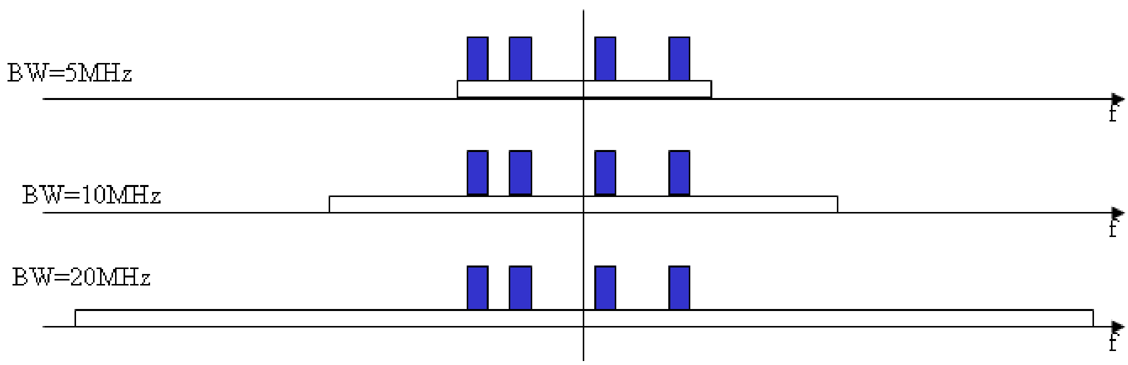

Figure h62—Desired spectral densities for different channel BWs

In *Radio signal* definition ~~*Table h 4*~~ the radio signals SFQ1…SFQ9 are ~~is~~ defined such to minimize the cross correlation properties. These signals are used for synchronization or time marking. The preambles can be also used for frequency-keyed message coding, in which case the preamble defined for a sub-channel represents the binary value "1" if it is transmitted.

Table h4—Radio signal definition

	Bin number ~~/Signal number~~	b0	b1	b2	b3~~6~~	b4~~8~~	b5~~10~~	b6~~12~~	b7~~14~~	b8~~18~~	b9	b10	b11	b12~~20~~	b13~~22~~	b14~~2~~4	b15~~26~~
	~~sub~~Sub-channel index (1..31)	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31
Signal Number	Signal Name																
SFQ1	~~1 (~~Header~~)~~				H	L	L	H	H	L				L	L	H	L

SFQ2	~~2 (~~Tx_start~~)~~				L	H	L	L	H	H				L	L	L	H
SFQ3	~~3 (~~Rx_start or Rx_slot~~)~~				H	L	H	L	L	H				H	L	L	L
SFQ4	~~4 (~~Tx_end~~)~~				L	H	L	H	L	L				H	H	L	L
SFQ5	~~5 (~~Rx_end~~)~~				L	L	H	L	H	L				L	H	H	L
SFQ6	~~6 (NACK)~~				L	L	L	H	L	H				L	L	H	H
SFQ7	~~7 (~~CSI_Start~~)~~				H	L	L	L	H	L				H	L	L	H
SFQ8	~~8 (~~CSI_Continuation~~)~~				L	H	H	L	L	H				L	H	L	L
SFQ9	~~9~~ NACK				L	L	H	H	L	L				H	L	H	L

Synchronization using CXCC

(delete the existing paragraph 15.2.1.5)

The synchronization signals are transmitted by the Master BS and SS/MS, at the beginning of the CXCC slots The first two time-slots of the coexistence control channel, scheduled during the DL MAC sub-frames and during the UL sub-frames are used for the synchronization. A synchronization signal will be placed at the start of the Control time-slot, in the following way:

- BS synchronized by GPS will use the first CXCC sub-channel
- BS synchronized by another BS will use the 3d CXCC sub-channel
- SS associated with a BS which is synchronized by GPS will send the synchronization signal in the first CXCC sub-channel, using an UL allocation, if instructed by the BS to do so;
- SS associated with a BS, which is synchronized by another BS or by NTP, will send the synchronization signal in the 3d CXCC sub-channel, using an UL allocation, if instructed by the BS to do so;

The synchronization signal is a sub-set of the radio signals defined in ***Error! Reference source not found.***, *Radio signal* definition. The

	Allocation	**1st signal**	**2nd signal**	**3rd signal**
1st DL CXCC sub-channel	Master 1	SFQ1	SFQ4	SFQ5
	Master 2	SFQ1	SFQ3	SFQ6
	Master 3	SFQ1	SFQ2	SFQ7
3d DL CXCC sub-channel	Master 1	SFQ2	SFQ5	SFQ6
	Master 2	SFQ2	SFQ4	SFQ7
	Master 3	SFQ2	SFQ3	SFQ8
1st UL CXCC sub-channel	Master 1	SFQ3	SFQ6	SFQ7
	Master 2	SFQ3	SFQ5	SFQ8
	Master 3	SFQ3	SFQ4	SFQ1
3d UL CXCC sub-channel	Master 1	SFQ4	SFQ7	SFQ8
	Master 2	SFQ4	SFQ6	SFQ1
	Master 3	SFQ4	SFQ5	SFQ2

Seq indicates the sequence of the Radio signals to be used for marking the slots of the coexistence control channel. These signals are defined in such a way that a cognitive radio can detect to which CXCC allocation correspond the detected synchronization signals.
All the BS synchronized to the GPS shall send the same radio signaling, as defined in the

	Allocation	**1st signal**	**2nd signal**	**3rd signal**
1st DL CXCC sub-channel	Master 1	SFQ1	SFQ4	SFQ5
	Master 2	SFQ1	SFQ3	SFQ6
	Master 3	SFQ1	SFQ2	SFQ7
3d DL CXCC sub-channel	Master 1	SFQ2	SFQ5	SFQ6
	Master 2	SFQ2	SFQ4	SFQ7
	Master 3	SFQ2	SFQ3	SFQ8
1st UL CXCC sub-channel	Master 1	SFQ3	SFQ6	SFQ7
	Master 2	SFQ3	SFQ5	SFQ8
	Master 3	SFQ3	SFQ4	SFQ1
3d UL CXCC sub-channel	Master 1	SFQ4	SFQ7	SFQ8
	Master 2	SFQ4	SFQ6	SFQ1
	Master 3	SFQ4	SFQ5	SFQ2

Seq.

Table h2—

	Allocation	**1st signal**	**2nd signal**	**3rd signal**
1st DL CXCC sub-channel	Master 1	SFQ1	SFQ4	SFQ5
	Master 2	SFQ1	SFQ3	SFQ6
	Master 3	SFQ1	SFQ2	SFQ7
3d DL CXCC sub-channel	Master 1	SFQ2	SFQ5	SFQ6
	Master 2	SFQ2	SFQ4	SFQ7
	Master 3	SFQ2	SFQ3	SFQ8
1st UL CXCC sub-channel	Master 1	SFQ3	SFQ6	SFQ7
	Master 2	SFQ3	SFQ5	SFQ8
	Master 3	SFQ3	SFQ4	SFQ1
3d UL CXCC sub-channel	Master 1	SFQ4	SFQ7	SFQ8
	Master 2	SFQ4	SFQ6	SFQ1
	Master 3	SFQ4	SFQ5	SFQ2

Table h2—Sequence of radio signals sent in the coexistence control channel

The interval between the radio signals is 1/8 of the symbol length.

Changes to 10.5.2, table 345c

Timer	Chapter	Reference	Value
Tcc	***Error! Reference source not found.*** ~~15.1.5.3~~, ***Error! Reference source not found.*** ~~15.1.4.1.2~~	Average period of the coexistence control channel time-slots or 1/2 period between DL slots or 1/2 period of the UL slots	~~200ms~~161ms
Tcc_s	***Error! Reference source not found.*** ~~15.1.5.3~~, ***Error! Reference source not found.*** ~~15.1.4.1.2~~	Duration of the coexistence control channel slots	1.9ms
Tcc_ss	***Error! Reference source not found.*** ~~15.1.5.3~~, ***Error! Reference source not found.*** ~~15.1.4.1.2~~	Offset of the DL coexistence control channel slots from the start of the MAC Frame	1ms
Tcc_se	***Error! Reference source not found.*** ~~15.1.5.3~~, ***Error! Reference source not found.*** ~~15.1.4.1.2~~	Duration from the end of the UL coexistence control channel slots to the end of the MAC Frame, for MAC Frames of 5,10 and 20ms	0.2ms
Tcxcc	***Error! Reference source not found.*** ~~15.1.5.3~~, ***Error! Reference source not found.*** ~~15.1.4.1.2~~	Duration of the coexistence control channel (CXCC)Cycle.	~~10~~ 5.12 sec

Changes to 10.5.1 Radio signaling

10.5.1 Radio 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.

~~**Table 345a—Parameter of absolute time reference**~~

~~**Absolute time reference**~~	~~**Chapter**~~	~~**Reference**~~	~~**Value**~~
~~AT1~~	~~Registration (15.4.3.2)~~	~~Start of the first MAC Frame (no. N) of CXCC~~	~~0003:000, 15:000, 27:000, 39:000, 51:000~~
~~AT2~~	~~Registration (15.4.3.2)~~	~~Start of the 2nd MAC Frame of CXCC~~	~~AT1+0001:000~~
~~AT3~~	~~Registration (15.4.3.2)~~	~~Start of the 3rd MAC Frame of CXCC~~	~~AT1+0002:000~~
~~AT4~~	~~Registration (15.4.3.2)~~	~~Start of the 4th MAC Frame of CXCC~~	~~AT1+0004:000~~

Table 345a—

Table 345b—Parameter of radio signaling timer

Timer	Chapter	Reference	Value
~~T_cogn~~	~~Registration (15.4.3.2)~~	~~Repetition period of the CXCC~~	~~12s~~
Tad_reg	Registration (Registration ~~15.4.3.2~~)	Maximum time-interval in which an ~~ad-hoc~~ backhaul-less unit has to repeat the registration	1800s
~~T_iptx~~	~~Registration (15.4.3.2)~~	~~Time interval between the start of consecutive CSI slots for the transmission of the IP address using frequency-keyed energy pulses~~	~~20ms~~

Table 345b—