IEEE P802.11
Wireless LANs

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| Resolutions for the CCA zoo in 11mc/D4.0 (SBmc1) |
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Abstract

CID 6305 et al.

|  |  |  |
| --- | --- | --- |
| Identifiers | Comment | Proposed change |
| CID 6129Michael Fischer3.112.35 | "Carrier sense" is not defined herein | Either change "carrier sense (CS)" to "clear channel assessment (CCA)" or provide a definition for "carrier sense (CS)" |
| CID 6214Mark RISON | There are references to "physical carrier sense", "virtual carrier sense" and "physical CS" and "virtual CS" but the terms are never defined | Define the terms. Arguably, virtual CS is defined at 1247.61 (though why it is "referred to as the NAV" is unclear -- or maybe virtual CS also includes considering the medium busy for the duration indicated in a received PPDU header?), but physical CS is not well-defined. 1247.57 says each PHY provides the details, but the term is only used at 2280.45 and merely reflects back to the PHY. Something needs to tie "physical CS" with the zoo of CS/CCA/energy detect/ED/blahblahblahPHYwibblings terminology used in each PHY |
| CID 6215Mark RISON | Use "CS" rather than "carrier sense" except when defined etc. | Use "CS" rather than "carrier sense" at 74.14, 833.8, 1239.15, 1664.39, 1664.40, 3187.59 (2x), 860.43, 864.52, 1378.5, 1679.57, 2184.52, 2437.59 |
| CID 6216Mark RISON | The terms PHYCS and PHYED are defined but barely used | Delete them from subclause 3.4 and replace them in the other locations with their full-fat equivalents, i.e. physical CS and physical ED (4 instances each) |
| CID 6302Mark RISON | "is being received at the antenna" -- PPDUs can't be received anywhere else | Delete "at the antenna" in both instances of the cited text |
| CID 6303Mark RISON17.3.8.52227.34 | It says "the timer of CCA Mode 2 shall be overridden by this requirement." but there is no timer in CCA Mode 2 (in fact, there is no CCA Mode 2 in HR/DSSS) | Change "2" to "4" in the cited text |
| CID 6305Mark RISON | There is a zoo of inconsistent terminology for "carrier sense", whch makes it hard to understand exactly what is meant where and how the various PHYs compare: CS, CCA, CS/CCA, energy detect, ED, PHYED, CCA-ED, CCA Mode 1-5 | First rename CCA-ED to PHYRED (regulatory ED). Then call the ED which everybody uses PHYED, and the preamble detect PHYPD. Call the combination of things which yield the PHY part of "carrier sense" PHYCS. Kill the terms CS, CCA, CS/CCA, CCA Mode, ED. Make it clear how "I'm currently transmitting" fits into "carrier sense", and whether "I've received the PPDU header so I know how long to consider the medium busy even though the energy has gone away" is considered part of PHYCS or part of MACCS/virtual CS |
| CID 6306Mark RISON | "CCA-ED" just confuses everyone, because everyone thinks it means CCA using ED, when in fact it means some wacko mode of operation in wacky regulatory domains/bands | Rename CCA-ED to something more obscure, so that people can use this term for the CCA-ED which is actually used in practice |

Discussion:

[Work in progress!]

Whereas:

1. CS (as in “CSMA/CA”) consists of the following, where any causes the medium to be considered busy (1248.9: “The CS mechanism combines the NAV state and the STA’s transmitter status with physical CS to determine the busy/idle state of the medium”):
	1. NAV
		1. The network allocation vector, set by Duration fields (1247.61: “A virtual CS mechanism shall be provided by the MAC. This mechanism is referred to as the NAV.”)
	2. Local tx in progress
		1. Delineated by PHY-TXSTART.request and PHY-TXEND.request
	3. CCA
		1. Delineated by PHY-CCA.indication (BUSY) and PHY-CCA.indication (IDLE) (1247.56: “A physical CS mechanism shall be provided by the PHY. See Clause 7 (PHY service specification) for how this information is conveyed to the MAC. The details of physical CS are provided in the individual PHY specifications.”)
2. CCA consists of one or more of the following (depending on the PHY and in some cases on the CCA mode), where any causes the medium to be indicated as busy (via PHY-CCA.indication):
	1. CCA-ED is energy detect
		1. This is typically at 20 dB above the sensitivity
	2. CCA-PD is PPDU detect (which holds CCA busy for the duration indicated in the PPDU header)
		1. L-SIG TXOP protection relies on this
		2. Note PHY-RXSTART.indication and PHY-RXEND.indication are independent of this (e.g. carrier might be lost before the end of the PPDU as indicated in the PPDU header)
	3. CCA-SD is signal detect (i.e. detection of symbols generated by a particular PHY)
		1. Note some modes (e.g. “CCA mode 3” for DSSS) have an energy threshold too
		2. Note some modes (e.g. “CCA mode 4” for HR/DSSS) have a timer too
	4. CCA-RED is regulatory energy detect (only applicable to the 3G6 band in the FCC regulatory domain)
	5. CCA-SCSD is signal detect on a non-primary channel (only applicable to the VHT and TVHT PHYs)

This is illustrated graphically in the following figure (I am grateful to Guido HIERTZ for the starting design):



Here is the zoo of existing terminology, and how it maps to the terminology above:

|  |  |  |
| --- | --- | --- |
| Term | Location | Meaning |
| virtual CS mechanismvirtual carrier sense mechanismvirtual carrier sense (CS) mechanismvirtual carrier sensevirtual CSvirtual CS indicationvirtual CS condition | 25.28, 74.14, 1239.15 (obsolete – PCF), 1243.14, 1243.17, 1246.21, 1246.24, 1247.5, 1247.33, 1247.61, 1248.11, 1248.14, 1252.39, 1270.34, 1271.32, 1358.25, 1358.28, 1665.14, 2276.35, 2977.53 | NAV [only] |
| physical or virtual carrier sense(CS) mechanismphysical or virtual CS mechanismphysical or virtual CSPHY and virtual CS mechanismsthe virtual carrier sense mechanism orthe physical carrier sense mechanismPhysical and virtual CS functionsthe CS function provided by the PHY, the virtual CS function provided by the MAC via the NAVthe NAV and physical CS | 833.8, 1247.52, 1252.48, 1268.8, 1323.24, 1327.36, 1358.24, 1358.30, 1664.39, 1700.43, 3187.59 | CS mechanism [including “local tx”] |
| physical CS mechanismphysical carrier sense mechanismphysical CS | 1247.56, 1247.57, 1248.9, 1271.4, 1271.13, 1324.54, 2280.45 | CCA |
| carrier sense mechanismcarrier-sense mechanism [hyphen sic]“CS mechanism” [quotes sic] | 860.43, 864.52, 1378.5, 1679.57, 2280.44 | CS mechanism |
| CS function | 9 instances | CS mechanism |
| CS | 1398.21 | CS mechanism |
| PHYCSPHY carrier sense (PHYCS) | 56.64, 2184.52, 2184.56, 2211.28, 2211.30 | CCA-PD |
| PHYEDPHY energy detection (PHYED) | 57.1, 2184.53, 2184.56, 2211.28, 2211.30 | CCA-ED |
| PHY CS/CCACS/CCAcarrier sense/clear channel assessment (CS/CCA)CCA/CS | 551.36, 2185.13, 2212.7, 2264.32 (better to reword to include next sentence too, i.e. say something like “including CCA-RED, for operating classes requiring this”), 2264.39, 2264.44, 2264.45, 2264.47, 2269.10, 2271.4, 2373.13, 2374.1, 2375.4, 2375.37, 2376.53, 2445.7, 2447.5, 2562.2, 2563.3, 3353.22, 3355.16 | CCA |
| CS/CCA | 3351.57 (delete the item immediately above) | CCA including CCA-RED |
| code lock | 2176.8 (2x) | CCA-SD? |
| IEEE Std 802.11 DSSS correlation | 2687.60 | DSSS PPDU detection |
| CShigh rate CS | 2717.24, 2717.26 | DSSS and HR/DSSS PPDU detection |
| CS | 2722.36 | DSSS, HR/DSSS and ERP PPDU detection |
| carrier sense | 3197.37, 3197.38, 3197.61, 3197.62, 3197.63, 3197.64, 3206.59, 3206.60, 3206.61, 3206.62 | PPDU detection |
| energy detection (ED) and/or code lockED and/or code lock | 2183.61, 2209.61 | CCA-ED and/or CCA-SD? |
| energy detectenergyEnergyEnergy DetectionCCA-ED energy | 2190.18, 2220.47, 2265.4, 2554.3, 2628.56, 2687.58, 2697.23, 2717.22, 2717.26, 2722.35, 3198.11 (also lowercase “Threshold”), 3205.35 (ditto) | ED |
| energy detect | 3197.36, 3197.38, 3197.60, 3197.62, 3197.64, 3206.58, 3206.60, 3206.62 | energy detection |
| energy detect or CS | 2196.18, 2227.19 | energy or signal detection |
| CCA-Energy Detect (CCA-ED)CCA-ED [sometimes followed without space “Behavior” appended; this should be preserved]CCA-Energy DetectCCA-EnergyDetect | 2264.33 (+many others in this subclause), 2265.5, 2368.25 (+5 in next para), 2553.48 (+in subclause heading and many others in the subclause), 2627.59 (+in subclause heading and many others in the subclause), 2697.19, 3205.7 (also rename MIB variable + change “that” to “whether”), 3205.20 (ditto; also either delete “PHY” or prepend “OFDM”), 3205.35, 3332.13, 3336.5, 3336.8, 3339.36, 3339.38, 3339.40, 3347.11, 3347.12, 3347.15, 3351.56, 3351.63 | CCA-RED |

Adrian STEPHENS notes that IEEE Std 100 defines “carrier sense” as: “In a local area network, an ongoing activity of a data station to detect whether another station is transmitting.”

MIB changes also required:

dot11EDThreshold: should be stated to be in dBm with a UNITS, have a sensible range.

dot11TIThreshold: should be deleted from C18 and C20 (no apparent connection to anything (TI?)).

dot11OFDMEDThreshold: should be renamed to be dot11OFDMREDThreshold, be stated to be in dBm with a UNITS, have a sensible range, and have a DEFVAL of -72.

2227.5/6: “a high rate PHY signal”; 2227.22: “a valid high rate signal”; 2227.10: “a high rate PPDU” – all these include a DSSS signal, right? Note also 2227.37: “an equivalent High-Rate signal” [sic]

Make “The 3.65 ms timeout is the duration of the longest possible 5.5 Mb/s PSDU” in 17.3.8.5 a NOTE. Make the CCA wording consistent (at least for DSSS, HR/DSSS and ERP) [ERP]. What does the “only” in “report a medium busy condition only upon the detection of a high rate PHY signal” mean? Either have “at the antenna” everywhere or nowhere, and if present, make it say “at the antenna connector”. What does the “true” in “The CCA shall indicate true” [ERP] mean? Make sure everywhere includes aCCATime (except maybe (HR/)DSSS since this has grotesque preambles). “IDLE medium” should be “medium idle condition”. “is present at the start of the PHY slot” [ERP] – the PHY does not have slots, and the only requirement is to detect within aCCATime.

Do we have consensus that DSSS symbol detection is required for CCA Modes 2 and 3, but that only HR/DSSS PPDU (preamble+header) detection is required for CCA Modes 4 and 5?

Proposed changes:

Make the following changes:

**9.3.2.1 CS mechanism**

~~Physical and virtual CS~~PHY-based and MAC-based functions are used to determine the state of the medium (see Figure 9-x). ~~When either function indicates a busy medium, the medium shall be considered busy; otherwise, it shall be considered idle.~~



**Figure 9-x—The CS mechanism**

~~A physical CS mechanism shall be provided by the PHY.~~ The PHY-based function is referred to as CCA. See Clause 7 (PHY service specification) for how ~~this~~ CCA information is ~~conveyed~~indicated to the MAC. The details of ~~physical CS~~CCA are provided in the individual PHY specifications; CCA involves one or more of PPDU detection (CCA-PD), symbol detection (CCA-SD), energy detection (CCA-ED), symbol detection on a secondary channel (CCA-SCSD) and regulatory energy detection (CCA-RED).

~~A virtual CS mechanism shall be provided by the MAC. This mechanism~~ One component of the MAC-based function is referred to as the NAV. The NAV maintains a prediction of future traffic on the medium based on duration information that is announced in RTS/CTS frames by non-DMG STAs and RTS/DMG CTS frames by DMG STAs prior to the actual exchange of data. The duration information is also available in the MAC headers of all frames sent during the CP other than PS-Poll frames, and during the BTI, the A-BFT, the ATI, the CBAP, and the SP. The mechanism for setting the NAV using RTS/CTS or RTS/DMG CTS in the DCF is described in 9.3.2.4 (Setting and resetting the NAV), use of the NAV in PCF is described in 9.4.3.3 (NAV operation during the CFP), and the use of the NAV in HCF is described in 9.22.2.2 (EDCA backoff procedure) and 9.22.3.4 (NAV operation of a TXOP under HCCA). Additional details regarding NAV usage and update appear in 9.3.2.5 (RTS/CTS with fragmentation), 9.3.2.13 (NAV distribution), 9.36.10 (Updating multiple NAV timers), and 9.26 (Protection mechanisms). The NAV may be thought of as a counter, which counts down to 0 at a uniform rate. When the counter is 0, the indication is that the medium is idle; when the counter is nonzero, the indication is that it is busy. If a DMG STA supports multiple NAV timers as defined in 9.36.10 (Updating multiple NAV timers) and all counters are 0, the indication is that the medium is idle; when at least one of the counters is nonzero, the indication is that it is busy.

The other component of the MAC-based function is the STA’s transmitter status, as delineated by PHY‑TXSTART.request and PHY‑TXEND.confirm primitives (see Clause 7). If the STA is transmitting, the indication is that the medium is busy; otherwise the indication is that it is idle.

The CS mechanism combines the NAV ~~state~~ indication ~~and~~, the ~~STA’s~~ transmitter status indication ~~with~~, and ~~physical CS~~the CCA indication to determine the busy/idle state of the medium. When any of these indicates busy, the medium shall be considered busy; otherwise, it shall be considered idle. ~~The NAV may be thought of as a counter, which counts down to 0 at a uniform rate. When the counter is 0, the virtual CS indication is that the medium is idle; when the counter is nonzero, the indication is busy. If a DMG STA supports multiple NAV timers as defined in 9.36.10 (Updating multiple NAV timers) and all counters are 0, the virtual CS indication is that the medium is idle; when at least one of the counters is nonzero, the indication is busy. The medium shall be determined to be busy when the STA is transmitting.~~

At aRxTxTurnaroundTime + AirDelay + aRxPHYDelay + 10% of aSlotTime after each MAC slot boundary as defined in 9.3.7 (DCF timing relations) and 9.22.2.4 (Obtaining an EDCA TXOP), the MAC shall issue a PHY-CCARESET.request primitive to the PHY, where AirDelay is aAirPropagationTime indicated in the Coverage Class field of the Country element received from the AP of the BSS with which the STA is associated or the DO of the IBSS of which the STA is a member or from another mesh STA in the same MBSS, or if no Country element has been received from the AP of the BSS with which the STA is associated, the value of aAirPropagationTime indicated in the PLME-CHARACTERISTICS.confirm primitive.

**9.2.4.3 HCF controlled channel access (HCCA)**

*[…]*

The HCF protects the transmissions during each CAP using the ~~virtual CS mechanism~~NAV.

A STA may initiate multiple frame exchange sequences during a polled TXOP of sufficient duration to perform more than one such sequence. The use of ~~virtual CS~~the NAV by the HC provides improved protection of the CFP, in addition to the protection provided by having all STAs in the BSA setting their NAVs to dot11CFPMaxDuration at the target beacon transmission time (TBTT) of DTIM Beacon frames.

**9.3 DCF**

**9.3.1 General**

*[…]*

The CSMA/CA protocol is designed to reduce the collision probability between multiple STAs accessing a medium, at the point where collisions would most likely occur. Just after the medium becomes idle following a busy medium (as indicated by the CS ~~function~~mechanism) is when the highest probability of a collision exists. This is because multiple STAs could have been waiting for the medium to become available again. This is the situation that necessitates a random backoff procedure to resolve medium contention conflicts.

*[…]*

The CS ~~function~~mechanism of a DMG STA might not indicate the medium busy condition due to the predominant nature of directional transmissions and receptions. The transmission of a STA might interfere (collide) with the transmission of another STA even though the CS ~~function~~mechanism at the first STA does not indicate medium busy. The interference (collision) is identified when the expected response frame is not received. SPSH is achieved by the proper combination of the STA antenna configuration during the media access and data transfer phases.

CS shall be performed ~~both~~ through ~~physical and virtual~~both PHY-based and MAC-based mechanisms.

The ~~virtual CS~~MAC-based mechanism is achieved by distributing reservation information announcing the impending use of the medium. The exchange of RTS and CTS frames prior to the actual Data frame is one means of distribution of this medium reservation information. The RTS and CTS frames contain a Duration field that defines the period of time that the medium is to be reserved to transmit the actual Data frame and the returning Ack frame. A STA receiving either the RTS frame (sent by the originating STA) or the CTS frame (sent by the destination STA) shall process the medium reservation. Thus, a STA might be unable to receive from the originating STA and yet still know about the impending use of the medium to transmit a Data frame.

*[…]*

NOTE—A STA configured not to initiate the RTS/CTS mechanism updates its ~~virtual CS mechanism~~NAV with the duration information contained in a received RTS or CTS frame, and responds to an RTS frame addressed to it with a CTS frame if permitted by medium access rules.

*[…]*

To support the proper operation of the RTS/CTS by non-DMG STAs, RTS/DMG CTS by DMG STAs, and the ~~virtual CS mechanism~~NAV, a non-DMG STA shall be able to interpret Control frames with the Subtype field equal to RTS or CTS, and a DMG STA shall be able to interpret Control frames with the Subtype field equal to RTS or DMG CTS.

**9.3.2.3.1 General**

The time interval between frames is called the IFS. A STA shall determine that the medium is idle through the use of the CS ~~function~~mechanism for the interval specified. Ten different IFSs are defined to provide priority levels for access to the wireless medium. Figure 9-4 (Some IFS relationships) shows some of these relationships. All timings are referenced from occurrence of the PHY interface primitives PHY-TXEND.confirm, PHY-TXSTART.confirm, PHY-RXSTART.indication, and PHY-RXEND.indication.

**9.3.2.3.7 EIFS**

A DCF shall use EIFS before transmission, when it determines that the medium is idle following reception of a frame for which the PHY-RXEND.indication primitive contained an error or a frame for which the MAC FCS value was not correct. Similarly, a STA’s EDCA mechanism under HCF shall use the EIFS-DIFS+AIFS[AC] interval. The duration of an EIFS is defined in 9.3.7 (DCF timing relations). The EIFS or EIFS-DIFS+AIFS[AC] interval shall begin following indication by the PHY that the medium is idle after detection of the erroneous frame, without regard to the ~~virtual CS mechanism~~NAV. The STA shall not begin a transmission until the expiration of the later of the NAV and EIFS or EIFS-DIFS+AIFS[AC]. The EIFS and EIFS-DIFS+AIFS[AC] are defined to provide enough time for another STA to acknowledge what was, to this STA, an incorrectly received frame before this STA commences transmission. Reception of an error-free frame during the EIFS or EIFS-DIFS+AIFS[AC] resynchronizes the STA to the actual busy/idle state of the medium, so the EIFS or EIFS-DIFS+AIFS[AC] is terminated and medium access (using DIFS or AIFS as appropriate and, if necessary, backoff) continues following reception of that frame. At the expiration or termination of the EIFS or EIFS-DIFS+AIFS[AC], the STA reverts to the ~~NAV and physical~~ CS mechanism to control access to the medium.

**9.3.4.3 Backoff procedure for DCF**

This subclause describes backoff procedure that is to be invoked when DCF is used. For the backoff procedure when EDCA is used, see 9.22.2.10 (Retransmit procedures).

A STA shall invoke the backoff procedure to transfer a frame when finding the medium busy as indicated by ~~either~~ the ~~physical or virtual~~ CS mechanism (see Figure 9-15 (Backoff procedure)). A transmitting STA shall invoke the backoff procedure when the STA infers a failed transmission as defined in 9.3.2.7 (CTS and DMG CTS procedure) or 9.3.2.9 (Ack procedure).

[Figure 9-17 on page 1270 has “Virtual CS=busy” and “CS=busy”? Do these both refer to NAV only? The text below, in fact, suggests the first is the CS mechanism in general, but the latter is just CCA. (I have no idea why this stuff is buried in a subclause about the DCF anyway.)]

STA B receives the frame transmitted by STA A (to STA E), and the CS mechanism ~~(physical and virtual)~~ in STA B indicates a busy medium during the exchange between STA A and STA E.

STA D is not able to receive the frame transmitted by STA A or the response transmitted by STA E; hence the CS mechanism in STA D indicates ~~IDLE~~idle for the duration of the exchange between STA A and STA E.

The ~~physical CS function~~CCA of STA C indicates a medium busy condition when it receives the response sent by STA E, but indicates an idle medium condition during the transmission from STA A.

STA A and STA E (which are directly involved in the frame exchange), STA B (which received the frame sent by STA A), and STA C (which received the response sent by STA E) are synchronized at point A, where the transaction between STA A and STA E completes.

Since STA D cannot hear the directional transmissions from either STA A or STA C, its ~~physical CS~~CCA indicates an idle medium condition for the duration of the frame exchange, enabling a frame exchange with STA B at the same time as the frame exchange between STA A and STA E. This is an example of SPSH.

Because STA C is unaware of the transmission of the frame from STA A to STA E, STA C transmits an RTS to STA B. But STA C does not receive a DMG CTS from STA B since the CS mechanism at STA B ~~is~~indicates busy when STA B receives the RTS from the STA C. This causes STA C to retry the RTS transmission following the expiration of a backoff count, which occurs after the completion of the exchange between STA A and STA E.

**9.3.4.4 Recovery procedures and retransmit limits**

Under DCF, error recovery is always the responsibility of the STA that initiates a frame exchange sequence (described in Annex G). Many circumstances may cause an error to occur that requires recovery. For example, the CTS frame might not be returned after an RTS frame is transmitted. This may happen due to a collision with another transmission, due to interference in the channel during the RTS or CTS frame, or because the STA receiving the RTS frame has a NAV~~n active virtual CS condition~~ ~~(~~indicating a busy medium ~~time period)~~.

**9.22.2.2 EDCA backoff procedure**

*[…]*

The backoff procedure shall be invoked by an EDCAF when any of the following events occurs:

a) An MA-UNITDATA.request primitive is received that causes a frame with that AC to be queued for transmission such that one of the transmit queues associated with that AC has now become non-empty and any other transmit queues associated with that AC are empty, the medium is busy on the primary channel as indicated by ~~either physical or virtual~~the CS mechanism, and the backoff timer has a value of 0 for that AC.

**9.22.2.4 Obtaining an EDCA TXOP**

*[…]*

EDCAF operations shall be performed at slot boundaries, defined as follows on the primary channel, for each EDCAF:

a) Following AIFSN[AC] × aSlotTime – aRxTxTurnaroundTime of idle medium after SIFS (not necessarily idle medium during the SIFS) after the last busy medium on the antenna that was the result of a reception of a frame with a correct FCS.

b) Following EIFS – DIFS + AIFSN[AC] × aSlotTime + aSIFSTime – aRxTxTurnaroundTime of idle medium after the last indicated busy medium as determined by ~~the physical CS mechanism~~CCA that was the result of a frame reception that has resulted in FCS error, or PHY-RXEND.indication (RXERROR) primitive where the value of RXERROR is not NoError.

*[…]*

d) Following AIFSN[AC] × aSlotTime – aRxTxTurnaroundTime of idle medium after SIFS (not necessarily medium idle during the SIFS) after the last busy medium on the antenna that was the result of a transmission of a frame for any EDCAF and which did not require an acknowledgment.

e) Following AIFSN[AC] × aSlotTime + aSIFSTime – aRxTxTurnaroundTime of idle medium after the last indicated idle medium as indicated by the CS mechanism that is not covered by a) to d).

f) Following aSlotTime of idle medium, which occurs immediately after any of these conditions, a) to f), is met for the EDCAF.

**9.22.2.5 EDCA channel access in a VHT or TVHT BSS**

*[…]*

e) Restart the channel access attempt by invoking the backoff procedure as specified in 9.22.2 (HCF contention based channel access (EDCA)) as though the medium is busy on the primary channel as indicated by ~~either physical or virtual~~the CS mechanism and the backoff timer has a value of 0.

**9.23.3.9.2 Access during an MCCAOP by mesh STAs that are not the MCCAOP owner**

The MAC of a mesh STA with dot11MCCAActivated is true shall provide a Reservation Allocation Vector (RAV) mechanism to indicate a busy medium from the start of an MCCAOP corresponding to a reservation in its interference periods until the receipt of a frame transmitted by either the MCCAOP owner or the MCCAOP responder. The RAV mechanism is provided in addition to the ~~PHY and virtual~~ CS mechanism~~s~~ described in 9.3.2.1 (CS mechanism). It is different from the ~~virtual CS mechanism~~NAV in two aspects. Firstly, a mesh STA might be neighbor to multiple ongoing MCCAOPs corresponding to different reservations and the regular NAV setting and updating rules do not suffice to prevent interference during these reservations. Secondly, the ~~virtual CS mechanism~~NAV is set immediately upon receipt of a frame, whereas the RAV mechanism is based on reservation frames received at some earlier time instant. When either the ~~CS function provided by the PHY, the virtual CS function provided by the MAC via the NAV,~~CS mechanism or the RAV mechanism indicate a busy medium during an MCCAOP for which the mesh STA is neither the MCCAOP owner nor the MCCAOP responder, the medium shall be considered busy; otherwise, it shall be considered idle.

**9.24.10.3 GCR block ack BlockAckReq and BlockAck frame exchanges**

*[…]*

— The ~~carrier sense~~CS mechanism (see 9.3.2.1 (CS mechanism)) indicates that the medium is idle at the TxPIFS slot boundary (defined in 9.3.7 (DCF timing relations)) after the expected start of a BlockAck frame, and

**9.28.3 Rules for RD initiator**

*[…]*

NOTE 5—After transmitting a PPDU containing an RDG, if the response is corrupted so that the state of the RDG/More PPDU subfield is unknown, the RD initiator of the RD exchange is not allowed to transmit after a SIFS. Transmission can occur a PIFS after ~~deassertion of CS~~ the CS mechanism indicates idle.

**9.38.5.2 Operation during the A-BFT**

*[…]*

The responder shall decrement the backoff count by one at the end of each SSW slot, even if the CS ~~function~~mechanism at the responder indicates the medium busy condition for that SSW slot.

*[…]*

The responder shall decrement the backoff count by one at the end of each SSW slot, even if the CS ~~function~~mechanism at the responder indicates the medium busy condition for that SSW slot.

**10.11.9.3 Channel Load report**

If dot11RMChannelLoadMeasurementActivated is true and a station accepts a Channel Load request, it shall respond with a Radio Measurement Report frame containing one Measurement (Channel Load) Report element. The Channel Load field is defined as the percentage of time, linearly scaled with 255 representing 100%, the STA sensed the medium was busy, as indicated by ~~either the virtual carrier sense mechanism or the physical carrier sense mechanism over the requested channel width (together referred to as~~ the CS mechanism over the requested channel width~~)~~.

**10.11.9.4 Noise Histogram report**

*[…]*

To compute the IPI densities, the STA shall measure the IPI in the specified channel at the specified channel width as a function of time over the measurement duration when NAV is equal to 0 ~~(when virtual CS mechanism indicates idle channel)~~ except during frame transmission or reception.

**10.11.15.2 Measurement Pilot frame generation by an AP**

*[…]*

In case the medium is determined by the ~~carrier-sense~~CS mechanism (see 9.3.2.1 (CS mechanism)) to be unavailable at the TMPTT, the AP shall delay the actual transmission of a Measurement Pilot frame

**10.16.9 STA CCA sensing in a 20/40 MHz BSS**

*[…]*

b) Restart the channel access attempt. In this case, the STA shall invoke the backoff procedure as specified in 9.22.2 (HCF contention based channel access (EDCA)) as though the medium is busy as indicated by ~~either physical or virtual~~the CS mechanism and the backoff timer has a value of 0.

**8.4.2.27 BSS Load element**

*[…]*

The Channel Utilization field is defined as the percentage of time, linearly scaled with 255 representing 100%, that the AP sensed the medium was busy, as indicated by ~~either~~ the ~~physical or virtual carrier sense (~~CS~~)~~ mechanism.

**8.4.2.38 BSS Average Access Delay element**

*[…]*

The value 254 indicates that DCF or EDCAF services are currently unable to access the channel due to continuous ~~carrier sense~~CS mechanism deferral

**8.4.2.43 BSS AC Access Delay element**

*[…]*

The value 254 indicates that EDCA services are currently unable to access the channel due to continuous ~~carrier sense~~CS mechanism deferral to higher priority AC transmissions

**4.3.9.6 Noise Histogram**

The Noise Histogram request/report pair returns a power histogram measurement of non-IEEE Std 802.11 noise power by sampling the channel when ~~virtual carrier sense~~the NAV indicates idle and the STA is neither transmitting nor receiving a frame.

**3.2 Definitions specific to IEEE Std 802.11**

**average noise power indicator (ANPI):** A medium access control (MAC) indication of the average noise plus interference power measured when the channel is idle as defined by three simultaneous conditions: 1) the ~~virtual carrier sense (CS) mechanism~~ network allocation vector (NAV) indicates idle channel, 2) the station (STA) is not transmitting a frame, and 3) the STA is not receiving a frame.

**3.4 Abbreviations and acronyms**

Delete the entries for “PHYCS” and “PHYED” and add five entries after “CCA”:

CCA-ED CCA based on energy detection

CCA-PD CCA based on PPDU detection

CCA-RED CCA based on regulatory energy detection

CCA-SCSD CCA based on symbol detection on a secondary channel

CCA-SD CCA based on symbol detection

**7.3.5.10 PHY-CCARESET.request**

**7.3.5.10.4 Effect of receipt**

The effect of receipt of this primitive by the PHY entity is to reset the ~~PHY CS/~~CCA timers to the state appropriate for the end of a received frame and to initiate a new CCA evaluation cycle.

**17. High rate direct sequence spread spectrum (HR/DSSS) PHY specification**

Change “CS/CCA” to “CCA” in the figure at 2212.7.

**17.2.6 Receive PHY**

*[…]*

The receive PHY is shown in Figure 17-8 (Receive PHY).***<paragraph break>***

In order to receive data, the PHY-TXSTART.request primitive shall be disabled so that the PHY entity is in the receive state. Further, through station management via the PLME, the PHY shall be set to the appropriate channel and the CCA ~~method~~mode chosen. Other receive parameters, such as RSSI, RCPI, SQ, and indicated DATARATE, may be accessed via the PHY-SAP.

Upon receiving the transmitted energy, according to the selected CCA mode, a PHY-CCA.indication(BUSY) primitive shall be issued for CCA-ED and/or ~~code lock~~CCA-SD prior to correct reception of the PHY header. The PHY measures the ~~SQ,~~ RSSI, ~~and~~ RCPI and SQ ~~parameters~~ and these parameters are reported to the MAC in the RXVECTOR.

*[…]*

A PHY-RXEND.indication(NoError) primitive shall be issued. A PHY-CCA.indication(IDLE) primitive shall be issued following a change in ~~PHYCS~~CCA-PD and/or ~~PHYED~~CCA-ED according to the selected CCA ~~method~~mode.

If~~n the event that~~ a change in ~~PHYCS~~CCA-PD or ~~PHYED~~CCA-ED ~~would~~ causes the status of CCA to return to the IDLE state before the complete reception of the PSDU~~, as indicated by the PHY LENGTH field~~, the error condition shall be reported to the MAC using a PHY-RXEND.indication(CarrierLost) primitive~~. T~~, and the ~~CCA of the high rate~~ PHY shall indicate a busy medium for the intended duration of the transmitted ~~PPDU~~PSDU.

If the PHY header ~~is successful~~has a valid CRC, but the indicated rate ~~or modulation~~ in the SIGNAL ~~and SERVICE~~ field~~s~~ is not within the capabilities of the receiver, a PHY-RXSTART.indication primitive shall not be issued~~. T~~, and the PHY shall indicate the error condition using a PHY-RXEND.indication(UnsupportedRate) primitive and shall indicate a busy medium for the intended duration of the transmitted PSDU.***<paragraph break>***

If the PHY header ~~is~~has an invalid CRC, a PHY-RXSTART.indication primitive shall not be issued, and the PHY shall indicate the error condition using a PHY-RXEND.indication(FormatViolation) primitive. Also, in both cases, the ~~CCA of the high rate~~ PHY shall indicate a busy medium for the intended duration of the transmitted PSDU~~, as indicated by the LENGTH field~~.***<paragraph break and smaller font>***

NOTE—The intended duration of the transmitted PSDU is indicated by the LENGTH field (LENGTH × 1 µs).

**17.3.6.8 TX-to-RX turnaround time**

The TX-to-RX turnaround time shall be less than 10 µs, including the power-down ramp specified in 17.3.7.7 (Transmit power-on and power-down ramp).

The TX-to-RX turnaround time shall be measured at the air interface from the trailing edge of the last transmitted symbol to the valid CCA detection of the incoming signal. The CCA should occur within 25 µs (10 µs for turnaround time~~,~~ plus 15 µs for ~~energy detect~~ED), or by the next slot boundary occurring after the 25 µs has elapsed (see 17.3.8.5 (CCA)). A receiver input signal 3 dB above the ED threshold described in 17.3.8.5 (CCA) shall be present at the receiver.

**17.3.8.5 CCA**

The high rate PHY shall provide the capability to perform CCA according to at least one of the following three ~~methods~~modes:

— CCA Mode 1: Energy above threshold (CCA-ED). ~~CCA~~The PHY shall ~~report~~indicate a busy medium upon ~~detecting~~the detection of any energy above the ED threshold.

— CCA Mode 4: ~~CS~~PPDU detection with timer (CCA-PD with timer). ~~CCA~~The PHY shall start a timer whose duration is 3.65 ms and ~~report~~indicate a busy medium ~~only~~ upon the detection of ~~a high rate PHY signal~~ an HR/DSSS PPDU. ~~CCA~~The PHY shall (subject to item c below) ~~report~~indicate an ~~IDLE~~idle medium after the timer expires and no ~~high rate PHY signal~~ HR/DSSS PPDU is detected.***<paragraph break; then reduced font size>***

NOTE 1—The 3.65 ms timeout is the duration of the longest possible 5.5 Mb/s PSDU.

NOTE 2—An HR/DSSS PPDU can be detected from the preamble and header.

[I don’t see the point of the timer. I think this can simply be (remembering to delete the reference to the timer in item c below):]

— CCA Mode 4: ~~CS~~PPDU detection ~~with timer~~ (CCA-PD ~~with timer~~). ~~CCA~~The PHY shall ~~start a timer whose duration is 3.65 ms and report~~indicate a busy medium ~~only~~ upon the detection of ~~a high rate PHY signal~~ an HR/DSSS PPDU. ~~CCA shall report an IDLE medium after the timer expires and no high rate PHY signal is detected. The 3.65 ms timeout is the duration of the longest possible 5.5 Mb/s PSDU.~~

NOTE—An HR/DSSS PPDU can be detected from the preamble and header.

— CCA Mode 5: A combination of ~~CS~~PPDU detection and energy above threshold (CCA-PD with CCA-ED). ~~CCA~~The PHY shall ~~report~~indicate a busy medium upon the detection of an HR/DSSS PPDU~~at least while a high rate PPDU~~ with energy above the ED threshold ~~is being received at the antenna~~.

A busy channel shall be indicated by a PHY-CCA.indication(BUSY) primitive. ~~A clear~~An idle channel shall be indicated by a PHY-CCA.indication(IDLE) primitive.

dot11HRCCAModeSupported shall indicate the ~~appropriate operation~~ CCA modes supported by the PHY. The PHY shall use the mode ~~be~~ configured through dot11CurrentCCAMode. An HR/DSSS PHY that uses CCA Mode 4 shall also use CCA Mode 2 (for DSSS signals; see 16.4.6.5). An HR/DSSS PHY that uses CCA Mode 5 shall also use CCA Mode 3 (for DSSS signals; see 16.4.6.5).

The ~~CCA~~PHY shall indicate ~~a clear~~an idle channel if it does not detect a busy medium~~there is no energy detect or CS~~. ~~The~~ CCA ~~parameters are~~is subject to the following criteria:

a) ~~If a valid high rate signal is detected during its preamble within the CCA window, t~~The ED threshold (see dot11EDThreshold) shall be less than or equal to –76 dBm for TX power > 100 mW; –73 dBm for 50 mW < TX power ≤ 100 mW; and –70 dBm for TX power ≤ 50 mW.

b) ~~With~~If a valid signal (according to the CCA mode ~~of operation~~) is detected ~~present at the receiver antenna~~ within 5 µs of the start of a MAC slot boundary, the PHY~~-CCA.indication(BUSY) primitive~~ shall ~~be generated~~ indicate a busy medium no later than aMACProcessingDelay before the end of the slot ~~time. Refer to~~ (see Figure 9-19 (DCF timing relationships) (in 9.3.7 (DCF timing relations)) for a slot ~~time~~ boundary definition).

c) If~~n the event that~~ a ~~correct~~valid PHY header is received, the ~~high rate~~ PHY shall not ~~generate a PHY-CCA.indication (IDLE) primitive~~ indicate an idle medium until the end of the PPDU as determined by TXTIME in 17.3.4 (High rate TXTIME calculation). ~~Upon reception of a correct PHY header, t~~The timer of CCA Mode ~~2~~4 shall be overridden by this requirement.

Compliance to the high rate PHY CCA shall be demonstrated by applying an equivalent High-Rate signal above the appropriate ED threshold (item a) so that all conditions described in item b and item c are demonstrated.

**16. DSSS PHY specification for the 2.4 GHz band designated for ISM applications**

Change “CS/CCA” to “CCA” in the figure at 2185.13.

**16.3.7 Receive PHY**

*[…]*

In order to receive data, the PHY-TXSTART.request primitive shall be disabled so that the PHY entity is in the receive state. Further, through STA management via the PLME, the PHY ~~is~~shall be set to the appropriate channel and the CCA ~~method~~mode ~~is~~ chosen. Other receive parameters, such as RSSI, RCPI, ~~signal quality (~~SQ~~)~~, and indicated DATARATE, may be accessed via the PHY-SAP.

Upon receiving the transmitted energy, according to the selected CCA mode, ~~A~~a PHY-CCA.indication(BUSY) primitive shall be issued for ~~energy detection (~~CCA-ED~~)~~ and/or ~~code lock~~CCA-SD prior to correct reception of the PHY header. The PHY measures the RSSI, RCPI and SQ and these parameters are reported to the MAC in the RXVECTOR.

*[…]*

A PHY-RXEND.indication(NoError) primitive shall be issued. A PHY-CCA.indication(IDLE) primitive shall be issued following a change in ~~PHY carrier sense (PHYCS)~~CCA-PD and/or ~~PHY energy detection (PHYED)~~CCA-ED according to the selected CCA ~~method~~mode.

If~~n the event that~~ a change in ~~PHYCS~~CCA-PD or ~~PHYED~~CCA-ED ~~would~~ causes the status of CCA to return to the IDLE state before the complete reception of the ~~MPDU~~PSDU~~, as indicated by the PHY LENGTH field~~, the error condition shall be reported to the MAC using a PHY-RXEND.indication(CarrierLost) primitive~~. T~~, and the ~~CCA of the DSSS~~ PHY shall indicate a busy medium for the intended duration of the transmitted ~~packet~~PSDU.

If the PHY header ~~is successful~~has a valid CRC, but the indicated rate in the SIGNAL field is not within the capabilities of the receiver~~able~~, a PHY-RXSTART.indication primitive shall not be issued~~. T~~, and the PHY shall indicate the error condition ~~by issuing~~using a PHY-RXEND.indication(UnsupportedRate) primitive and shall indicate a busy medium for the intended duration of the transmitted PSDU.***<paragraph break>***

If the PHY header ~~is~~has an ~~successful, but the SERVICE field is out of IEEE Std 802.11 DSSS specification~~invalid CRC, a PHY-RXSTART.indication primitive shall not be issued~~. T~~, and the PHY shall indicate the error condition using a PHY-RXEND.indication(FormatViolation) primitive. Also, in both cases, the ~~CCA of the DSSS~~ PHY shall indicate a busy medium for the intended duration of the transmitted ~~frame~~PSDU. ***<paragraph break and smaller font>***

NOTE—The intended duration of the transmitted PSDU is indicated by the LENGTH field (~~length~~LENGTH × 1 μs).

**16.4.4.7 TX-to-RX turnaround time**

The TX-to-RX turnaround time shall be less than 10 μs, including the power-down ramp specified in 16.4.5.8 (Transmit power-on and power-down ramp).

The TX-to-RX turnaround time shall be measured at the air interface from the trailing edge of the last transmitted symbol to the valid CCA detection of the incoming signal. The CCA should occur within 25 μs (10 μs for turnaround time plus 15 μs for ~~energy detect~~ED) or by the next slot boundary occurring after 25 μs has elapsed (refer to 16.4.6.5 (CCA)). A receiver input signal 3 dB above the ED threshold described in 16.4.6.5 (CCA) shall be present at the receiver.

**16.4.6.5 CCA**

The DSSS PHY shall provide the capability to perform CCA according to at least one of the following three ~~methods~~modes:

— CCA Mode 1: Energy above threshold (CCA-ED). ~~CCA~~The PHY shall ~~report~~indicate a busy medium upon the detection of any energy above the ED threshold.

— CCA Mode 2: ~~CS only~~Symbol detection (CCA-SD). ~~CCA~~The PHY shall ~~report~~indicate a busy medium ~~only~~ upon the detection of a DSSS ~~signal~~symbol. ~~This signal may be above or below the ED threshold.~~

— CCA Mode 3: ~~CS with~~ A combination of symbol detection and energy above threshold (CCA-SD with CCA-ED). ~~CCA~~The PHY shall ~~report~~indicate a busy medium upon the detection of a DSSS ~~signal~~symbol with energy above the ED threshold.

A busy channel shall be indicated by a PHY-CCA.indication(BUSY) primitive. ***<delete paragraph break>*** A clear channel shall be indicated by a PHY-CCA.indication(IDLE) primitive.

~~The~~ dot11CCAModeSupported shall indicate the ~~appropriate operation~~CCA modes supported by the PHY. The PHY shall ~~be~~use the mode configured through dot11CurrentCCAMode.

The ~~CCA~~PHY shall indicate ~~a clear~~an idle channel if it does not detect a busy medium~~there is no energy detect or CS~~. ~~The~~ CCA ~~parameters are~~is subject to the following criteria:

a) The ED threshold (see dot11EDThreshold) shall be ≤ –80 dBm for TX power > 100 mW, –76 dBm for 50 mW < TX power ≤ 100 mW, and –70 dBm for TX power ≤ 50 mW.

b) ~~With~~If a valid signal (according to the CCA mode ~~of operation~~) is detected ~~present at the receiver antenna~~ within 5 μs of the start of a MAC slot boundary, the PHY~~-CCA.indication(BUSY) primitive~~ shall ~~be generated~~ indicate a busy medium no later than aMACProcessingDelay before the end of the slot ~~time. Refer to~~ (see Figure 9-19 (DCF timing relationships) (in 9.3.7 (DCF timing relations)) for a ~~definition of~~ slot ~~time~~ boundary definition).

c) If~~n the event that~~ a ~~correct~~valid PHY header is received, the ~~DSSS~~ PHY shall not ~~generate a PHY-CCA.indication (IDLE) primitive~~ indicate an idle medium until the end of the PPDU as determined by TXTIME in 16.4.7.

Compliance to DSSS PHY CCA shall be demonstrated by applying a DSSS signal, above the appropriate ED threshold (item a), so that all conditions described in item b and item c are demonstrated.

**18. Orthogonal frequency division multiplexing (OFDM) PHY specification**

Change “CS/CCA” to “CCA” in the figures at 2269.10, 2271.3.

**18.3.10.6 CCA requirements**

The PHY shall indicate a ~~medium~~ busy medium ~~condition~~ by issuing a PHY-CCA.indication(BUSY) primitive when ~~the carrier sense/~~clear channel assessment (~~CS/~~CCA) ~~mechanism~~ detects a channel busy condition.***<paragraph break and smaller font>***

NOTE 0—This includes CCA-RED, f~~F~~or the operating classes requiring this~~CCA-Energy Detect (CCA-ED), the PHY shall also indicate a medium busy condition when CCA-ED detects a channel busy condition~~.

The start of a valid OFDM PPDU~~transmission~~ at a receive level greater than or equal to the minimum modulation and coding rate sensitivity (–82 dBm for 20 MHz channel spacing, –85 dBm for 10 MHz channel spacing, and –88 dBm for 5 MHz channel spacing) shall (CCA-PD) cause ~~CS/~~CCA to detect a channel busy condition with a probability > 90% within 4 µs for 20 MHz channel spacing, 8 µs for 10 MHz channel spacing, and 16 µs for 5 MHz channel spacing.

NOTE 1—~~CS/~~CCA-PD ~~detect time~~ is based on finding the short sequences in the preamble, so when *TSYM* doubles, so does ~~CS/~~CCA-PD detect time.

Additionally, ~~the CS/~~CCA ~~mechanism~~ shall (CCA-ED) detect a medium busy condition within 4 µs of any signal with a received energy that is 20 dB above the minimum modulation and coding rate sensitivity (minimum modulation and coding rate sensitivity + 20 dB resulting in –62 dBm for 20 MHz channel spacing, –65 dBm for 10 MHz channel spacing, and –68 dBm for 5 MHz channel spacing).

For improved spectrum sharing, CCA-RED is required in some bands. The behavior class indicating CCA-RED is given in Table D-2 (Behavior limits sets). The operating classes requiring the corresponding CCA-RED behavior class are given in E.1 (Country information and operating classes). A STA that is operating within an operating class that requires CCA-RED shall operate with CCA-RED. Unless required by regulation, ~~the~~ CCA-RED shall not be required for license-exempt operation.

CCA-RED shall indicate a channel busy condition when the received signal strength exceeds the CCA-RED threshold as given by dot11OFDMREDThreshold. The CCA-RED thresholds for the operating classes requiring CCA-RED are subject to the criteria in D.2.5 (CCA-ED threshold).

NOTE 2—The requirement to indicate a channel busy condition for any signal 20 dB above the minimum modulation and coding rate sensitivity (minimum modulation and coding rate sensitivity + 20 dB resulting in –62 dBm for 20 MHz channel spacing, –65 dBm for 10 MHz channel spacing, and –68 dBm for 5 MHz channel spacing) is a mandatory ED~~energy detect~~ requirement on all Clause 18 (Orthogonal frequency division multiplexing (OFDM) PHY specification) receivers. Support for CCA-RED is an additional requirement that relates specifically to the sensitivities described in D.2.5 (CCA-ED threshold).

**18.3.12 Receive PHY**

The receive PHY is shown in Figure 18-19 (Receive PHY).***<paragraph break>***

In order to receive data, the PHY-TXSTART.request primitive shall be disabled so that the PHY entity is in the receive state. Further, through STA management ~~(~~via the PLME~~)~~, the PHY ~~is~~shall be set to the appropriate frequency. Other receive parameters, such as RSSI, RCPI, and indicated DATARATE, may be accessed via the PHY-SAP.

Upon receiving the transmitted ~~PHY preamble, the PHY measures the received signal strength level. This indicates activity to the MAC via PHY-CCA.indication primitive. A~~energy, a PHY-CCA.indication(BUSY) primitive shall be issued for reception of a signal prior to correct reception of the ~~PPDU~~PHY header. The PHY measures the RSSI and this parameter is reported to the MAC in the RXVECTOR.

*[…]*

A PHY-RXEND.indication(NoError) primitive shall be issued.

If~~n the event that~~ a change in the RSSI causes the status of ~~the~~ CCA to return to the IDLE state before the complete reception of the PSDU~~, as indicated by the PHY LENGTH field~~, the error condition shall be reported to the MAC using a PHY-RXEND.indication(CarrierLost) primitive~~. T~~, and the ~~CCA of the OFDM~~ PHY shall indicate a busy medium for the intended duration of the transmitted ~~packet~~PSDU.

If the parity check of the PHY header is valid, but the indicated rate in the SIGNAL field is not within the capabilities of the receiver~~able~~, a PHY-RXSTART.indication primitive shall not be issued~~. T~~, and the PHY shall indicate the error condition using a PHY-RXEND.indication(UnsupportedRate) primitive and ~~hold CCA~~shall indicate a busy medium for the ~~calculated~~intended duration of the transmitted PSDU~~PPDU~~. ***<paragraph break>***

If ~~the PHY header is receivable, but~~ the parity check of the PHY header is not valid, a PHY-RXSTART.indication primitive shall not be issued~~. T~~, and the PHY shall indicate the error condition using a PHY-RXEND.indication(FormatViolation) primitive.

NOTE—The intended duration of the transmitted PSDU is indicated by the LENGTH and RATE fields.

**19. Extended Rate PHY (ERP) specification**

Change “CS/CCA” to “CCA” in the figures at 2269.10, 2271.3.

**19.3.4 CCA**

The PHY shall provide the capability to perform a CCA and report the results of the assessment to the MAC. The CCA mechanism shall detect a “medium busy” condition for all supported preamble and header types. That is, the CCA mechanism shall detect that the medium is busy for the ~~PHY~~ PPDUs specified in 18.3.2 (PPDU format) and 17.2.2 (PPDU format). The CCA mechanism performance requirements are given in 19.4.6 (CCA performance).

The ERP shall ~~provide the capability to~~ perform CCA according to all the following ~~method~~modes:***<deindent and replace with hyphenated list as for DSSS and HR/DSSS>***

— CCA Mode 2 or 3. DSSS symbol detection (CCA-SD) or a combination of DSSS symbol detection and energy above threshold (CCA-SD with CCA-ED). See 16.4.6.5.

— CCA Mode 4 or 5. HR/DSSS PPDU detection (CCA-PD) or a combination of HR/DSSS PPDU detection and energy above threshold (CCA-PD with CCA-ED). See 17.3.8.5.

— CCA Mode 6: Energy above threshold (CCA-ED). The PHY shall indicate a busy medium upon the detection of any energy above –62 dBm.

**~~CCA Mode~~** ~~(ED and CS):~~— CCA Mode 7: A combination of ~~CS~~PPDU detection and energy above threshold (CCA-PD with CCA-ED). ~~CCA shall have a mechanism for CS that detects all mandatory Clause 19 (Extended Rate PHY (ERP) specification) sync symbols. This CCA’s mode’s CS shall include both Barker code sync detection and OFDM sync symbol detection.~~ ~~CCA~~The PHY shall ~~report~~indicate a busy medium upon the detection of an ERP-OFDM ~~at least while a~~ PPDU with energy above the ED threshold ~~is being received at the antenna~~.

A busy channel shall be indicated by a PHY-CCA.indication(BUSY) primitive. ~~A clear~~An idle channel shall be indicated by a PHY-CCA.indication(IDLE) primitive.

**19.4.6 CCA performance**

~~The CCA shall indicate true if there is no CCA “medium busy” indication. The~~ CCA ~~parameters are~~is subject to the following criteria:

a) ~~When~~If a valid signal (according to the CCA modes) ~~with a signal power of –76 dBm or greater~~ is detected~~at the receiver antenna connector is present~~ at the start of the ~~PHY~~a MAC slot boundary, the PHY~~receiver’s CCA indicator~~ shall ~~report the channel~~indicate a busy medium with probability CCA\_Detect\_Probability within ~~a~~ aCCATime. CCA\_Detect\_Probability is the probability that the CCA does respond correctly to a valid signal and shall be at least 99% for the long slot time and at least 90% for the short slot time. The values for the other parameters are found in Table 19-6 (ERP characteristics). Note that the CCA Detect Probability and the power level are performance requirements.

b) If~~n the event that~~ a ~~correct~~valid PHY header is received, the ERP shall not indicate an idle medium until the end of the PPDU as determined by TXTIME in 19.5.3~~hold the CCA signal inactive (channel busy) for the full duration, as indicated by the PHY LENGTH field~~. ~~Should a loss of CS occur in the middle of reception, the CCA shall indicate a busy medium for the intended duration of the transmitted PPDU.~~

**19.3.2.4 ERP-OFDM PPDU format**

*[…]*

~~The “CS mechanism” described in 9.3.2.1 (CS mechanism) combines the NAV state and the STA’s transmitter status with physical CS to determine the busy/idle state of the medium. The time interval between frames is called the IFS. A STA shall determine that the medium is idle through the use of the CCA mechanism for the interval specified. The starting reference of slot boundaries is the end of the last symbol of the previous frame on the medium. For ERP-OFDM frames, this includes the length extension.~~ For ERP-OFDM PPDUs~~frames~~, ~~a STA~~the PHY shall generate the ~~PHY RX\_END~~ PHY-RXEND.indication~~,~~ aSignalDuration after the end of the last symbol of the PPDU~~previous frame~~ on the medium. This adjustment shall be performed by the ~~STA~~PHY based on local configuration information set using the PLME SAP.

**C.3 MIB Detail**

dot11EDThreshold OBJECT-TYPE

SYNTAX Integer32

UNITS "dBm"

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"This is a control variable.

It is written by an external management entity.

Changes take effect as soon as practical in the implementation.

The ~~current~~ E~~nergy~~ D~~etect~~ ~~T~~threshold ~~being used by the DSSS~~

~~PHY~~ for CCA modes 1, 3 and 5. The allowed values are TX power dependent (see 16.4.6.5 and 17.3.8.5)."

::= { dot11PhyDSSSEntry 4 }

dot11OFDMREDThreshold OBJECT-TYPE

SYNTAX ~~Unsigned32 (0..255)~~Integer32

UNITS "dBm"

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"This is a control variable.

It is written the SME when the device is initialized for operation in a

band defined by an Operating Class to require CCA-RED, or written by an external management

entity.

Changes take effect as soon as practical in the implementation.

The ~~current~~ E~~nergy~~ D~~etect~~ ~~T~~threshold ~~being used by the OFDM PHY~~ for CCA-RED."

::= { dot11PhyOFDMEntry 11 }

dot11CCAModeSupported OBJECT-TYPE

SYNTAX Unsigned32 (1..7)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This is a capability variable.

Its value is determined by device capabilities.

dot11CCAModeSupported is a bit-significant value, representing all of the

CCA modes supported by the PHY. Valid values are:

energy detection only (~~ED\_ONLY~~edonly) = ~~0~~1,

~~carrier sense~~symbol detection only (~~CS\_ONLY~~sdonly) = ~~0~~2,

~~carrier sense~~symbol and energy detection (~~ED\_and\_CS~~sdanded)= ~~0~~4

or the logical sum of any of these values.

This attribute is not used to indicate the CCA modes supported by an ~~higher~~

~~rate extension~~HR/DSSS PHY. Rather, the dot11HRCCAMode~~Implemented~~Supported attribute is

used ~~to indicate the CCA modes of the higher rate extension PHY~~."

::= { dot11PhyDSSSEntry 2 }

dot11CurrentCCAMode OBJECT-TYPE

SYNTAX INTEGER {

edonly(1),

csonly(2),

edandcs(4), ~~cs~~hrpdwithtimer(8),

hr~~cs~~pdanded(16) }

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"This is a control variable.

It is written by an external management entity.

Changes take effect as soon as practical in the implementation.

***<blank line>***

The ~~current~~ CCA ~~method~~mode in operation. Valid values are:

***<blank line>***

energy detection only (edonly) = ~~0~~1,

DSSS symbol detection ~~carrier sense~~ only (~~c~~sdonly) = ~~0~~2,

DSSS symbol ~~carrier sense~~ and energy detection (~~edandcs~~sdanded) = ~~0~~4

~~carrier sense~~HR/DSSS PPDU detection with timer (~~cs~~hrpdwithtimer) = ~~0~~8

~~high rate carrier sense~~HR/DSSS PPDU and energy detection (hr~~cs~~pdanded) = 16.

hrpdwithtimer and hrpdanded are not valid for a DSSS STA.

csonly and edandcs are not valid for an HR/DSSS STA, but

note that hrpdanded implies sdanded (for DSSS PPDUs)

and hrpdwithtimer implies sdonly (for DSSS PPDUs)."

::= { dot11PhyDSSSEntry 3 }

Dot11PhyHRDSSSEntry ::=

SEQUENCE {

dot11ShortPreambleOptionImplemented TruthValue,

dot11HRCCAMode~~Implemented~~Supported Unsigned32 }

dot11HRCCAMode~~Implemented~~Supported OBJECT-TYPE

SYNTAX Unsigned32 (1..31)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This is a capability variable.

Its value is determined by device capabilities.

dot11HRCCAMode~~Implemented~~Supported is a bit-significant value, representing all of

the CCA modes supported by the PHY. Valid values are:

***<blank line>***

energy detection only (~~ED\_ONLY~~edonly) = ~~0~~1,

DSSS symbol detection ~~carrier sense~~ only (~~CS\_ONLY~~sdonly) = ~~0~~2,

DSSS symbol ~~carrier sense~~ and energy detection (~~ED\_and\_CS~~sdanded)= ~~0~~4,

~~carrier sense~~HR/DSSS PPDU detection with timer (~~CS\_and\_Timer~~hrpdwithtimer)= ~~0~~8,

~~high rate carrier sense~~HR/DSSS PPDU and energy detection (~~HRCS\_and\_ED~~hrpdanded)= 16

or the logical sum of any of these values.

***<paragraph break>***

In the ~~high rate extension~~HR/DSSS PHY,

this attribute is used ~~in preference to~~instead of the dot11CCAModeSupported attribute.

Note that hrpdanded requires sdanded (for DSSS PPDUs)

and hrpdwithtimer requires sdonly (for DSSS PPDUs)."

::= { dot11PhyHRDSSSEntry 5 }

dot11PhyHRDSSSComplianceGroup OBJECT-GROUP

OBJECTS {

dot11CurrentChannel,

~~dot11CCAModeSupported,~~

dot11CurrentCCAMode,

dot11EDThreshold,

dot11ShortPreambleOptionImplemented,

dot11HRCCAMode~~Implemented~~Supported }

STATUS current

DESCRIPTION

"Attributes that configure the HR/DSSS PHY for IEEE Std 802.11."

::= { dot11Groups 23 }

**20. High Throughput (HT) PHY specification**

Change “CS/CCA” to “CCA” in the figures at 2373.13, 2374.1, 2375.4, 2375.37.

**20.3.20.5 CCA sensitivity**

**20.3.20.5.1 CCA-Regulatory Energy Detection (CCA-RED)**

For improved spectrum sharing, CCA-RED is required in some bands. The behavior class indicating CCA-RED is given in Table D-2 (Behavior limits sets). The operating classes requiring the corresponding CCA-RED behavior class are given in E.1 (Country information and operating classes). An HT STA that is operating within an operating class that requires CCA-RED shall operate with CCA-RED as defined in 18.3.10.6 (CCA requirements).

**20.3.20.5.2 CCA sensitivity for non-HT PPDUs**

CCA sensitivity requirements for non-HT PPDUs in the primary channel are described in 18.3.10.6 (CCA requirements) and 19.4.6 (CCA performance).

**20.3.20.5.3 CCA sensitivity in 20 MHz**

This subclause describes the CCA sensitivity requirements for an HT STA with the operating channel width equal to 20 MHz.

~~For an HT STA with the operating channel width equal to 20 MHz, t~~The start of a valid 20 MHz HT signal at a receive level greater than or equal to the minimum modulation and coding rate sensitivity of –82 dBm shall cause the PHY to ~~set PHY-CCA.indication(BUSY)~~ indicate a busy medium with a probability > 90% within 4 µs.***<paragraph break>***

The ~~receiver~~PHY shall indicate a ~~channel busy condition~~ busy medium for any signal 20 dB or more above the minimum modulation and coding rate sensitivity (–82 + 20 = –62 dBm) in the ~~20 MHz~~ channel.

A~~n HT STA~~ PHY that does not support the reception of HT-GF format PPDUs shall indicate ~~a channel busy condition (PHY-CCA.indication(BUSY))~~ busy medium for any valid HT-GF signal in the ~~20 MHz~~ channel at a receive level greater than or equal to –72 dBm.

**20.3.20.5.4 CCA sensitivity in 40 MHz**

This subclause describes the CCA sensitivity requirements for an HT STA with the operating channel width equal to 40 MHz.

The ~~receiver~~PHY of a 20/40 MHz STA with the operating channel width equal to 40 MHz shall provide CCA on both the primary and secondary channels.

When the secondary channel is idle, the start of a valid 20 MHz HT signal in the primary channel at a receive level greater than or equal to the minimum modulation and coding rate sensitivity of –82 dBm shall cause the PHY to generate a PHY-CCA.indication(BUSY, {primary}) primitive with a probability > 90% within 4 µs.***<paragraph break>***

The start of a valid 40 MHz HT signal that occupies both the primary and secondary channels at a receive level greater than or equal to the minimum modulation and coding rate sensitivity of –79 dBm shall cause the PHY to generate a PHY-CCA.indication(BUSY, {primary, secondary}) primitive ~~for both the primary and secondary channels~~ with a probability per channel > 90% within 4 µs.

A~~n HT STA~~ PHY that does not support the reception of HT-GF format PPDUs shall ~~indicate a {primary} channel busy condition (~~generate a PHY-CCA.indication(BUSY, {primary}) primitive~~)~~ for any valid HT-GF signal in the primary channel at a receive level greater than or equal to –72 dBm when the secondary channel is idle. A~~n HT STA~~ PHY that does not support the reception of HT-GF format PPDUs shall ~~indicate a {primary, secondary} channel busy condition (~~generate a PHY-CCA.indication(BUSY, {primary, secondary}) primitive~~)~~ for any valid 40 MHz HT-GF signal in both the primary and secondary channels at a receive level greater than or equal to –69 dBm.

The ~~receiver~~PHY shall ~~indicate a {primary} channel busy condition~~ generate a PHY-CCA.indication(BUSY, {primary}) primitive for any signal at or above –62 dBm in the ~~20 MHz~~ primary channel. This level is 20 dB above the minimum modulation and coding rate sensitivity for a 20 MHz PPDU. When the primary channel is idle, the ~~receiver~~PHY shall ~~indicate a {secondary} channel busy condition~~ generate a PHY-CCA.indication(BUSY, {secondary}) primitive for any signal at or above –62 dBm in the ~~20 MHz~~ secondary channel. The ~~receiver~~PHY shall ~~indicate a {primary, secondary} channel busy condition~~ generate a PHY-CCA.indication(BUSY, {primary, secondary}) primitive for any signal present in both the primary and secondary channels that is at or above –62 dBm in the primary channel and at or above –62 dBm in the secondary channel.

**20.3.22 PHY receive procedure**

*[…]*

While in the Signal Extension state, if the receiver detects a ~~CS/~~CCA event, it issues a~~n~~ PHY-RXEND.indication primitive (with the RXERROR parameter set to NoError or CarrierLost, depending on whether a carrier lost event occurred during the reception of the PPDU), leaves the Signal Extension state, and enters the Detect SIG state. This sequence occurs when signal-extended PPDUs are transmitted while separated by a RIFS.

***[Miscellaneous]***

Delete the space before “(BUSY)” at 1540.23.

Delete “20 MHz” before “primary channel” or “secondary channel” at 1700.14 (2x), 1700.30.

Delete “2.4 GHz” at 3189.64 and change “HRDSSS” to “HR/DSSS”.

Change “CCA/CS” to “CS” at 2447.6.

Change “OFDM frame” to “OFDM PPDU” at 2239.38.

Delete “frame” in “ERP-OFDM frame format” at 2281.10.

Change “dot11OFDMEDThreshold” to “dot11OFDMREDThreshold” throughout the spec (10 instances).

Change “virtual CS (RTS/CTS or CTS-to-self)” to “NAV (e.g. using RTS/CTS or CTS-to-self)” at 2276.35.

Change “Energy Only” to “Energy detection” at 2687.58, “IEEE Std 802.11 DSSS correlation” to “DSSS symbol detection” at 2687.60 and “Both methods” to “DSSS symbol detection with energy detection” at 2687.62.

Change “CCA Mode 1, energy only” to “Energy detection” at 2717.22, “CCA Mode 4, CS with timer” to “HR/DSSS PPDU detection” at 2717.25 and “CCA Mode 5, energy detect with high rate CS” to “HR/DSSS PPDU detection with energy detection”.

Need to add the HR/DSSS->DSSS etc. CCA dependencies in the PICS.

[Work in progress!]

Proposed resolution for CID 6129:

REJECTED

IEEE Std 100 already defines carrier sense as: “In a local area network, an ongoing activity of a data station to detect whether another station is transmitting.”

Proposed resolution for CIDs 6214, 6215, 6216, 6302, 6303, 6305, 6306:

REVISED

Make the changes shown under “Proposed changes” for CIDs 6214, 6215, 6216, 6302, 6303, 6305, 6306 in <this document>.

**References:**

802.11mc/D4.0