Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Consolidation of Uncoordinated Coexistence Mechanisms**
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Re:	IEEE 80216-07/013 Task Group Review of P802.16h/D2b
Abstract	Editorial instructions for consolidating mechanisms for uncoordinated coexistence into a single place in the document.
Purpose	To avoid the confusion caused by having related mechanisms distributed throughout the document.
Notice	
Release	
Patent Policy and Procedures	

Consolidation of Uncoordinated Coexistence Mechanisms

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1. Overview

Features such as the 4-frame sequence in section 15 are necessary for uncoordinated coexistence, but in the case of uncoordinated coexistence, the scope of use may be limited compared to the case where two systems can communicate with each other regarding power levels, neighbors, etc. In this document we propose modification to section 6.4 to clarify which aspects of features are used in uncoordinated coexistence.

If the task group feels it is appropriate, section 6.4 could be made section 15.1 with the current section 15 being made section 15.2.

The Frame maker file is available for the editor.

2. Specific Editorial Changes

This document provides changes to IEEE P802.16h/D2b [1].

Blue underlined text represents specific editorial changes.

~~Red strikethrough~~ text is to be deleted.

Black text is already in the draft.

Bold italics text is editorial instructions to the editor.

The following headers are just to get the section numbers correct since I don't know how to reset the numbers in Frame Maker.

3. Bogus H1

4. Bogus H1

5. Bogus H1

6. Bogus H1

6.1 Bogus H2

6.2 Bogus H2

6.3 Bogus H2

6.4 Bogus H2

6.4.1 Bogus H3

6.4.2 Bogus H3

6.4.2.1 Bogus H4

6.4.2.2 Bogus H4

6.4.2.3 Bogus H4

6.4.2.4 Uncoordinated Coexistence Protocol (UCP)

This clause describes the use of an Uncoordinated Coexistence Protocol (UCP). The UCP is designed to use passive cognitive radio techniques to allow co-channel coexistence between multiple 802.16 systems or between 802.16 systems and systems of other technologies such as 802.11 systems.

Upon system startup, the BS shall choose a suitable channel in which to operate. Channel selection will depend upon the requirements for operation in a given band. If the band contains SSUs, the BS shall use a protocol termed in this sub clause 'DFS' to attempt to find a channel free of SSUs; this protocol is described in sub clause *6.4.2.2*. If the band contains only non-SSUs, the BS ~~shall~~ uses the DCS protocol to find the best channel for operation; this protocol is described in sub clause *6.4.2.2*. In certain regulatory regimes where SSUs are not present, it may be sufficient for the choice of channel to be able to be performed manually with coordination between operators as needed. The definition of best for this purpose shall be left for vendor differentiation, but can be used to mean least interfered. If the band contains both SSUs and non-SSUs then both DFS and DCS protocols are used together. The DFS protocol is used to avoid interference to SSUs by vacating the channels on which SSUs are detected, and additionally DCS is used to select the best channel of the set of channels in the band that are cleared for operation by DFS.

The BS shall continue to perform DFS and DCS operation, as required, selecting the most appropriate channels based on the prevailing conditions and reacting to reported measurements from the SSs. For the case SSUs are detected on a channel then the DFS protocol shall attempt to select an alternative channel. For the non-SSU detection the BS shall use the DCS protocol in order to select an alterative channel, previously checked to be clear of SSUs~~,~~. For improved coexistence with other uncoordinated 802.16 systems, the BS shall claim a master frame [insert appropriate chapter 15 reference] sequence as described in section 6.4.3.2 and shall use the described mechanism to share the channel with up to two other 802.16 systems on a minimally interfering basis. To allow non-802.16 systems, such as 802.11 systems, to share the channel, the BS ~~or~~ shall use aEQPs, as described in sub clause ~~*6.4.3.2*~~ *6.4.3.4*, to ensure other detected systems have an opportunity to transmit. Also if systems other than SSUs are present in the channel, the BS shall use the listen-before-talk (LBT) protocol of sub clause ~~*6.4.3.4*~~ *6.4.3.5* to avoid scheduling a frame when another system is transmitting on the channel.

6.4.3 Support for uncoordinated coexistence

6.4.3.1 Enhanced Measurement and Reporting for Non-Exclusively Assigned or non-exclusively Licensed Bands

When operating in non-exclusively assigned or non-exclusively licensed bands, a system compliant to this standard shall be able to detect specific spectrum users (SSUs), if any, in their band. Which SSUs and the actions to be taken vary with the regulations for the various bands, but the typical action is the use of DFS [B11] and mandatory vacating of the channel.

When operating in non-exclusively assigned or non-exclusively licensed bands, a system compliant to this standard shall be able to detect energy. The required energy detection level is specified by regulations. If the regulations specify SSUs and the 802.16 system is unable to determine specifically that the energy is not from an SSU, the 802.16 system shall take the same action it would upon detection of a SSU.

When operating in non-exclusively assigned or non-exclusively licensed bands, a system compliant to this standard should be able to positively detect other systems compliant to this standard, differentiating them from SSUs, if any, and non-802.16 occupants of the band, such as 802.11 systems. The action taken upon detection may vary based upon the regulations and may include any of the uncoordinated coexistence mechanisms in clause *6.4*, or the coordinated coexistence mechanisms in Clause *15*.

When operating in non-exclusively assigned or non-exclusively licensed bands where 802.11 systems may also be present, a system compliant to this standard should be able to positively detect 802.11 systems, differentiating them from SSUs, if any, and non-802.11 occupants of the band. The action taken upon detection may vary based upon the regulations of the band and may include any of the uncoordinated coexistence mechanisms in clause *6.4*.

The reporting mechanisms for an SS informing the BS of the detection of another occupant are described in *6.3.2.3.33* for the REP-REQ/REP-RSP MAC messages. For further detail of message content, see *11.11* and *11.12* respectively).

Insert new section 6.4.3.2, renumbering the remaining sections

6.4.3.2 Claiming a Master Frame Sequence

Co-channel coexistence between multiple 802.16 systems is dependent upon synchronization. All BS must be synchronized to GPS or NTP if GPS is not available (see section 15.2.1). The coexistence frame number is a function of absolute time of day, so not only do all systems have the same DL/UL split (see section 15.7), but there is a knowledge of absolute time so the functionality or ownership of a particular frame can be agreed upon between different systems regardless of when they actually came on line. This allows sharing in time of the channel by up to three different uncoordinated 802.16 systems using a four frame sequence. It also lays the foundation for supporting the active cognitive radio techniques found in section 15.

The goal of the four frame repetitive sequence is to allow sharing of a channel by up to 3 different 802.16 systems. When using 5ms frames, this has good synergy with the 20ms packetization of VoIP. While ultimately, the sharing of the channel can be done in both time and power (simultaneous Tx with power level management), only systems communicating via the CXP protocol of section 15.5 have sufficient information available to adjust power or refrain from transmitting when necessary to enable simultaneous transmit. Therefore uncoordinated systems shall only share in time and shall not intentionally attempt to transmit in the same frame at the same time as neighbor systems.

When all systems attempting to coexist on the same channel are 802.16 systems, the end result after all three systems have entered the channel is a four frame sequence of frame usage as shown in Figure h 1. This is a simplified version of Figure h25 with the simplification being necessary since the uncoordinated systems cannot communicate with each other regarding interference and power levels.

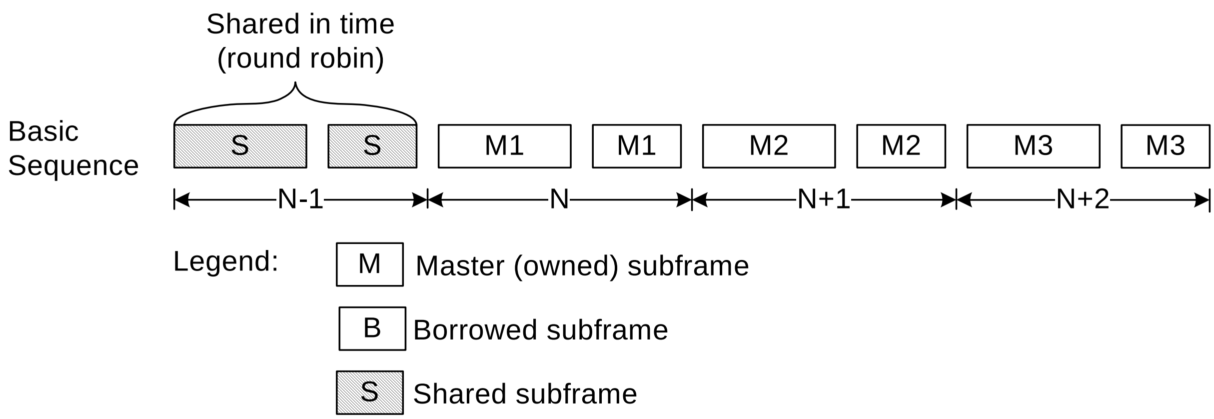

Figure 1—Basic four frame repetitive sequence

Initially when the channel has no occupants, the first system to operate on the channel shall claim a slot within the repetitive sequence as master. While a system may be allowed to borrow unused slots a system shall claim no more than a single slot as master. It does not matter which slot the first system claims although it is highly recommended that all BS on the given channel belonging to the same network operator should claim the same slot as this will reduce the need for operator coordination.

The result of the first system claiming slot 1 of the repetitive sequence is shown in Figure h 2.

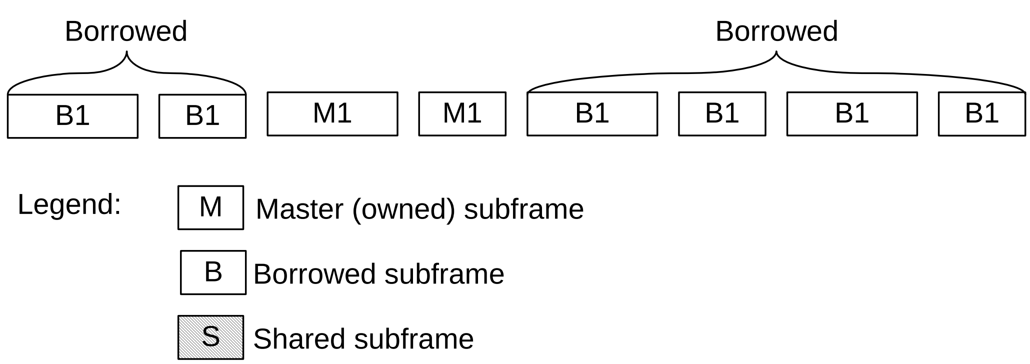

Figure 2—First 802.16 System Claiming Slot 1

The result after a second system has claimed slot 2 is shown in Figure h 3.

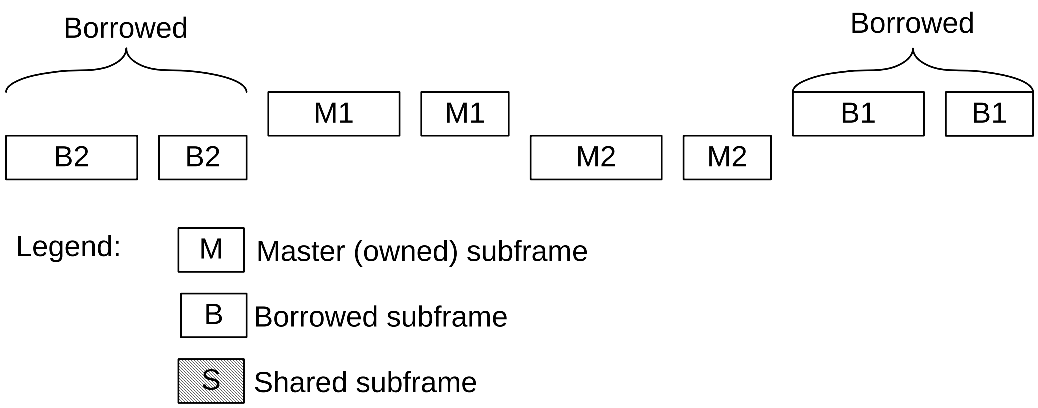

Figure 3—Second 802.16 System Claiming Slot 2

The result after a third system has claimed slot 3 is shown in Figure h 4. This creates the basic 4 frame sequence originally described.

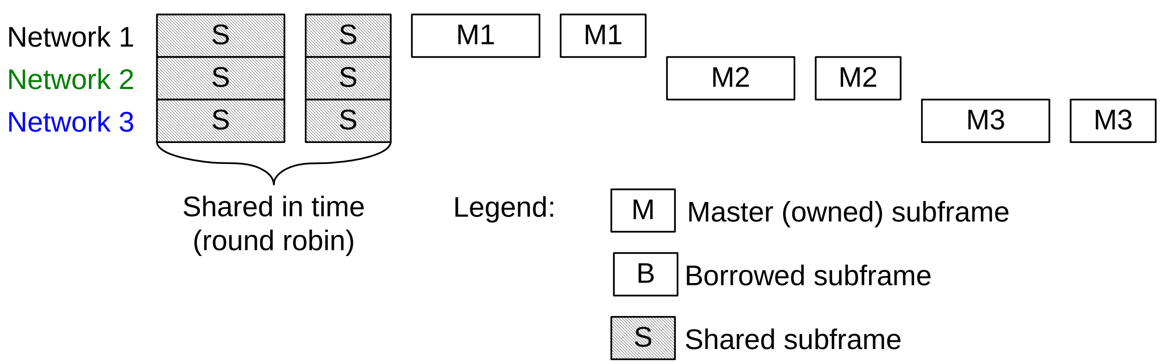

Figure 4—Third 802.16 System Claiming Slot 3

If the a single 802.16 system is sharing with a non-802.16 system such as 802.11, the 4 frame sequence would transition from just the 802.16 system to being shared with a non-802.16 system as shown in Figure h 5. If two 802.16 systems were to coexist with a non-802.16 system, the structure would appear as in Figure h 6. In these cases, the attempt is to give the non-802.16 system ample opportunity to transmit while maximizing regularity of the 802.16 system's opportunities. In both cases, the shared frames need not be completely given up to the non-802.16 systems but can be shared through use of the Listen-Before-Talk (LBT) feature described in 6.4.3.5. Attempts to use the shared frames shall be on a round robin basis between 802.16 systems since their synchronization defeats using LBT to avoid each other. Since 802.11 and other non-802.16 technologies do not have a concept of "owned" frames and do not realize they are "master" of certain time periods, there is a possibility of interference even in master frames. Therefore, 802.16 systems shall use the LBT mechanism prior to transmitting in master frames if there is reason to believe a non-802.16 system is co-channel. Additionally, aEQP shall be used to allow entry of the non-802.16 systems.

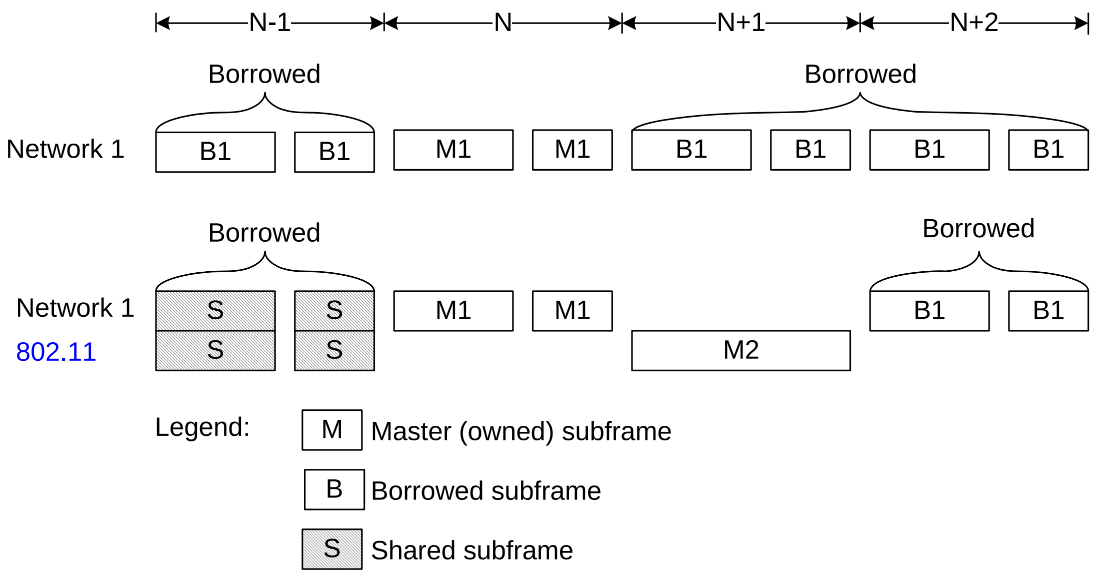

Figure 5—One 802.16 System Coexisting with Non-802.16 Systems

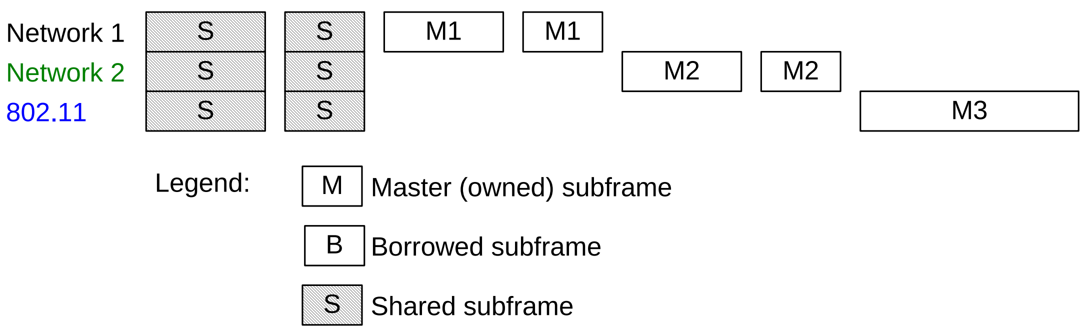

Figure 6—Two 802.16 Systems Coexisting with Non-802.16 Systems

The mechanism for uncoordinated systems claiming a slot within the repetitive 4 frame sequence is the same as it is for coordinated systems described in section 15. The slot claimed corresponds to a control channel opportunity. In particular, the master frame opportunities of CXCC sub-channels 2 and 4 shall be used to positively claim a slot in the 4 frame sequence. A system shall not borrow a frame during a scheduled CXCC opportunity. It shall only transmit in CXCC opportunities for which it has claimed master status. If a system is borrowing frames, it must monitor the corresponding CXCC opportunities in CXCC sub-channels 2 and 4 to determine if a new system is claiming master status for the corresponding slot.

6.4.3.3 Extended Quiet Periods (EQP)

Extended quiet periods (EQP) are periods of an integer number of frames during which both uplink and downlink transmission is suspended. The primary purpose of the EQPs is to give other uncoordinated users of non-exclusively assigned or non-exclusively licensed bands reasonable opportunity to operate when an alternative channel is not available. While not all future technologies with which 802.16 systems may need to coexist can be identified today, 802.16 systems are expected to coexist with other 802.16 systems and with 802.11 systems.

Since 802.16 systems have the capability to fragment SDUs, EQP duration of a single frame is sufficient for allowing another 802.16 system access to the spectrum. In fact, the synchronized sharing of the channel as described in section

6.4.3.2 is a form of synchronized EQP between two or more 802.16 systems. For 802.11 coexistence, the quiet period duration should be chosen to allow the maximum duration 802.11 transmission allowed in the band. For 802.11y, this is 4ms. For 802.11a, b, and g systems the maximum PHY PDU (PPDU) using the 802.11 5.5 Mbit/s PHY mode is used as a reference. 802.11 systems can operate with one of three channel bandwidths - 20 MHz, 10 MHz, or 5 MHz. This bandwidth affects the transmission duration of a maximum length 802.11 PPDU. The minimum EQP durations for various channel bandwidths are shown in *Table h 132g*. The number of integral frames required is a function of the chosen frame duration for the 802.16 system. 802.16 BS and SS shall retain respective DL and UL synchronization over the period of EQP. The use of the EQP protocol shall recognize appropriate use of the Lost DL/UL MAP Interval parameter in table 342.

Table 132g—Minimum EQP Durations for coexistence with 802.11a, b, and g

Channel Bandwidth	Minimum EQP Duration
20 MHz	3.65 ms
10 MHz	7.3 ms
5 MHz	14.6 ms

The duration, in frames, of the EQP is signaled in the DL-MAP using the EQP_IE defined in *8.4.5.3.29*. The EQP always starts in the frame following the DL-MAP containing the EQP_IE. In addition to the duration of the EQP, the Measurement_Reporting field indicates whether measurement and reporting on the channel should be performed during the EQP. If the Measurement_Reporting bit is set to 0, no automatic measurement and reporting are required. When Measurement_Reporting is set to '1', then all SS shall make measurement in order to create a Report Type 1.1, Bit#0 = 1, type 'Basic Report' in REP-REQ (*11.11*). if so required. An SS will transmit a corresponding REP-RSP message if a measurement detected activity above the *detection threshold* for the frequency band of operation. In such bands with specific requirements for avoidance of SSUs enabling for reporting of prevailing SSUs shall be such so as to comply with the mandated regulatory requirements. The need for bandwidth to transmit a report may be signaled through any of the standard methods for signaling a need for UL bandwidth. When the UL-MAP relevance is the next frame the UL-MAP transmitted in the last DL subframe before an EQP describes the allocations for the first UL subframe after the EQP. This is shown in *Figure h 7*. The periodicity of EQP is described in the next sub clause. This discontinuity of the UL-MAP relevance does not exist in the case where the UL-MAP describes the allocations for the current UL subframe. In this case the DL and UL subframes can be more closely associated with each other. This is important for a listen-before-talk capability (*6.4.3.5*). The case of EQPs with UL-MAP relevance for the current frame is shown in *Figure h 8*.

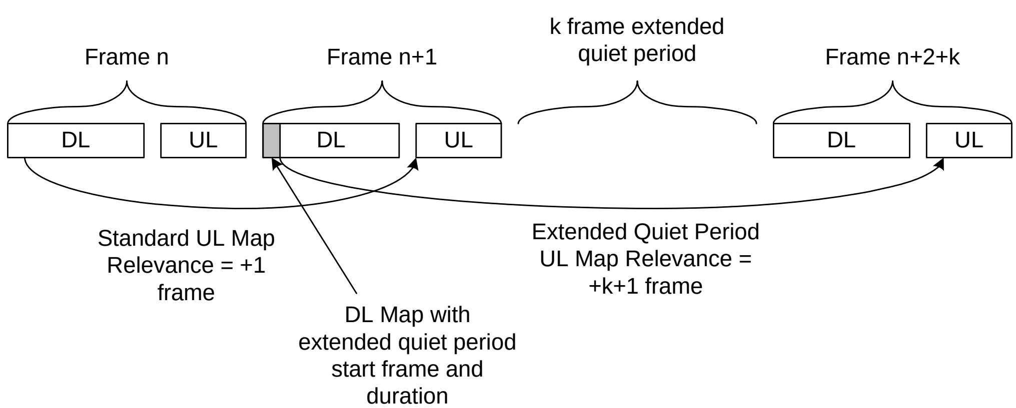

Figure h7—EQPs Map Relevance = n+1

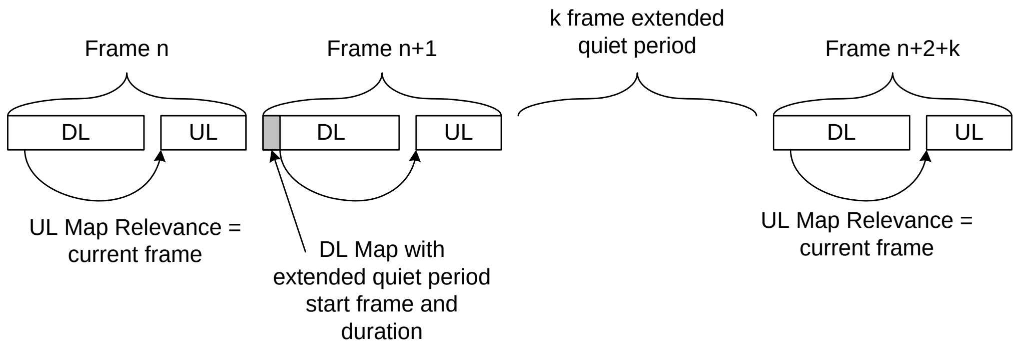

Figure h8—EQPs Map Relevance = n

6.4.3.4 Adaptive EQPs

There may be bands where there is a possibility of other users, but where the probability is low. This situation may occur where there are very few users present in the band, for example, in a particular rural geographical location. In these cases, it is important to not waste bandwidth catering to non-existent users of the band. When EQPs are used in a non-exclusively assigned or licensed band, a BS initially offering service shall perform an initial (see *6.4.2.4*) scan and pick the best channel (or this may be configured based on measurements made outside the scope of the 802.16 system or based on collaboration between operators). Based on this choice, if the channel is thought to be free of other users, the BS shall set the initial duty cycle to no more than max_duty_cycle. If another user was detected, the BS shall initially operate a duty cycle of no more than share_duty_cycle. Duty cycles are measured over a 1 second period. This duty cycle can be achieved a number of ways. For instance a 50% duty cycle can be achieved: with the use of every other frame, n frames on and n frames off, or operate in n/2 of n frames, etc. The method of achieving the duty cycle shall be left for vender differentiation which increases the likelihood of randomization of the algorithm of two different BS from two different operators which in turn increases the likelihood of their ability to eventually detect each other or an SS associated with the other BS. If the 802.16 system is already sharing the channel with another 802.16 system as described in section 6.4.3.2 the duty cycle shall be calculated based solely on the master and borrowed frames used by the particular system. Refraining from transmitting during a master or borrowed frame of another system shall not count as having been quiet for the purposes of aEQP.

If after a prolonged period which is band specific in duration, the BS and its associated SSs have not detected other users in the band through measurement and reporting during EQPs coupled with measurement and reporting as performed for DCS (see *6.4.2.3.2*) then the BS may increase its duty cycle by duty_cycle_step. The duty cycle shall not increase above max_duty_cycle as measured over a 1 second period. The BS shall continue to measure and shall continue to instruct SSs to measure and report using the EQPs and the DCS (see *6.4.2.3.2*) mechanism. If a SSU is detected, the band specific regulations shall be followed. If another user that is not a SSU is detected the BS shall reduce its duty cycle to at most intermediate_duty_cycle within 10 frames of the BS becoming aware of the detection. If the detected user persists, the BS shall reduce the duty cycle to at most share_duty_cycle. The flow is shown in *Figure h 9* using example parameters: share_duty_cycle = 50%, intermediate_duty_cycle = 75%, max_duty_cycle = 90%, and duty_cycle_step = 10%.

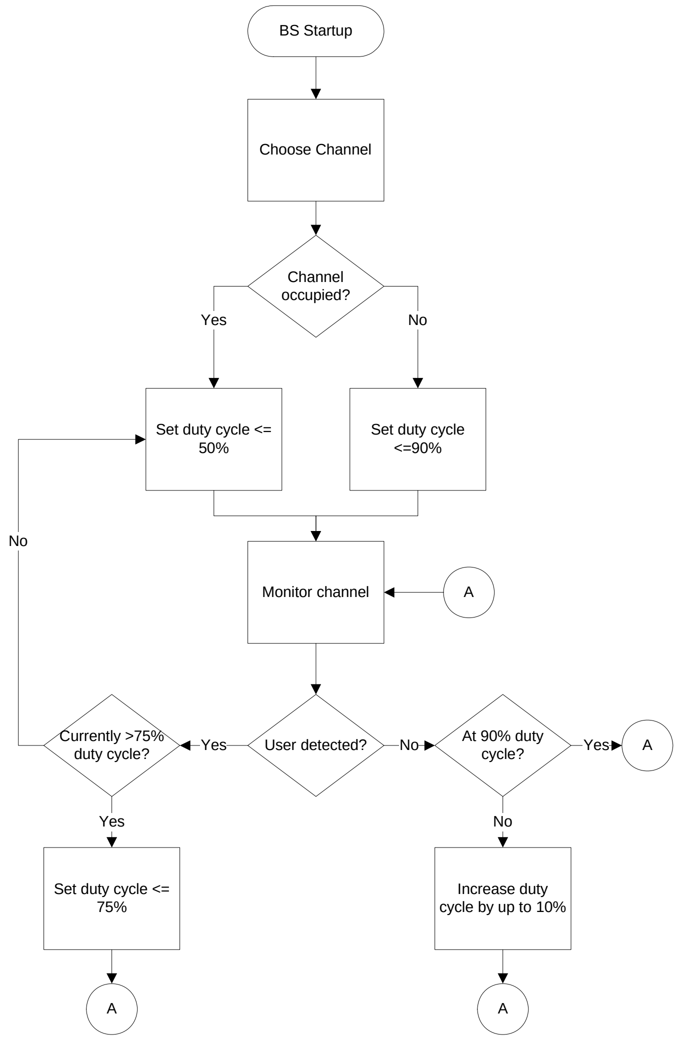

Figure h9—Adaptive EQP (with example parameter numbers)

6.4.3.5 Listen-Before-Talk (LBT)

When attempting to coexist with certain non-802.16 users of non-exclusively assigned or non-exclusively licensed bands, EQPs may not be sufficient. In these cases, a LBT protocol must be used. In such bands, the BS shall operate with a UL-MAP relevance of the current frame. This allows the DL and UL subframes to be logically viewed as a single "packet" of constant duration equal to the frame duration. The BS shall periodically allocate ~~part of the DL sub-frame as an opportunity~~ opportunities for an SS to measure and report on the current state of the channel, and provide input to the LBT protocol. An Extended Channel Measurement IE (see for example sub clause 8.4.5.3.5) may be used~~, along with a gap in DL transmission,~~ to provide such an opportunity. In a similar way in the gap between the UL and DL subframes, as close to time to transmit the DL as possible, the BS shall ~~part of the UL subframe may be reserved from SS transmission for the BS to~~ make measurements on the current state of the channel ~~and update the LBT protocol accordingly.~~ Given that the LBT protocol detects energy above the defined threshold then no transmission will take place in the succeeding subframe. ~~In the event there is no downlink transmissions then the SS will apply the last received DL-MAP/UL-MAP over the period of no transmission.~~ The use of the LBT protocol shall recognize appropriate use of the Lost DL/UL MAP Interval parameter in table 342. Transmission recommences when energy levels drop below the threshold level. Due to the fact that there may be no time to signal an energy detection event then a BS or SS shall ~~reliable~~ reliably handle the absence of a subframe where it was previously scheduled by the DL or UL-MAP. An example of this arrangement is given in *Figure h 10*. ~~This time period~~ The frame in which the system refrained from transmitting shall be used to sense other non-802.16 systems. The minimum duration is 4 us. Specific implementation of this protocol is not specified and is left for vendor differentiation. Use of LBT shall not eliminate any requirements for other measurement and reporting that may be required for operation in a particular mode or band. Use of listen-before-talk shall not eliminate any requirement for use of EQPs. However, refraining from transmitting during a frame due to energy detection during the LBT “listen” period shall count towards fulfilling the quite percentage of the aEQP duty cycle.

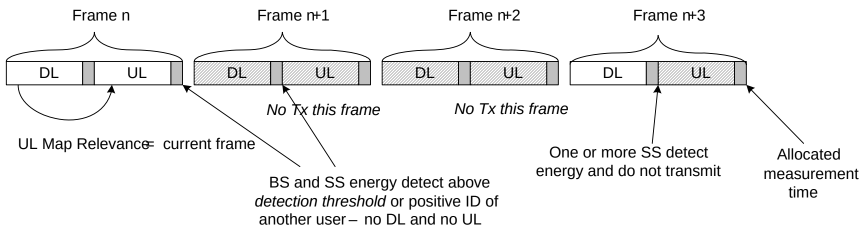

Figure h10—LBT

7. References

[1] IEEE P802.16h/D2b: *Air Interface for Fixed Broadband Wireless Access Systems Improved Coexistence Mechanisms for Licensed Exempt Operation*, Working Group Draft.