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Title	**Action Item from Session #46: Consolidation of UCP – Uncoordinated Coexistence Protocol**
Date Submitted	**2007-01-17**
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Re:	Working Group Letter Ballot #24 for IEEE P802.16h/D1.
Abstract	This document contains proposed editorial and technical changes to sub clause 6.4.2.4 '*Uncoordinated Coexistence Protocol (UCP)*' and associated sub clauses. A number of comments from Working Group Letter Ballot #24 considered at Session #46 are related to this clause. This document addresses these comments and suggests a harmonization of the comments presenting accompanying editorial instruction to implement the changes.
Purpose	
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Action Item from Session #46: Consolidation of UCP – Uncoordinated Coexistence Protocol

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Overview

This contribution addresses an action item assigned to the author at Session #45 concerning sub clause 6.4.2.4 '*Uncoordinated Coexistence Protocol (UCP)*' and associated sub clauses in [1].

A number of comments from [2] are resolved through this contribution. Specifically the comments from [2] are 22, 114, 116, 117, 125, 127,131, 133, 135, 139, 553, 141, 146, 147, 149, 151, 157, 196, 222, and 233. These comments are detailed in Annex 1. The following section provides specific editorial instruction specifying changes required to [1] to address the comments described. The comments listed in Annex 1 are addressed accordingly:

Comment 22: Ken Stanwood: Implemented as proposed.

Comment 114: David Grandblaise: Adequately described in the paragraph three of 6.4.2.1. Also 6.4.2.4 now provides additional information to address this comment. No changes required.

Comment 116: Avi Freedman: Remedy suggested.

Comment 117: David Grandblaise: Remedy suggested.

Comment 125: Ken Stanwood: Remedy suggested.

Comment 127: Achim Brandt: I presume the contribution cited in this comment is IEEE C80216h-06_108. In which case this comment is superseded by the acceptance of IEEE C80216h-06_108r3.

Comment 131: Ken Stanwood: Text proposed.

Comment 133: Avi Freedman: Proposed text accepted.

Comment 135: Xuyong Wu: Sub clause 6.4.2.4 has been modified based on the acceptance of IEEE C80216h-06_108r3. The use of coordinated mechanisms are not precluded based on that which is mandated in this sub clause. The sub clause describes, in broad terms, what is required for the implementation of UCP from the 'tools' presented in the sub clauses that follow.

Comment 139: David Grandblaise: Comment possibly superseded by IEEE C80216h-06_108r3.

Comment 553: Aik Chindapol: Contribution C80216h-06_108r3 was accepted at Session #46 – the text has been included in this document for completeness.

Comment 141: Maximilian Riegel: 6.4.3.1 deleted.

Comment 146: David Grandblaise: Remedial text proposed.

Comment 147: Mariana Goldhamer: Additional explanatory text is provided. Three points are raised by this comment. They are dealt with in turn:

How are the existing 802.16 OFDM and OFDMA MAC Frame durations supported? Frames are supported in the same way as the base standard. A EQP MAP IE indicates when a frame will not be transmitted and the SS is not expecting to receive it. As the text explains there are only integer numbers of frames omitted.

How is the violation of the 802.16 MAC Frame structure avoided? The reply above applies equally to this question.

How are existing SS sync if a number of MAC sub-frames are skipped? A EQP MAP IE indicates when a frame will not be transmitted and the SS is not expecting to receive it. 'Existing SS' will require modification to work with the 16h amendment and so will have capabilities to work where frames are missed.

Comment 149: David Grandblaise: Remedial text proposed.

Comment 151: Mariana Goldhamer: Additional explanatory text is provided. Two points are raised by this comment. They are dealt with in turn:

The proposed mechanism violates the OFDM and OFDMA Frame structure, by introducing silence periods at and eliminating preambles, FCH, MAPs etc. LBT does not violate OFDM/OFDMA frame structure. It is right and proper to introduce quiet periods and make interference assessment by way of *channel measurement IE* (8.4.5.3.5). Preambles, FCH and MAPs are still present.

The proposed mechanism violates the coexistence rules established between 802.16h users, as the interference-free periods provided by the Master sub-frames: There is no violation for coexistence rules between 802.16h users. There is nothing that requires WirelessMAN-CX systems to implement LBT. It seems from previous discussion that aEQP and LBT is a means of facilitating WirelessMAN-CX systems.

Comment 157: Gaspare Licitra: Text added to clarify operation of this message. NB there is no need for a reporting period to be defined in EQP IE. The bit flag in EQP IE is used to enable/disable reporting of measurements in an unsolicited manner during the EQP. Reporting is controlled by the REP-REQ/REP-RSP MAC messages or other existing mechanisms.

Comment 196: Ken Stanwood: Remedial text proposed.

Comment 222: David Grandblaise: Figure h12 describes the initialization procedure and so it is not appropriate to reference UCP at this stage. Refer to text in 6.4.2.4. Comment possibly superseded by IEEE C80216h-06_108r3.

Comment 233: Xuyong Wu: No changes possible – no proposed text.

Specific editorial changes

This section provides a list of changes to IEEE P802.16h/D1 document [1].

Blue underlined text represents specific editorial additions.

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

Black text is text already in the draft.

Bold italic text is editorial instructions to the editor.

~ ~ ~

Make the following changes to sub clause 6.4, and renumber accordingly. Note to the editor: the base text below is text taken from [1].

6.4.2 Uncoordinated coexistence mechanisms

6.4.2.1 Introduction

This subclause details a number of uncoordinated coexistence mechanisms.

The mechanism overviewed in subclause *6.4.2.2* is intended to protect Specific Spectrum Users (SSUs) where regulation mandates. Subclause *6.4.2.3* provides a general uncoordinated coexistence mechanism suitable, for example, in bands where no mandatory coexistence behavior is required. In a band such as this, with assignments made in a non-exclusive manner, a mechanism is required to ensure a system possess the ability to satisfactorily coexist with other wireless users (Non-~~s~~Specific Spectrum Users) also using the band.

In bands containing both SSUs and non-SSUs~~Non-specific Spectrum Users~~, it can be expected that a combination of schemes presented in this subclause will be required to provide mandatory protection for the SSUs and as well as a means of coexistence with Non-specific Spectrum Users.

Subclause *6.4.2.4* provides an Uncoordinated Coexistence Protocol (UCP) to provide a further mechanism to allow operation in non-exclusively assigned and non-exclusively licensed bands.

6.4.2.2 Coexistence with specific spectrum users (SSUs)

Editorial instruction missed during editing of IEEE C80216h-06_072r2

Move sub clause 6.3.15 from 802.16-2004 to 6.4.2.2 (deleting the existing 6.4.2.2) and renumber accordingly. Change the title of 6.3.15 to 'Coexistence with specific spectrum users (SSUs)'.

The section numbering mapping then becomes:

6.3.15 goes to 6.4.2.2
6.3.15.1 goes to 6.4.2.2.1
6.3.15.2 goes to 6.4.2.2.2
6.3.15.3 goes to 6.4.2.2.3
Etc…

Change all references in the base standard and Working Document accordingly, i.e. 6.3.15 references become references to 6.4.2.2.

Add the following text and figure at the end of section 6.4.2.2.1.

Figure h2 provides an illustrative flowchart of a generic scheme for operation in bands with SSUs. The flowchart highlights the main operational requirements for coexistence and overviews the description in the remainder of this sub clause. Figure h2a illustrates possible behavior at the BS, while Figure h2b illustrates the behavior at the SS. Figure hxyz1 provides a link level example of message exchange in the event an SSU is detected at (a) the BS, and (b) the SS.

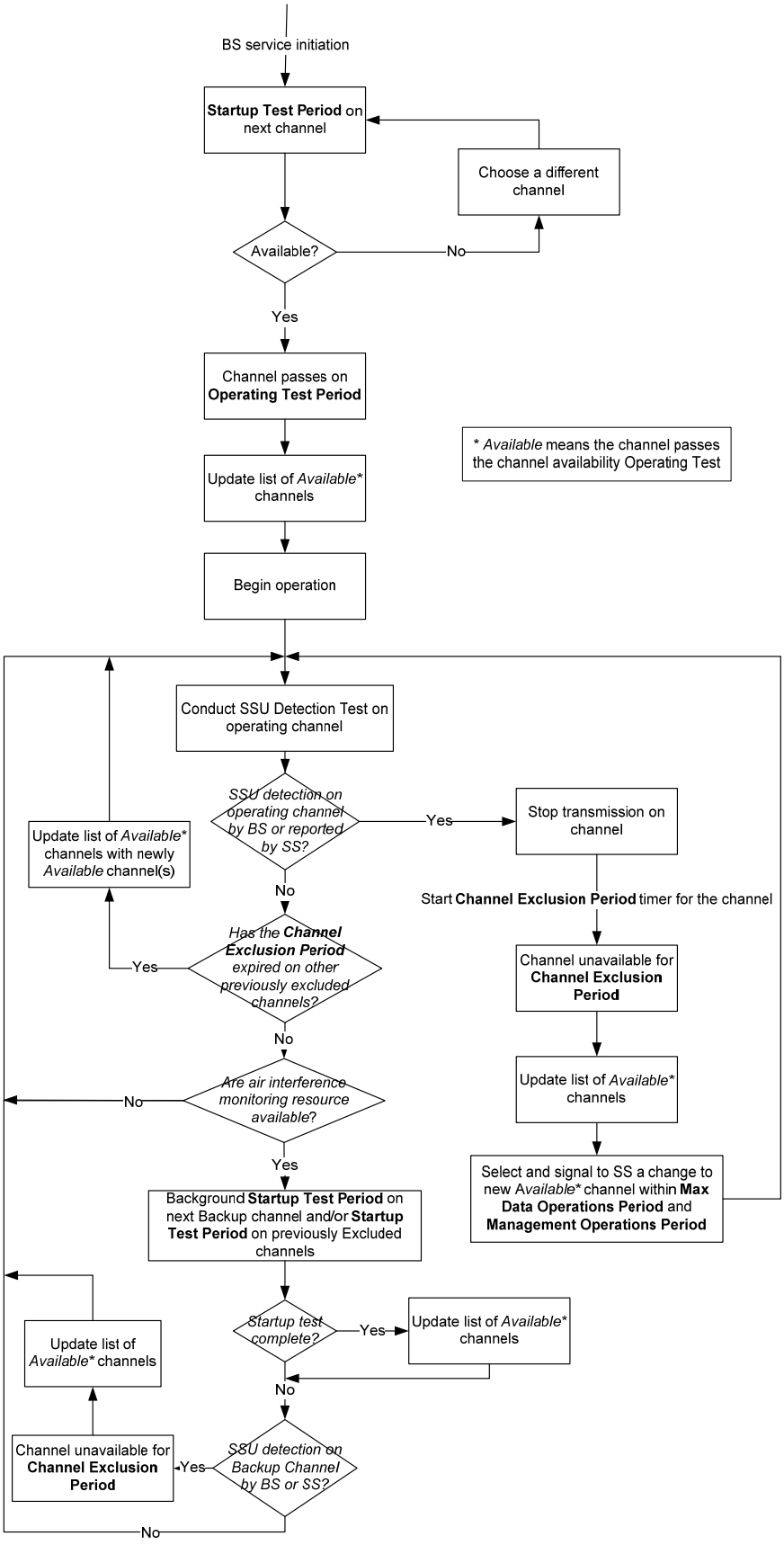

BS service initiation
Startup Test Period on next channel
Choose a different channel
Available?
No
Yes
Channel passes on Operating Test Period
* Available means the channel passes the channel availability Operating Test
Update list of Available* channels
Begin operation
Conduct SSU Detection Test on operating channel
SSU detection on operating channel by BS or reported by SS?
Yes
Stop transmission on channel
Update list of Available* channels with newly Available channel(s)
No
Start Channel Exclusion Period timer for the channel
Has the Channel Exclusion Period expired on other previously excluded channels?
Yes
Channel unavailable for Channel Exclusion Period
No
Update list of Available* channels
Are air interference monitoring resource available?
No
Yes
Select and signal to SS a change to new Available* channel within Max Data Operations Period and Management Operations Period
Background Startup Test Period on next Backup channel and/or Startup Test Period on previously Excluded channels
Startup test complete?
Yes
Update list of Available* channels
Update list of Available* channels
No
Channel unavailable for Channel Exclusion Period
SSU detection on Backup Channel by BS or SS?
Yes
No

Figure h2a Flowchart showing generic operation at the BS in bands with SSUs ~~specific spectrum users~~ *[Note: revised figures]*

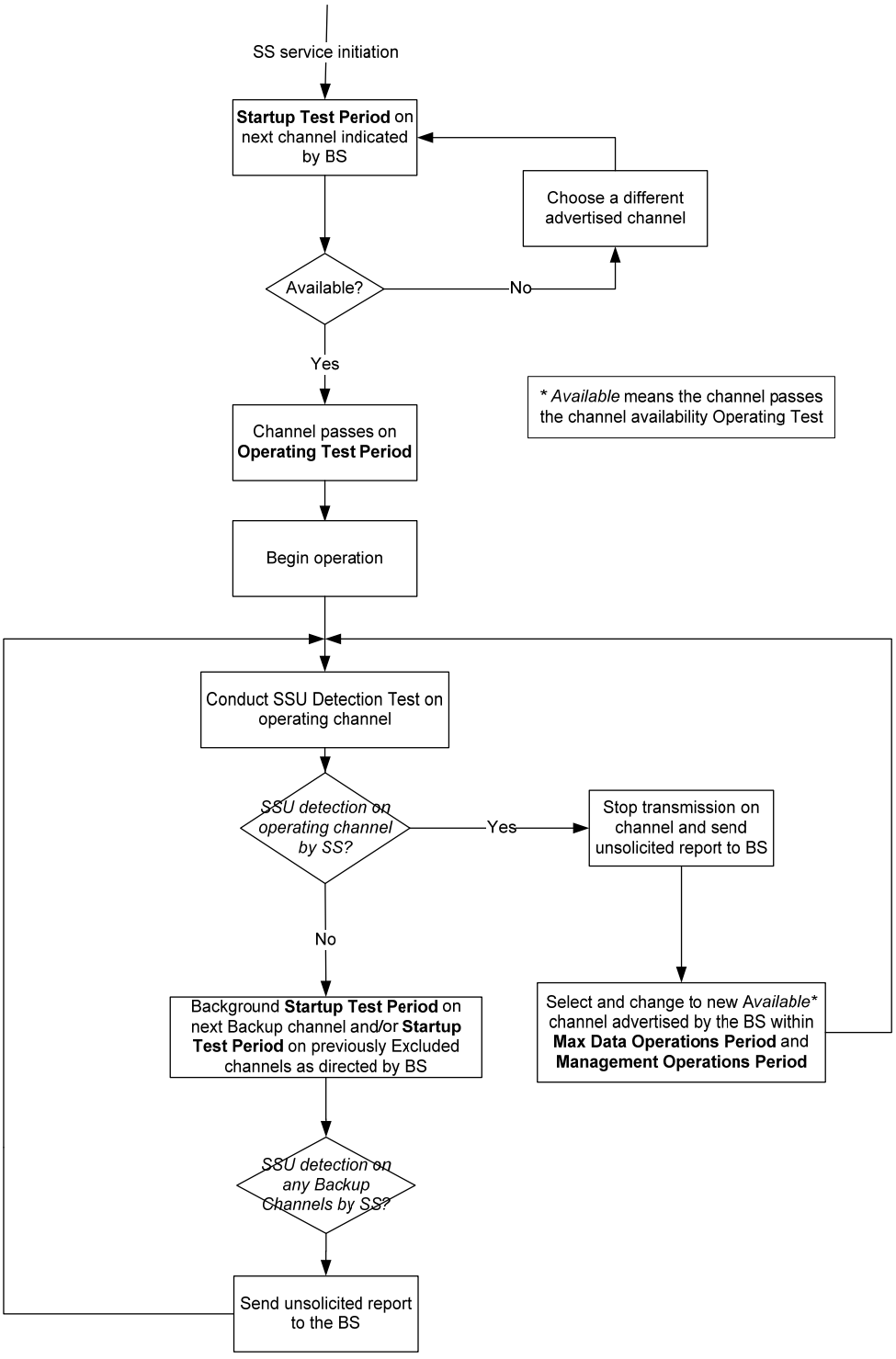
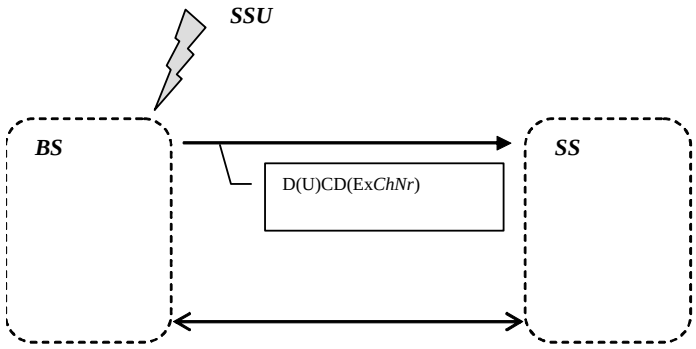


Figure h2b Flowchart showing generic operation at the SS in bands with SSUs

(a) SSU reporting and remedial action at the BS



(b) SSU reporting and remedial action at the SS

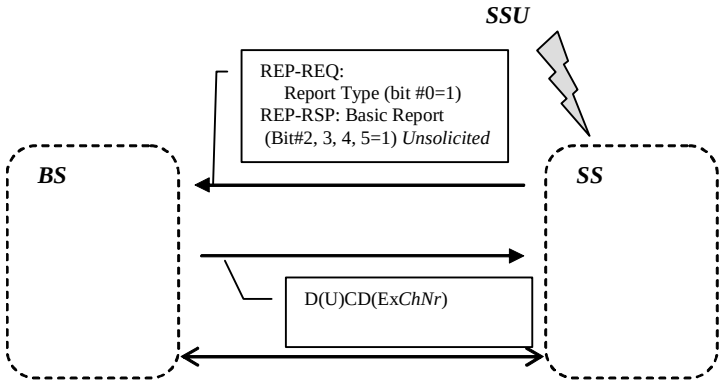


Figure hxyz1 – Link level representation of BS and SS in bands with SSUs

Add the following sentence at the end of section 6.4.2.2.3

The detection of a specific spectrum user will mean the channel is unusable for **Channel Exclusion Period.** The channel is marked as an Excluded Channel for a period defined by regulation.

6.4.2.3 Uncoordinated coexistence with Non-specific Spectrum Users (Non-SSUs)

6.4.2.3.1 Introduction

This subclause considers uncoordinated coexistence mechanisms for use in bands where Non-sSpecific Spectrum uUsers (Non-SSUs) are present. The mainimportant distinction for coexistence with Non-specific Spectrum usersNon-SSUs, when compared with SSUs (*6.4.2.2*), is that there are noless stringent, if any,

regulatory demands placed on the coexistence solution~~.~~. ~~such as~~Aspects where requirements may be relaxed include: monitoring resource requirements and accompanying detection times, probability of detection requirements, or time to vacate the operating ~~frequency~~channel. When a ~~Non-specific Spectrum user~~Non-SSU is detected it is not mandated that the operating ~~frequency~~channel be vacated~~.~~, it may be possible to use a more robust modulation scheme, or use an AAS beamforming approach to focus energy and reduce interference, however to meet with some guidelines on coexistence in non-exclusively assigned and non-exclusively licensed bands then channel changing to a less interfered channel may be a preferred option. One realization of uncoordinated coexistence with ~~Non-specific Spectrum users~~Non-SSUs is termed Dynamic Channel Selection (DCS).

6.4.2.3.2 Dynamic Channel Selection (DCS)

Dynamic Channel Selection (DCS) is ~~a realization of~~ an uncoordinated coexistence mechanism and provides the ability for a system to switch to different ~~logical~~physical frequency channel, based on channel ~~measurement~~conditions, and ~~thus~~thereby avoiding interference in non-exclusively assigned and non-exclusively licensed bands. ~~Logical channels can be constructed from an operating frequency and time component, or a portion thereof. Channel measurement and interference avoidance provide a DCS algorithm with the means of obtaining interference isolation in time and frequency. This approach enables a number of systems to share a given frequency. The approach contrasts to that of subclause *6.4.2.2.*, which specifies SSUs avoidance in which the physical frequency is vacated due to the potential interference to the SSU.~~DCS can be used as a means of finding a least interfered channel at system startup or can be used during normal system operation to provide constant interference monitoring capabilities and, with the ability to monitor other channels, provide a list of backup channels for informed switchover to a different, less interfered, channel. An illustrative example is given in Figure hxyz2a for possible behavior at the BS, while Figure hxyz2b illustrates the behavior at the SS.

Quiet periods for m~~M~~easurement ~~periods~~ 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). ~~This is achieved via measurement IEs (see for example 8.4.5.3.5).~~ These m~~M~~echanisms are supported with the REP-REQ/ REP-RSP (*6.3.2.3.33*) MAC messages to provide reports of incident interference ~~and therefore logical channel usability~~. Once a ~~logical~~ channel is deemed unusable due to prevailing interference that has surpassed a predetermined threshold or degraded the BER sufficiently, the BS may chose to move to a new ~~logical~~ channel. This new ~~logical~~ channel may be unmeasured or a member of a *backup* list of available ~~logical~~ channels previously measured by the BS or SSs. Depending on the ~~prevailing~~ air interface resources available for monitoring, the number of *backup* ~~logical~~ channels may vary. Also the 'freshness' of a channel (in terms of when the~~y~~ channel was~~ere~~ last measured and how accurate the measurement is likely to be) may also depend on available resources to accomplish this task. ~~In the same way t~~The previously interfered ~~logical~~ channel ~~previously~~that was vacated may be monitored for usability after some defined period. *Figure h2* (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.

A general example of a DCS solution is provided in *Figure h3* in which interference detection results in a channel change. ~~provides agility in frequency and time to reduce the effects of the incident interference.~~ *Figure h3* (a) indicates the events that occur following~~happen after~~ interference ~~is~~ detect~~ed~~ion at the BS. ~~Since the interference is deemed not to be an SSU, and therefore not protected by regulation, t~~The DCS algorithm ~~has the choice to either clear the channel (as would be required for the detection of an SSU) or find a less interfered area of the frame~~has a choice to either vacate the channel or overcome the interference by using a more robust modulation scheme. The DCD/UCD, containing the ExChNr (*6.4.1.2*), is used to make the channel change~~,~~

~~while the DL-MAP/UL-MAP provides a change of location in the frame~~. A similar procedure is followed for interference detection at the SS, illustrated in *Figure h3* (b), however in this case the REP-RSP, sent by the SS in an unsolicited manner, initializes the ~~messaging undertaken~~response by the BS.

The flowchart given in h1 (*6.4.2.2*) may be used to maintain a list of available backup channels for use in the event interference is detected on a channel and needs vacating due to high levels of interference.

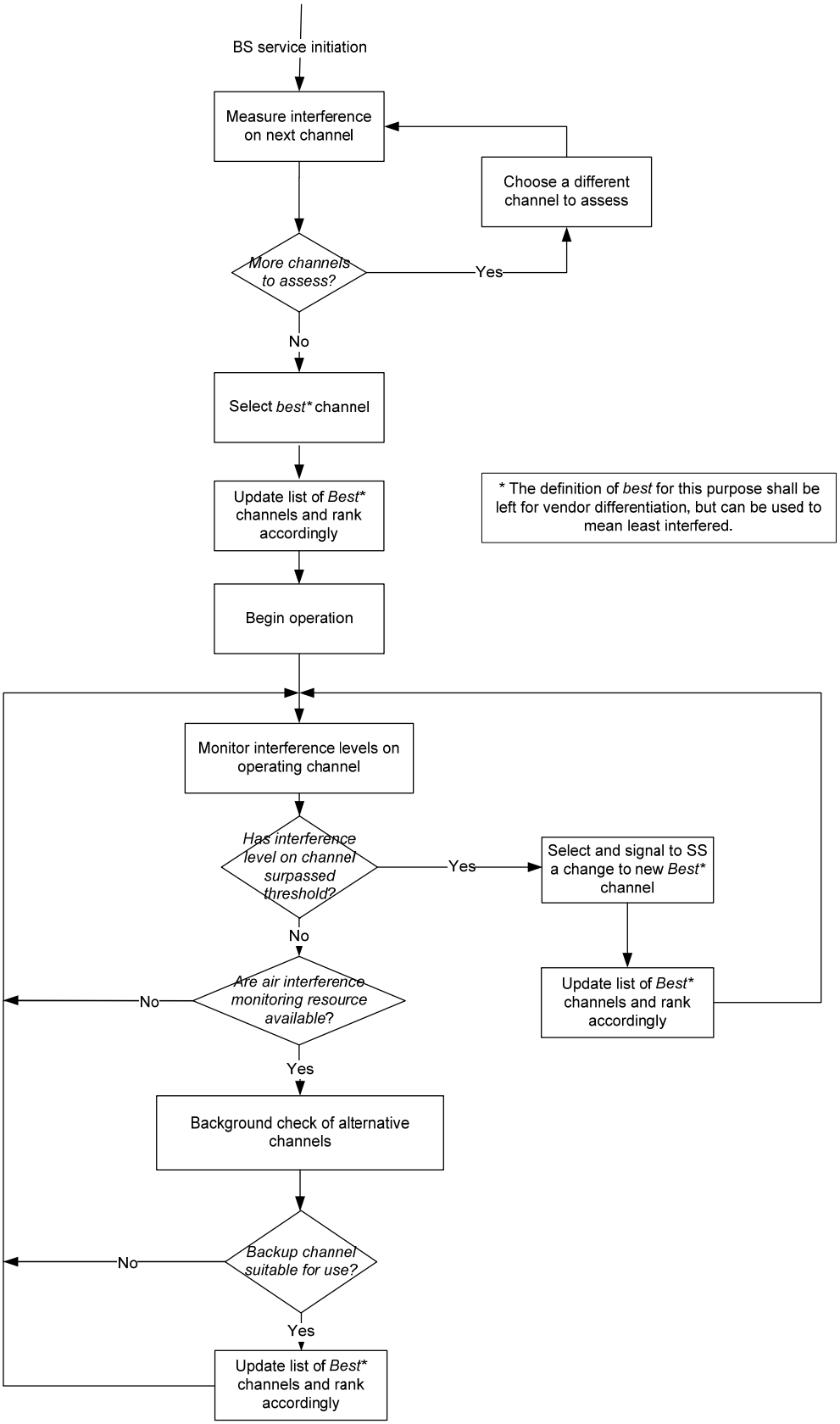

BS service initiation
Measure interference on next channel
Choose a different channel to assess
More channels to assess?
Yes
No
Select best* channel
Update list of Best* channels and rank accordingly
* The definition of best for this purpose shall be left for vendor differentiation, but can be used to mean least interfered.
Begin operation
Monitor interference levels on operating channel
Has interference level on channel surpassed threshold?
Yes
Select and signal to SS a change to new Best* channel
No
Are air interference monitoring resource available?
No
Update list of Best* channels and rank accordingly
Yes
Background check of alternative channels
Backup channel suitable for use?
No
Yes
Update list of Best* channels and rank accordingly

Figure hxyz2a Flowchart showing generic operation at the BS in bands with non-SSUs only

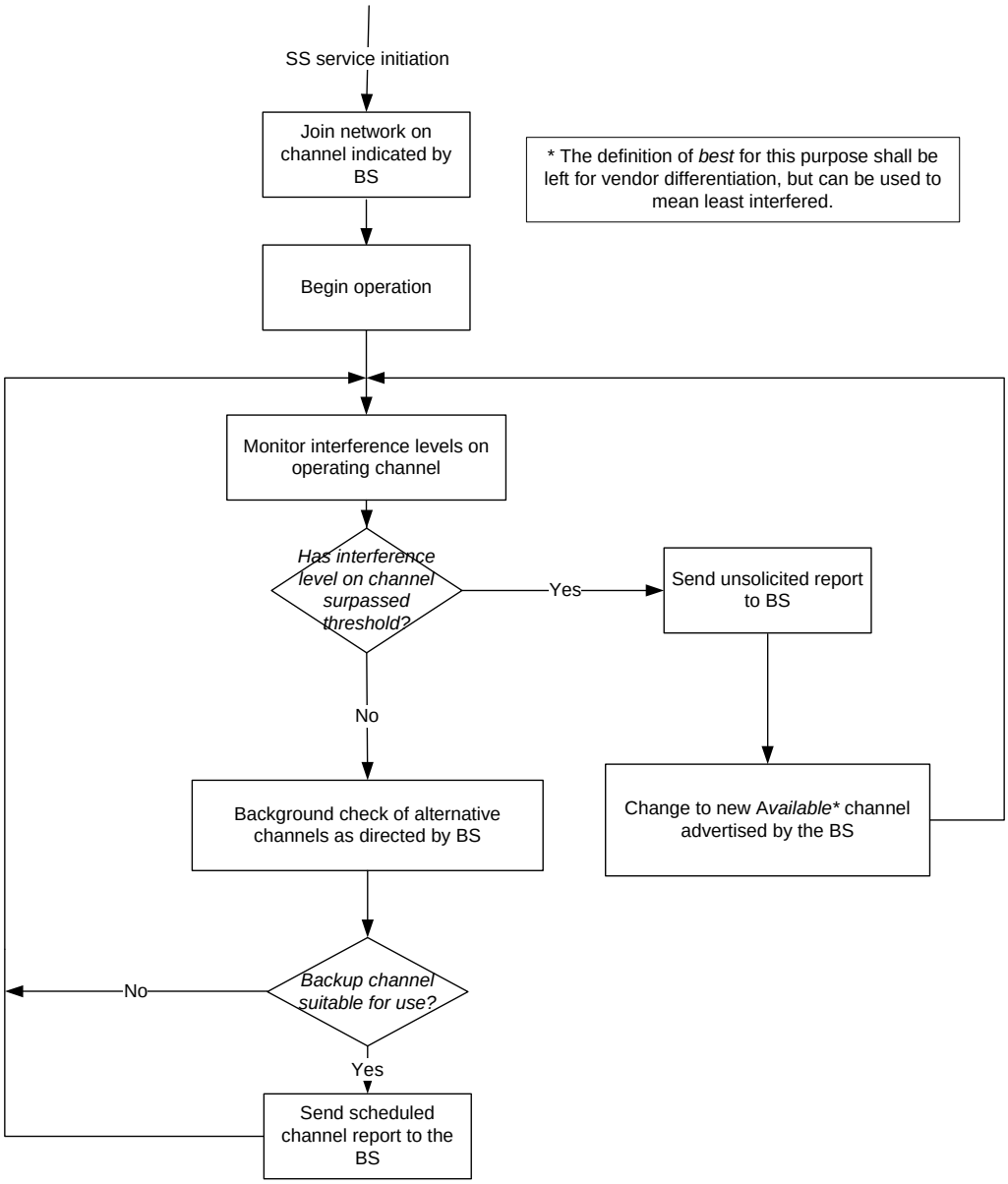
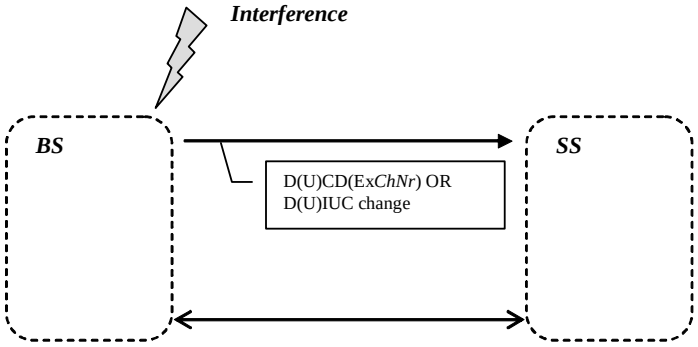


Figure hxyz2b Flowchart showing generic operation at the SS in bands with non-SSUs only

(a) Interference reporting and remedial action at the BS ***[Note: revised figures]***



(b) Interference reporting and remedial action at the ~~MS/~~SS ***[Note: revised figures]***

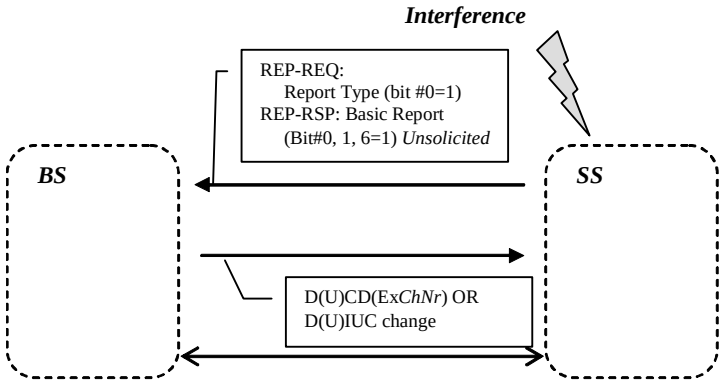


Figure h3—Link level representation of DCS operation

6.4.2.4 Uncoordinated Coexistence Protocol (UCP)

[Editor's note: The changes shown below in 6.4.2.4 amend that text accepted at Session #46 as resolved in contribution IEEE C80216h-06_108r3.]

The clause describes the use of an Uncoordinated Coexistence Protocol (UCP).

Upon system startup, the BS shall choose a suitable channel in which to operate. ~~perform DFS/DCS~~Channel selection will depend upon the requirements for operation in a given band.~~to choose the channel on which to operate. If the band has SSUs, the BS shall use DFS to find a channel free of SSUs. DCS shall be used to choose the *best* channel that not occupied by a SSU. The definition of *best* for this purpose shall be left for vendor differentiation.~~ 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 use the DCS protocol to find the *best* channel for operation; this protocol is described in sub clause 6.4.2.2. 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 eared 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, or shall ~~The BS shall implement~~ use ~~adaptive~~ aEQPs, as described in sub clause 6.4.3.3, to ensure other detected systems have an opportunity to transmit. ~~The BS shall require measurement and reporting from the SSs per the DFS/DCS protocol, and move to a better channel should one come available~~. Also i~~I~~f systems other than ~~other 802.16 systems and~~ SSUs are ~~may be~~ present in the channel, the BS shall use the listen-before-talk (LBT) protocol of sub clause 6.4.3.5 to avoid scheduling a frame when another system is transmitting on the channel. Flowcharts representing this operation are given in Figures hcup1 and hucp2 for the BS and SS respectively.

6.4.3 Support for uncoordinated coexistence

6.4.3.1 ~~Co-existence zone (CXZ) for downlink and uplink~~

~~The addition of a CXZ provides the means to include all co-existence enhancements in a defined region within the WirelessMAN-OFDMA PHY. It is expected that all co-existence operation will occur within this zone.~~

6.4.3.2 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 ~~tools~~ in ~~this~~ clause *6.4* or the coordinated coexistence mechanisms ~~tools~~ 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 ~~tools~~ in ~~this~~ 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).

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, they 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. For 802.11 coexistence, the quiet period duration should be chosen to allow ~~transmission of an entire~~ the maximum ~~length~~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. 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 h1*. 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 h1— 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

Table h1—

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_R~~r~~eporting ~~_requested~~ field indicates whether measurement and reporting on the channel should be performed during the EQP. If the Measurement_R~~r~~eporting ~~_requested~~ bit is set to 0, no automatic measurement and reporting is permitted~~requested~~. When Measurement_R~~r~~eporting~~it~~ is set to '1', then all SS will make measurement ~~as if commanded to~~ in order to create a Report Type 1.1, Bit#0 = 1, type 'Basic Report' in REP-REQ (*11.11*) if so required. ~~They~~ An SS will transmit a corresponding REP-RSP message if a measurement detected activity above the 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 ~~as it is for WirelessMAN-OFDMA based systems,~~ 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 4*. 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 ~~as is possible in some WirelessMAN modes~~. In this case the DL and UL subframes can be more closely associated with each other. This ~~will be~~ 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 5*.

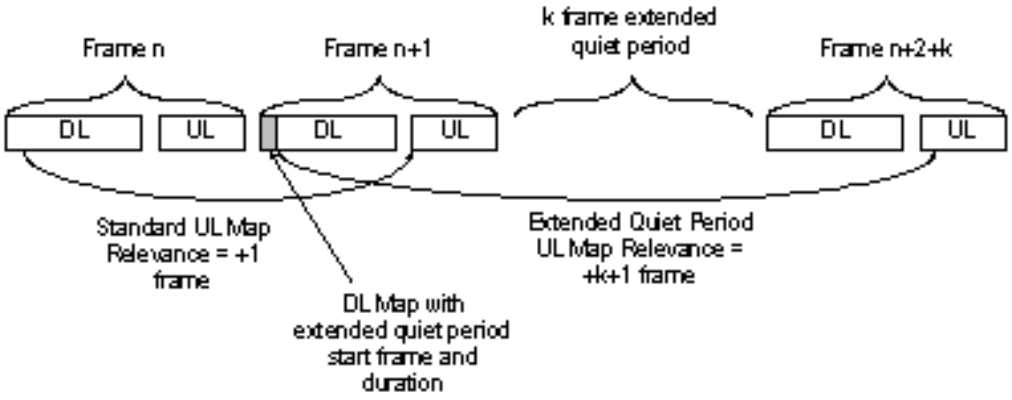


Figure h4—EQPs Map Relevance = n+1

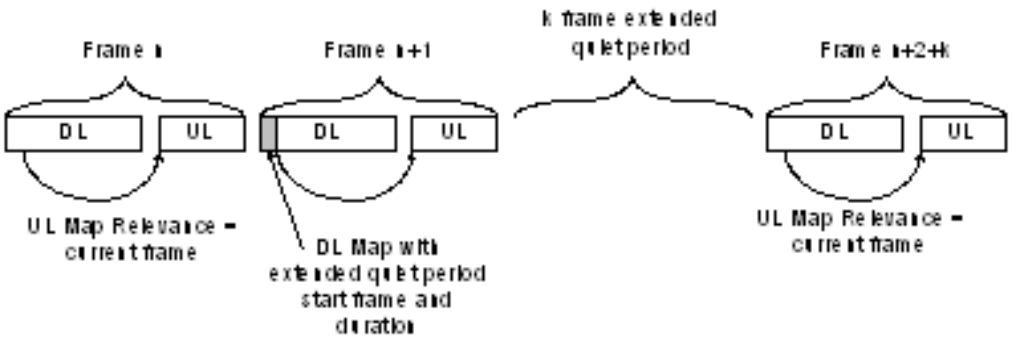


Figure h5—EQPs Map Relevance = n

6.4.3.4 Adaptive EQPs (aEQP)

There may be bands where there is a possibility of other users, but 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 (~~DFS/DCS~~see sub clause 6.4.2.4) scan and pick the best channel. 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 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 ~~DFS/~~DCS (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 ~~DFS/~~DCS (6.4.2.3.2) mechanism~~s~~. 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 6* using example parameters: share_duty_cycle = 50%, intermediate_duty_cycle = 75%, max_duty_cycle = 90%, and duty_cycle_step = 10%.

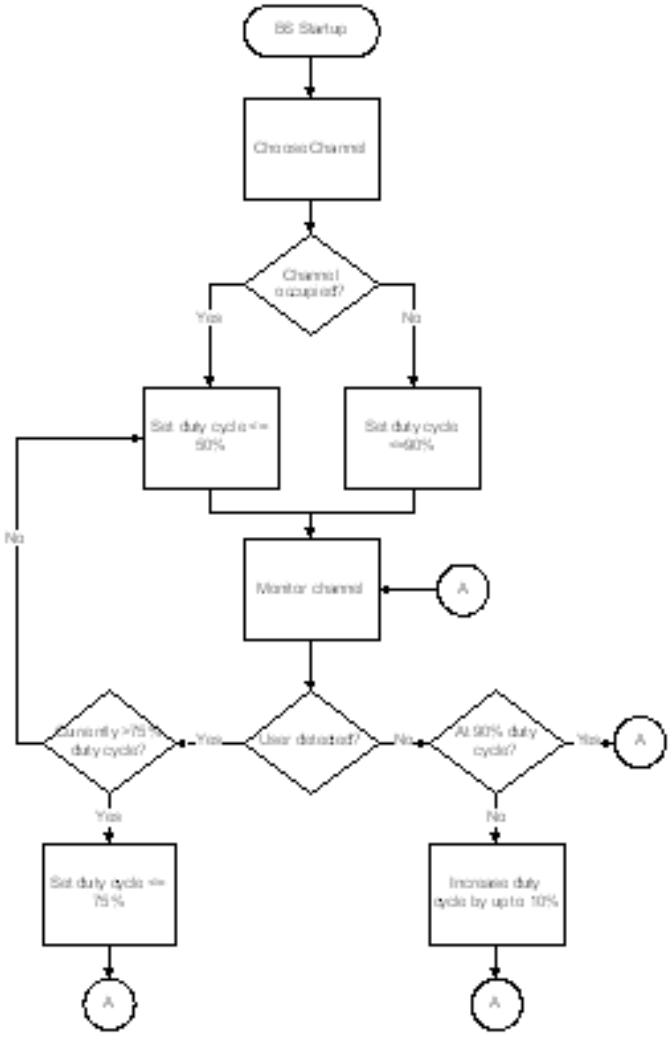


Figure h6—Adaptive EQP (with example parameter numbers)

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 ~~listen-before-talk~~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 allocate ~~the UL subframe such that a time period is reserved between the end of UL allocations and the start of the frame preamble for the next DL subframe as shown~~part of the DL subframe as an opportunity 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 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 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 7*. This time period shall be used to sense other non-802.16 systems and shall have at least the durations specified in *Table h 2*. The minimum LBT duration is determined from the CCA (Clear Channel Assessment) duration of 802.11. The actual LBT duration may be longer than these values based on the inter-frame behavior of 802.11 and the CCA requirements of different 802.11 variants. Specific implementation of this protocol is not specified and is left for vendor differentiation. Use of ~~listen-before-talk~~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.

Table h2—Minimum Listening Intervals

Channel Bandwidth	Minimum Listen-Before-Talk Duration
20 MHz	4 µ~~m~~s
10 MHz	8 µ~~m~~s
5 MHz	16 µ~~m~~s

Table h2—

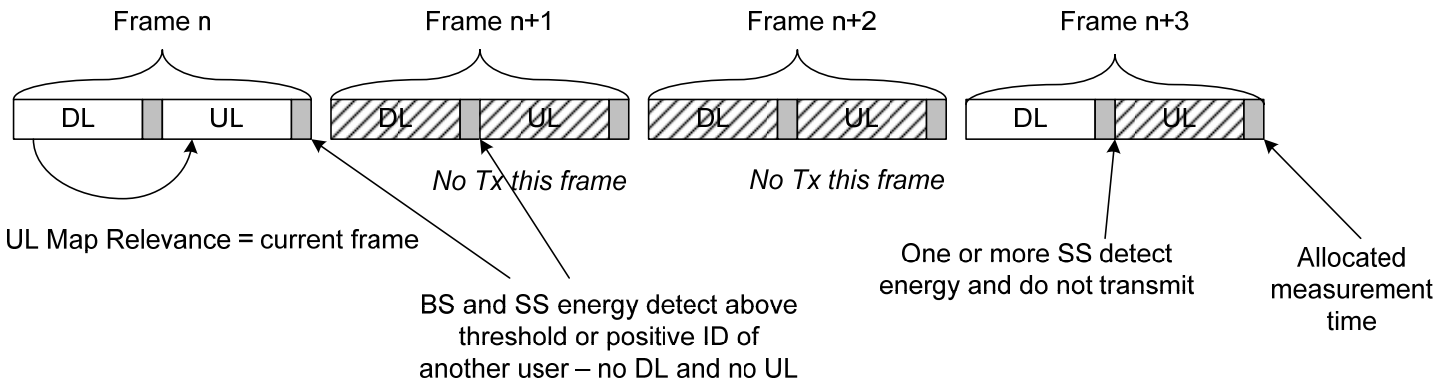


Figure h7—~~listen-before-talk~~LBT *[Note: revised figure]*

~ ~ ~

[Insert a new section 8.4.5.3.29:]

8.4.5.3.29 Extended Quiet Period (EQP) IE format

The start, on the next frame boundary, of an extended quiet period is signaled by using the extended DIUC=15 with the EQP_IE (0x09) in the extended DIUC field. The EQP_IE indicates that there will be no transmissions in either the DL or the UL, starting in the next frame and continuing for the specified number of frames after which normal transmission shall resume. When used, the CID in the DL-MAP_IE() shall be set to the broadcast CID.

Table 286ab—EQP IE

Syntax	Size	Notes
EQP_IE() {		
Extended DIUC	4 bits	EQP_IE = 0x0A
Length	4 bits	Length = 0x01
Measurement Reporting~~requested~~	1 bit	0 = ~~no measurement report required~~Measurement reporting disabled 1 = ~~measurement report required on detection~~Measurement reporting enabled Report is REP-REQ Report Type = 1.1, Bit #0=1 (Basic report)
Duration	7 bits	1-127 frames, 0 not valid
}		

Table 286ab—

~ ~ ~

15.1.2 Mechanisms in WirelessMAN-CX

Three basic mechanisms for achieving coexistence are:

— MAC Frame Synchronization, including Tx and Rx intervals, for separating BS and SS transmissions and enable operation in synchronized zones;

— ~~Adaptive~~ Dynamic C~~c~~hannel S~~s~~election (DCS), for finding a less interfered or less used frequency (6.4.2.3.2);

— Separation of the remaining interference in the time domain, by using coordinated scheduling and a fairness approach allows the usage of a frequency channel by more than one operator.

For inter-system communication, IP-level messages, MAC level messages and Cognitive Radio Signaling are defined at infrastructure and radio level.

Communication using IP-level messages is the most general case and is PHY independent. It allows distributed BS-BS communication as well as communication with a central database. The messages defined for such communication constitute the Coexistence Protocol.

The MAC-level messages are intended for systems using the same PHY profile. These messages may convey special information between the BS and its subscribers, or may send messages between systems. In the later case, the communication takes place during the Coexistence Messaging Interval.

The Cognitive Radio signaling uses elements of the existing PHY modes and allows simple communication between different systems. The radio signaling may be used to communicate with ad-hoc systems, or to indirectly transmit contact information for the IP network during the Coexistence Signaling Interval.

These simple signals are selected in such a way, to allow in the future the extension of these procedures for communication with other systems, not belonging to IEEE 802.16 family.

Different system parameters, including GPS coordinates and timing, may be shared between systems through distributed communication between Base Stations grouped in a Coexistence Community.

The level of interference and the interference source may be assessed using the Radio Signatures and the interferer identification procedures.

Interference-free sub-frames are initially created based on the selection of one of two possible rules and control of system power. The Coexistence Protocol includes procedures, which allow interference-free radio resource re-allocation. Some of these procedures use credit tokens and negotiations, such that the interference-free resources may be dynamically apportioned to support the changing character of the traffic.

The protocols and policies described in this chapter enable operation with reduced interference. The Coexistence Zone provides support at the MAC level for scheduling the interference-free sub-frames.

~~The following table shows a list of the coexistence mechanisms for WirelessMAN-CX. The mechanisms are classified with collaborative and non-collaborative. Collaborated means information exchanges between the systems in the mechanism, while non-collaborated means the systems do not exchange information in the mechanism:~~

Table h3—~~coexistence mechanism list for WirelessMAN-CX~~

~~Applicable~~	~~1: with wired IP communication available~~	~~Yes~~				~~No~~			
~~Condition~~	~~2: same PHY profile~~	~~Yes~~		~~No~~		~~Yes~~		~~No~~	
	~~3: in signaling/messaging range*~~	~~Y~~	~~N~~	~~Y~~	~~N~~	~~Y~~	~~N~~	~~Y~~	~~N~~
~~non-collaborative~~	~~*(CXCC:) dynamic frequency selection (DFS) (6.4.2.2)~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~
~~mechanism~~	~~*(CXCC:) GPS timing recovery (GPS/UTC) (15.2.1)~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~

	~~Extended quiet periods (EQP) (6.4.3.3)~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~
	~~Adaptive EQP (6.4.3.4)~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~
	~~Listen before talk (6.4.3.5)~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~
	~~Uncoordinated Coexistence Protocol (UCP) (6.4.2.4)~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~
~~**collaborative mechanism**~~	~~IP network message (CXP message) (15.5.2)~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~				
	~~coexistence proxy (CXPRX) (15.1.6)~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~				
	~~*(CXCC:) coexistence signaling (15.3.1) (CSI/ radio signature)~~	~~✓~~		~~✓~~		~~✓~~		~~✓~~	
	~~*(CXCC:) coexistence messaging (CMI/CCD) (15.3.2)~~	~~✓~~				~~✓~~			
	~~sub frame sharing (master sub frame) (15.4.2)~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~		~~✓~~	
	~~channel reallocation (ACS) (15.4.1)~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~		~~✓~~	
	~~Subframe Reallocation (ASFA) (15.4.2.2)~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~		~~✓~~	
	~~credit token (15.4.2.5)~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~				

~ ~ ~

To support the editorial changes in 6.4.3.5. Listen-Before-Talk (LBT) add the following subclause, and renumber as necessary.

8.4.5.3.30 Extended Channel Measurement IE format

An Extended IE with an extended DIUC value of 0x0C is issued by the BS to request a channel measurement report (). The IE includes a 16bit Extended Channel Number (ExChNr) value (6.4.1.2).

Table 286 Extended Channel Measurement IE

Syntax	Size	Notes
Extended_Channel_Measurement_IE() {		
Extended DIUC	4 bits	Extended_Channel_Measurement_IE = 0x0C
Length	4 bits	Length = 0x05
ExChNr	16 bits	Extended Channel Number (6.4.1.2)
OFDMA symbol offset	8 bits	
CID	16 bits	Basic CID of the SS for which the Extended Channel Measurement IE is directed
}		

Table 286ab—

~ ~ ~

[Insert the following rows to table 275a, section 8.4.5.3.2.1.]

Extended DIUC (hexadecimal)	Usage
0C	Extended_Channel_Measurement_IE
~~0C~~0D-0E	*reserved*

Annex 1

Comment 22:
Ken Stanwood

Clause: 6.4.3.3

Comment:
The duration of quiet periods in order to coexist with 802.11 systems turns out to be band specific.

Suggested Remedy:
On page 23, for the paragraph that starts on line 47. Change it as follows:

"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. For 802.11 coexistence, the quiet period duration should be chosen to allow ~~transmission of an entire~~ the maximum ~~length~~ duration 802.11 transmission allowed in the band. For 802.11y, this is 4 ms. For 802.11a, b, and g systems the maximum PHY PDU (PPDU) is determined using the 802.11 5.5 Mbit/s PHY mode. 802.11a 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 1. The number of integral frames required is a function of the chosen frame duration for the 802.16 system.

On page 23, line 56, change the table header:

Table h1 - Minimum EQP Durations for Coexistence with 802.11a, b, and g

Avi Freedman: How do we treat the 2.4GHz band? Should we refer to 802.11b/g at all?

Comment 114:
David Grandblaise

Clause: 6.4.2.1

Comment:

How the combination of schemes is done to ensure both SSU and non SSU coexistence when SSUs and non SSUs are in the same band?

Suggested Remedy:
Provide mechanisms for the combination

Avi Freedman: Isn't it what we are trying to do in the whole document?

Comment 116:
Avi Freedman

Clause: 6.4.2.2

Comment:
The coexistence mechanism described here should actually be implemented by both BS and SS. The diagram and the description miss the required operation when a "SSU" is detected by either the BS or SS. Namely the change to an alternative channel. In fact both BS and SS should scan the alternative channel constantly to ensure that the BS and any of the SS hasn't changed to that channel. If any SS or BS detect the interference they should immediately stop transmission, so they cannot notify any of the other parties about the change,

Suggested Remedy:
Correct the diagram to include scanning of the alternative channel and the hopping to the other channel.

AI Paul: add references in clause 15 concerning DFS and pointing to 6.4

Comment 117:
David Grandblaise

Clause: 6.4.2.2

Comment:
It is not mentioned whether the mechanisms of the flowchart are applicable to both UL and DL

Suggested Remedy:
Provide text to precise whether the mechanisms of the flowchart are applicable to both UL and DL

AI Paul: include the SS operation in the flow-chart

Comment 125:
Ken Stanwood

Clause: 6.4.2.2

Comment:
We should never get to the decision point "Channel Exclusion Period expired?" if the result would be false. The decision is in the wrong place in the flowchart. The timer can either be thought of as a separate parallel process (reality), or can be something that is periodically checked, in which case it should be part of the process of selecting a new channel in the box at the right-hand side around lines 46-48. Also, the starting of the channel exclusion period timer at line 36 is too simplistic because, as written, if any channel has an SSU detected then no channels are useable. Rather, there should be an independent exclusion timer for each channel on which an SSU is detected.

Suggested Remedy:
Fix the diagram to properly handle the exclusion timer. There are many ways to do this included what is described above.

Comment 127:
Achim Brandt

Clause: 6.4.2.3.1

Comment:
Any consideration for an non-fully occupied channel usage when initialization in the uncoordinated coexistence case?

Suggested Remedy:
Related scheme for non-fully occupied channel usage shall be added. See the corresponding contribution.

?

Comment 131:
Ken Stanwood

Clause: 6.4.2.3.2

Comment:
We need a true DCS mechanism - not a weakly hidden attempt at reiterating what's already in clause 15. That is to say, we need first a mechanism for choosing a physical channel. Once chosen, if a system wants to use the tools in clause 15 to time divide that physical channel into logical channels, it can. It was previously agreed that this section was to be combined with DFS (same thing, but SSU's). Instead, this section was expended to be redundant with the subframe concept of clause 15. This section should be rewritten appropriately.

Suggested Remedy:
Rewrite lines 24-61 to describe the process for finding a different physical channel as it was originally intended. Let clause 15 cover the additional concept of a logical channel.

Comment 133:
Avi Freedman

Clause: 6.4.2.3.2

Comment:
The system can also switch to a more robust profile and overcome the interference. Having too much agility will give 16h systems a disadvantage if they by policy will always vacate interfered channels.

Suggested Remedy:
Change:
"or find a less interfered area of the frame."
ti
", find a less interfered area of the frame or overcome the interference by using more robust means"

Comment 135:
Xuyong Wu

Clause: 6.4.2.4

Comment:
This section use "shall" all the time, which excludes the possibility to use coordinated mechanism.
6.4.2.4 Uncoordinated Coexistence Protocol (UCP)
The clause describes the use of an Uncoordinated Coexistence Protocol (UCP).

Upon system startup, the BS shall perform DFS/DCS to choose the channel on which to operate. If the band has SSUs, the BS shall use DFS to find a channel free of SSUs. DCS shall be used to choose the best channel that not occupied by a SSU. The definition of best for this purpose shall be left for vendor differentiation.
The BS shall implement adaptive EQPs as described in clause 6.4.3.3 to ensure other systems have an opportunity to transmit. The BS shall require measurement and reporting from the SSs per the DFS/DCS protocol, and move to a better channel should one come available.
If systems other than other 802.16 systems and SSUs may be present in the channel, the BS shall use the listen-before-talk protocol of 6.4.3.5 to avoid scheduling a frame when another system is transmitting on the channel.

Suggested Remedy:
Modify the expression following the conclusion of 16h- mandatory ad-hoc.
And check all the text within draft following the ad hoc resolution.

Comment 139:
David Grandblaise

Clause: 6.4.2.4

Comment:
The term "other systems" is vague

Suggested Remedy:
Specify what is heard by the "other systems" (SSU and non SSU?)

Comment 553:
Aik Chindapol

Clause: 6.4.2.4

Comment:
It is not clear of a mechanism to ensure that a station gets a transmission opportunity after EQP?

Suggested Remedy:
Accept solutions as specified in IEEE C802.16h-06/108

Comment 141:
Maximilian Riegel

Clause: 6.4.3.1

Comment:
What is the specific usage of CXZ support for uncoordinated coexistence?

Suggested Remedy:
Clarify in draft what kind of info should be carried in this field for uncoordinated coexistence for easy reading. If the CXZ are not used here, please delete the related section

Comment 146:
David Grandblaise

Clause: 6.4.3.2

Comment:

"any" is vague

Suggested Remedy:
Provide what "any" references to (DCS, UCP ?)

Comment 147:
Mariana Goldhamer

Clause: 6.4.3.3

Comment:
There is no clear explanation regarding:

- how are supported the existing 802.16 OFDM and OFDMA MAC Frame durations
- how to avoid the violation of the 802.16 MAC Frame structure
- how an existing SS will sync if a number of MAC sub-frames are skipped

Suggested Remedy:
Introduce the explications or remove the clause 6.4.3.3 and the related text

Comment 149:
David Grandblaise

Clause: 6.4.3.4

Comment:
"the probability is low" might be band specific ! ?

Suggested Remedy:
Specify to which case "the probability is low" is applicable

Comment 151:
Mariana Goldhamer

Clause: 6.4.3.5

Comment:
The proposed mechanism violates the OFDM and OFDMA Frame structure, by introducing silence periods at and eliminating preambles, FCH, MAPs etc.

The proposed mechanism violates the coexistence rules established between 802.16h users, as the interference-free periods provided by the Master sub-frames

Suggested Remedy:
The usage of this mechanisms needs more added rules to make sure that the 802.16 basic standard functionality is not violated

The usage of this mechanism needs more rules, such to not violate the existing 802.16h CX rules, based on the requirements in 15.1.5.1

If such rules will not be added, delete clause 6.4.3.5 and the related text

Avi Freedman: 802.16 SS's should be capable of recovering the BS transmission after losing it between frames. Especially in a synchronized environemnt, which we sugget here. However there are more implications that should be taken into account, the more important of which is to harmonize it with the CXCC

Comment 157:
Gaspare Licitra

Clause: 8.4.5.3.29

Comment:
No measurement report period defined in EQP IE, while the reports may be needed periodically in EQP.

Suggested Remedy:
Suggest to add a field to indicate the report period

Comment 196:
Ken Stanwood

Clause: 15.1.2

Comment:
Adaptive channel selection is just DFS/DCS from clause 6.4. There is no need to redefine the term here.

Suggested Remedy:
Change "adaptive channel selection" to "dynamic channel selection" here and throughout the document. Delete redundant definitions.

Comment 222:
David Grandblaise

Clause: 15.1.3.1

Comment:
The box "Perform DCS" could also support UCP

Suggested Remedy:
Update the content of the box with "Perform DCS or UCP"

Comment 233:
Xuyong Wu

Clause: 15.1.3.2

Comment:
Initialization procedure of the SS is very complex in the coexistence situation, this section is the only part of the draft talking about SS initialization.
To make a SS able to enter the network in coexistence condition is very challenging issue, and need absolutely carefully consideration.
Also see contribution C802.16h-06_113 for illustration on the issue.

Suggested Remedy:
1)Study carefully on all the possible interference situation of the SS, similiar as ANNEX B within the D1 document.
2) Figure out the resolution for these circumstance.

3) Provide all the necessary solution into the document.
4) Summarize these into 15.1.3.2.
5) Refer 15.1.3.2 in 6.3.9.

References

[1] IEEE P802.16h/D1: Air Interface for Fixed Broadband Wireless Access Systems Improved Coexistence Mechanisms for License-Exempt Operation, Draft Standard.

[2] IEEE 80216h-06_068r2: Letter Ballot #24 Commentary file with resolutions from Session #46.