IEEE P802.11  
Wireless LANs

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| Proposed resolution to CID 2458 | | | | |
| Date: 2014-05-10 | | | | |
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Abstract

This submission proposes a resolution to REVmc CID 2458.

The discussion is in reference to Draft P802.11REVmc\_D2.6.

R0 – Initial draft

R1 – Removed spurious track changes (formatting, numbering, etc)

R2 – Updates based on comments from May 2 telecon and e-mails.

This document presents some re-write change proposals to sub-clause 9.21, to address REVmc CID #2458.

| **CID** | **Page** | **Clause** | **Comment** | **Proposed Change** | **Owning Ad-hoc** |
| --- | --- | --- | --- | --- | --- |
| 2458 | 1160.60 | 9.20.2.3 | EDCAF operation needs help to improve understanding - it has not evolved well. For example, 9.19.2.3 has become a convoluted machine built from 4 separate bullet lists. 9.19.2.3 and 9.19.2.5 both discuss backoff counter decrements, and when they occur. 9.2 shows EDCA as "on top of" DCF, but EDCA TXOPs violate 9.3.4.3 (6th paragraph). Etc. | This needs off-line work, and a thought-out proposal. | MAC |

Note that the sub-clause referenced in the comment (as 9.19 [sic] and 9.20) is now 9.21.

This document presents the modified text in two steps. The first step only re-arranges existing text, nothing was added, deleted or modified, only moved. In this step, the paragraphs are numbered in (red) to reference back to the original order. The second step then modifies the rearranged text for grammar, clarity, removing redundancy, etc, and shows changes with the usual change indications.

The original text is at the end of the document, for reference, and shows the original paragraph numbering references in (red).

All the text is from REVmc Draft 2.6.

Proposed Resolution: Revised. Replace the text of clause 9.21.1 and 9.21.2 (Draft 2.6 numbering) with the text in <this document> in the section labeled, “Modified text (the final proposed version).”

***Re-arranged text (from D2.6 original)***

The overall flow after the rearranging, is (numbering is suggested new numbering):

* .1 Intro to HCF (EDCA, HCCA and CBAP)
* .2 HCF
* .2.1 EDCA Model (multiple queues, etc)
* .2.2 EDCA backoff procedure (CW, starting process)
* .2.3 EDCA TXOPs (intro to three modes: obtaining, continuing, sharing)
* .2.4 Obtaining EDCA TXOP (backoff timer, medium busy, AIFS, slot boundary checks)
* .2.5 EDCA channel access in VHT (special cases for wide bandwidth)
* .2.6 Sharing a TXOP (11ac DL-MU-MIMO special case)
* .2.7 Multiple frame transmission (TXOP continuation, TXNAV)
* .2.8 TXOP Limits
* .2.9 Truncation of TXOP (CF-End)
* .2.10 Retransmit procedures
* .2.10.1 General (long/short retry count)
* .2.10.2 Unsolicited retry procedure (11aa GCR)
* .3 HCCA (unchanged)
* .4 Admission Control (unchanged)

**Text:**

* HCF
* General

(1) Under HCF, the basic unit of allocation of the right to transmit onto the WM is the TXOP. Each TXOP is defined by a starting time and a defined maximum length. In a non-DMG network, (11ad) the TXOP may be obtained by a STA winning an instance of EDCA contention (see HCF ) during the CP or by a STA receiving a QoS (+)CF-Poll frame (see **Error! Reference source not found.**) during the CP or CFP. The former is called *EDCA TXOP*, while the latter is called *HCCA TXOP* or *polled TXOP*. An HCCA TXOP shall not extend across a TBTT.(#63) The occurrence of a TBTT implies the end of the HCCA TXOP, after which the regular channel access procedure (EDCA or HCCA) is resumed. It is possible that no frame was transmitted during the TXOP. The shortened termination of the HCCA TXOP does not imply an error condition.

(2) In a DMG BSS, the EDCAF operates only during CBAPs. Operation of the EDCAF is suspended at the end of a CBAP and is resumed at the beginning of the following CBAP. When the EDCAF is being suspended, the values of the backoff and NAV timers shall remain unchanged until the start of the following CBAP. A TXOP may be obtained only within a CBAP. A TXOP may be obtained by a DMG STA winning an instance of EDCA contention (see HCF ) or by a DMG STA receiving a Grant frame with the AllocationType field equal to 1. See **Error! Reference source not found.** and **Error! Reference source not found.** for additional rules regarding (#2203)contention based access in DMG BSSs. (11ad)

(3) HCCA is not used by DMG STAs.(11ad)

* HCF (#2203)contention based channel access (EDCA)
* Reference implementation

(4) The channel access protocol is derived from the DCF procedures described in **Error! Reference source not found.**.

(5) A model of the reference implementation is shown in **Error! Reference source not found.** for the case in which dot11AlternateEDCAActivated is false or not present and in **Error! Reference source not found.** for the case in which dot11AlternateEDCAActivated is true. These figures illustrate(11aa) a mapping from frame type or UP to the (11aa) transmit queues and the four independent EDCAFs.(11aa) The mapping of UP to the transmit queue and the mapping to AC are(11aa) described in **Error! Reference source not found.** and **Error! Reference source not found.**. The mapping of frame types to ACs is described in **Error! Reference source not found.**.



(6) A DMG STA may implement a single AC. If the DMG(#DMG) STA implements a single AC, all UP and frame types shall be mapped to AC\_BE. (11ad)

NOTE—A DMG STA that implements a single AC has only one queue in **Error! Reference source not found.**. (11ad)

* EDCA backoff procedure

(42) Each EDCAF shall maintain a state variable CW[AC], which shall be initialized to the value of the parameter CWmin[AC].

(43) For the purposes of this subclause, transmission success and transmission failure of an MPDU(11ac) are defined as follows:

* After transmitting an MPDU (even if(11ac) it is carried in an A‑MPDU or as part of a VHT MU PPDU that might have TXVECTOR parameter NUM\_USERS > 1)(11ac) that requires an immediate frame as a response, the STA shall wait for a timeout interval of duration of aSIFSTime + aSlotTime + aRxPHYStartDelay(#1486), starting at the PHY-TXEND.confirm primitive. If a PHY-RXSTART.indication primitive does not occur during the timeout interval, the STA concludes that the transmission of the MPDU has failed.
* If a PHY-RXSTART.indication primitive does occur during the timeout interval, the STA shall wait for the corresponding PHY-RXEND.indication primitive to determine whether the MPDU transmission was successful. The recognition of a valid response frame sent by the recipient of the MPDU requiring a response, corresponding to this PHY-RXEND.indication primitive, shall be interpreted as a successful response.
* (11aa)The recognition of a valid (#100)Data frame sent by the recipient of a PS-Poll frame shall also be accepted as successful acknowledgment of the PS-Poll frame.
* The transmission of an MPDU(11ac) that does not require an immediate frame as a response is defined as a successful transmission, unless it is one of the nonfinal (re)transmissions of an MPDU that is delivered using the GCR unsolicited retry retransmission policy (9.21.2.7.2 (Unsolicited retry procedure(11aa))).(11aa)
* The nonfinal (re)transmission of an MPDU that is delivered using the GCR unsolicited retry retransmission policy (9.21.2.7.2 (Unsolicited retry procedure(11aa))) is defined to be a failure.(11aa)
* The final (re)transmission of an MPDU that is delivered using the GCR unsolicited retry retransmission policy (9.21.2.7.2 (Unsolicited retry procedure(11aa))) is defined as a successful transmission.(11aa)
* The recognition of anything else, including any other valid frame, shall be interpreted as failure of the MPDU transmission.(11aa)

(44) The backoff procedure shall be invoked for an EDCAF when any of the following events occurs:

* 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,(#1439) the medium is busy on the primary channel(11ac) as indicated by either physical or virtual CS, and the backoff timer has a value of 0 for that AC.
* In the following, .11ac changed “successful” to “successful as defined in this subclause”. Comment 285 chaned “succesful” to “completed”. The .11ac change has been ignored.
* The transmission of the MPDU in the final PPDU transmitted(11ac) by the TXOP holder during the TXOP for that AC has completed(#285) and the TXNAV timer has expired, and the AC was a primary AC.(11ac)
* The expected immediate response to(11ac) the initial frame of a TXOP of that AC is not received and the AC was a primary AC.(11ac)
* The transmission attempt collides internally with another EDCAF of an AC that has higher priority, that is, two or more EDCAFs in the same STA are granted a TXOP at the same time.(11ac)
* The transmission attempt of a STA coordinated by an MM-SME collides internally with another STA coordinated by the same MM-SME (see 10.34 (MMSL cluster operation(11ad))), which is indicated to the first MAC entity with a (#2123)PHY-TXBUSY.indication (BUSY) as response to the PHY-TXSTART.request primitive. (11ad)
* Is the following necessary. See previous Editor Note. There may be no need to define “successful”.

NOTE 1—For the purpose of this subclause, reception of a valid immediate response to any of the MPDUs in this PPDU determines that transmission of all MPDUs in the PPDU was successful.

(45) In addition, the backoff procedure may be invoked for an EDCAF when the transmission of the MPDUs in a non-initial PPDU by the TXOP holder fails.(11ac)

NOTE 2(#1101)—A STA can perform a PIFS recovery, as described in Multiple frame transmission in an EDCA TXOP, or perform a backoff, as described in the previous paragraph, as a response to transmission failure within a TXOP. How it chooses between these two is implementation dependent.

(46) A STA that performs a backoff within its existing TXOP shall not extend the TXNAV timer value.

NOTE 3(#1101)—In other words, the backoff is a continuation of the TXOP, not the start of a new TXOP.

(47) If the backoff procedure is invoked for reason a) above, the value of CW[AC] shall be left unchanged. If the backoff procedure is invoked because of reason b) above, the value of CW[AC] shall be reset to CWmin[AC].

NOTE 4—If condition b) or c) occurs for a secondary AC, the backoff for the associated EDCAF continues without change to the backoff counter or to the value of CW[AC].(11ac)

(48) If the backoff procedure is invoked because of a failure event [reason c), d), or e)(11ad) above or the transmission failure of a non-initial frame by the TXOP holder], the value of CW[AC] shall be updated as follows before invoking the backoff procedure:

* If the QSRC[AC] or the QLRC[AC] (#1056)has reached dot11ShortRetryLimit or dot11LongRetryLimit respectively, CW[AC] shall be reset to CWmin[AC].
* If dot11RobustAVStreamingImplemented is true and either(#1056) the QSDRC[AC] or the QLDRC[AC] has reached dot11ShortDEIRetryLimit or dot11LongDEIRetryLimit, respectively, CW[AC] shall be reset to CWmin[AC].(11aa)
* Otherwise,
* If CW[AC] is less than CWmax[AC], CW[AC] shall be set to the value (CW[AC] + 1)×2 – 1.
* If CW[AC] is equal to CWmax[AC], CW[AC] shall remain unchanged for the remainder of any retries.

(50) All backoff slots occur following an AIFS[AC] period during which the medium is determined to be idle on the primary channel(11ac) for the duration of the AIFS[AC] period, or following an EIFS – DIFS + AIFS[AC] period during which the medium is determined to be idle on the primary channel(11ac) for the duration of the EIFS – DIFS + AIFS[AC] period, as appropriate (see **Error! Reference source not found.**), except as defined in Obtaining an EDCA TXOP, which allows the medium to be busy during the initial aSIFSTime of this period under certain conditions.(11ac)

* EDCA TXOPs

(7) There are three(11ac) modes of EDCA TXOP defined:(Ed) initiation of an EDCA TXOP, sharing an EDCA TXOP,(11ac) and multiple frame transmission within an EDCA TXOP. Initiation of the TXOP occurs when the EDCA rules permit access to the medium. Sharing of the EDCA TXOP occurs when an EDCAF has obtained access to the medium, making the corresponding AC the primary AC, and includes traffic from queues associated with other ACs in VHT MU PPDUs transmitted during the TXOP.(11ac) Multiple frame transmission within the TXOP occurs when an EDCAF retains the right to access the medium following the completion of a frame exchange sequence, such as on receipt of an (#1198)Ack frame.

* Obtaining an EDCA TXOP

(18) Each channel access timer shall maintain a backoff function (timer), which has a value measured in backoff slots.

(49) The backoff timer is set to an integer value chosen randomly with a uniform distribution taking values in the range [0,CW[AC]] inclusive.

(19) The duration AIFS[AC] is a duration derived from the value AIFSN[AC] by the relation

AIFS[AC] = AIFSN[AC] × aSlotTime + aSIFSTime.

(20) In EDCA, the value of AIFSN[AC] shall be greater than or equal to 2 for non-AP STAs.(#2437) In an infrastructure BSS, AIFSN[AC] is advertised by the AP in the EDCA Parameter Set element in Beacon and Probe Response frames transmitted by the AP. The value of AIFSN[AC] shall be greater than or equal to 1 for APs. An EDCA TXOP is granted to an EDCAF when the EDCAF determines that it shall initiate the transmission of a frame exchange sequence. Transmission initiation shall be determined according to the following rules:

(22) The specific slot boundaries at which exactly one of these operations shall be performed are defined as follows, for each EDCAF:

* Following AIFSN[AC] × aSlotTime – aRxTxTurnaroundTime of idle medium after SIFS (not necessarily idle medium during the SIFS(#156)) after the last busy medium on the antenna that was the result of a reception of a frame with a correct FCS.
* Following EIFS – DIFS + AIFSN[AC] × aSlotTime + aSIFSTime – aRxTxTurnaroundTime of idle medium after the last indicated busy medium as determined by the physical CS mechanism 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.
* When any other EDCAF at this STA transmitted a frame requiring acknowledgment, the earlier of
  + The end of the (#1627)ACKTimeout interval timed from the (#1601)PHY-TXEND.confirm primitive, followed by AIFSN[AC] (#1630)× aSlotTime + aSIFSTime – aRxTxTurnaroundTime of idle medium, and
* The end of the first AIFSN[AC] × aSlotTime – aRxTxTurnaroundTime of idle medium after SIFS (not necessarily medium idle during the SIFS(#156), the start of the SIFS(#156) implied by the length in the PHY(#61) header of the previous frame) when a PHY-RXEND.indication primitive occurs as specified in **Error! Reference source not found.**.
* Following AIFSN[AC] × aSlotTime – aRxTxTurnaroundTime of idle medium after SIFS (not necessarily medium idle during the SIFS(#156)) 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.
* 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).
* Following aSlotTime of idle medium, which occurs immediately after any of these conditions, a) to f), is met for the EDCAF.

(21) On specific slot boundaries as determined on the primary channel,(11ac) each EDCAF shall make a determination to perform one and only one of the following functions:

* Initiate the transmission of a frame exchange sequence for that access function.
* Decrement the backoff timer for that access function.
* Invoke the backoff procedure due to an internal collision.
* Do nothing for that access function.

NOTE—In the case that an EDCAF gains access to the channel and transmits MSDUs, A-MSDUs, or MMPDUs from a secondary AC, the EDCAF of the secondary AC is not affected by this operation. If the EDCAF of a secondary AC experiences an internal collision with the EDCAF that gained access to the channel, it performs the backoff procedure regardless of the transmission of any of its MSDUs, A-MSDUs, or MMPDUs.(11ac)

(24) At each of the above-described specific slot boundaries, each EDCAF shall decrement the backoff timer if the backoff timer for that EDCAF has a nonzero value.

(23) At each of the above-described specific slot boundaries, each EDCAF shall initiate a transmission sequence if

* There is a frame available for transmission at that EDCAF, and
* The backoff timer for that EDCAF has a value of 0, and
* Initiation of a transmission sequence is not allowed to commence at this time for an EDCAF of higher UP.

(25) At each of the above-described specific slot boundaries, each EDCAF shall report an internal collision (which is handled in EDCA backoff procedure) if

* There is a frame available for transmission at that EDCAF, and
* The backoff timer for that EDCAF has a value of 0, and
* Initiation of a transmission sequence is allowed to commence at this time for an EDCAF of higher UP.

(26) An example showing the relationship between AIFS, AIFSN, DIFS, and slot times immediately following a medium busy condition (and assuming that medium busy condition was not caused by a frame in error) is shown in **Error! Reference source not found.**. In this case, with AIFSN = 2, the EDCAF may decrement the backoff counter for the first time at 2 × aSlotTime following the (#1610)TxSIFS (where (#1610)TxSIFS is the time at which the MAC responds to the end of the medium busy condition if it is going to respond “after SIFS”). If, in this example, the backoff counter contained a value of 1 at the time the medium became idle, transmission would start as a result of an EDCA TXOP on-air at a time

aSIFSTime + 3 × aSlotTime

following the end of the medium busy condition.



(16) A STA shall save the TXOP holder address for the BSS in which it is associated, which is the MAC address from the Address 2 field of the frame that initiated a frame exchange sequence except when this is a CTS frame, in which case the TXOP holder address is the Address 1 field. If the TXOP holder address is obtained from a Control frame(Ed), a VHT STA shall save the non-bandwidth signaling TA value obtained from the Address 2 field. If a non-VHT STA receives(11ac) an RTS frame with the RA address matching the MAC address of the STA and the MAC address in the TA field in the RTS frame matches the saved TXOP holder address, then the STA shall send the CTS frame after SIFS, without regard for, and without resetting, its NAV. If a VHT STA receives an RTS frame with the RA address matching the MAC address of the STA and the non-bandwidth signaling TA value obtained from the Address 2 field in the RTS frame matches the saved TXOP holder address, then the STA shall send the CTS frame after SIFS, without regard for, and without resetting, its NAV.(11ac) When a STA receives a frame addressed to it that requires an immediate response, except for RTS, it shall transmit the response independent of its NAV. The saved TXOP holder address shall be cleared when the NAV is reset or when the NAV counts down to 0.

* EDCA channel access in a VHT BSS(11ac)

(76) If the MAC receives a PHY-CCA.indication primitive with the channel-list parameter present, the channels considered idle are defined in Channels indicated idle by the channel-list parameter.

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| * Channels indicated idle by the channel-list parameter(11ac) | |
| PHY-CCA.indication channel-list element | Idle channels |
| primary | None |
| secondary | Primary 20 MHz channel |
| secondary40 | Primary 20 MHz channel and secondary 20 MHz channel |
| secondary80 | Primary 20 MHz channel, secondary 20 MHz channel, and secondary 40 MHz channel |

(17) When a STA and the BSS, of which the STA is a member, both support multiple channel widths, an EDCA TXOP is obtained based solely on activity of the primary channel. “Idle medium” in this subclause means “idle primary channel.” Likewise “busy medium” means “busy primary channel.” Once an EDCA TXOP has been obtained according to this subclause, further constraints defined in 10.16.9 (STA CCA sensing in a 20/40 MHz BSS) and **Error! Reference source not found.** might limit the width of transmission during the TXOP or deny the channel access, based on the state of CCA on secondary channel, secondary 40 MHz channel, or secondary 80 MHz channel.(11ac)

(77) In the following description, the CCA is sampled according to the timing relationships defined in **Error! Reference source not found.**. Slot boundaries are determined solely by activity on the primary channel. “Channel idle for an interval of PIFS” means that whenever CCA is sampled during the period of PIFS that ends at the start of transmission, the CCA for that channel was determined to be idle.

(78) If a STA is permitted to begin a TXOP (as defined in Obtaining an EDCA TXOP) and the STA has at least one MSDU pending for transmission for the AC of the permitted TXOP, the STA shall perform exactly one of the following steps:

* Transmit a 160 MHz or 80+80 MHz mask PPDU if the secondary channel, the secondary 40 MHz channel, and the secondary 80 MHz channel were idle during an interval of PIFS immediately preceding the start of the TXOP.
* Transmit an 80 MHz mask PPDU on the primary 80 MHz channel if both the secondary channel and the secondary 40 MHz channel were idle during an interval of PIFS immediately preceding the start of the TXOP.
* Transmit a 40 MHz mask PPDU on the primary 40 MHz channel if the secondary channel was idle during an interval of PIFS immediately preceding the start of the TXOP.
* Transmit a 20 MHz mask PPDU on the primary 20 MHz channel.
* Restart the channel access attempt by invoking the backoff procedure as specified in HCF as though the medium is busy on the primary channel as indicated by either physical or virtual CS and the backoff timer has a value of 0.

NOTE 1—In the case of rule e), the STA selects a new random number using the current value of CW[AC], and the retry counters are not updated (as described in Multiple frame transmission in an EDCA TXOP; backoff procedure invoked for event a)).

NOTE 2—For both an HT and a VHT STA, an EDCA TXOP is obtained based on activity on the primary channel (see Obtaining an EDCA TXOP). The width of transmission is determined by the CCA status of the non-primary channels during the PIFS interval before transmission (see Multiple frame transmission in an EDCA TXOP).

* Sharing an EDCA TXOP(11ac)

(27) This mode applies only to an AP that supports DL-MU-MIMO. The AC associated with the EDCAF that gains an EDCA TXOP becomes the primary AC. TXOP sharing is allowed when primary AC traffic is transmitted in a VHT MU PPDU and resources permit traffic from secondary ACs to be included, targeting up to four STAs. The inclusion of secondary AC traffic in a VHT MU PPDU shall not increase the duration of the VHT MU PPDU beyond that required to transport the primary AC traffic. If a destination is targeted by frames in the queues of both the primary AC and at least one secondary AC, the frames in the primary AC queue shall be transmitted to the destination first, among a series of downlink transmissions within a TXOP. The decision of which secondary ACs and destinations are selected for TXOP sharing, as well as the order of transmissions, are implementation specific and out of scope for this specification.

(28) When sharing, the TXOP duration that applies is the TXOP limit of the primary AC.

NOTE—An AP can protect the immediate response by preceding the VHT MU PPDU (which might have TXVECTOR parameter NUM\_USERS > 1) with an RTS/CTS exchange or a CTS-to-self transmission.

(29) An illustration of TXOP sharing is shown in Illustration of TXOP sharing and PPDU construction. In this figure, the AP has frames in queues of three of its ACs. It is assumed that the TXOP was obtained by AC\_VI and is shared by AC\_VO and AC\_BE. It is also assumed that these frames are targeting three STAs, STA-1 to STA-3.

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| * Illustration of TXOP sharing and PPDU construction(11ac) |

* Multiple frame transmission in an EDCA TXOP

(34) A frame exchange may be one of the following:(11ac)

* A frame not requiring immediate acknowledgment (such as a group addressed frame or a frame transmitted with an acknowledgement policy that does not require immediate acknowledgement) or an A-MPDU containing only such frames
* A frame requiring acknowledgment (such as an individually addressed frame transmitted with an acknowledgement policy that requires immediate acknowledgement) or an A-MPDU containing at least one such frame, followed after SIFS by a corresponding acknowledgment frame
* Either
* a VHT NDP Announcement frame followed after SIFS by a VHT NDP, or
* a Beamforming Report Poll frame

followed after SIFS by a PPDU containing one or more VHT Compressed Beamforming frames

(31) The TXNAV timer is a timer that is initialized with the duration from the Duration/ID field in the frame most recently successfully transmitted by the TXOP holder. The TXNAV timer begins counting down from the end of the transmission of the PPDU containing that frame. Following the (#192)BlockAck frame response, the HT STA may start transmission of another MPDU or A‑MPDU a SIFS after the completion of the immediately preceding frame exchange sequence. The HT STA may retransmit unacknowledged MPDUs within the same TXOP or in a subsequent TXOP.

(30) Multiple frames may be transmitted in an EDCA TXOP that was acquired following the rules in Obtaining an EDCA TXOP if there is more than one frame pending in the primary(11ac) AC for which the channel has been acquired. However, those frames that are pending in other ACs shall not be transmitted in this EDCA TXOP except when sent in a VHT MU PPDU with TXVECTOR parameter NUM\_USERS > 1 and if allowed by the rules in Sharing an EDCA TXOP.(11ac) If a TXOP holder has in its transmit queue an additional frame of the primary(11ac) AC and the duration of transmission of that frame plus any expected acknowledgment for that frame is less than the remaining TXNAV timer value, then the TXOP holder(11ac) may commence transmission of that frame a SIFS (or RIFS, if the conditions defined in **Error! Reference source not found.** are met(11ac)) after the completion of the immediately preceding frame exchange sequence, subject to the TXOP limit restriction as described in EDCA TXOPs. A STA shall not commence the transmission of an RTS with a bandwidth signaling TA until at least PIFS time after the immediately preceding frame exchange sequence.(11ac) An HT STA that is a TXOP holder may transmit multiple MPDUs of the same AC within an A‑MPDU as long as the duration of transmission of the A‑MPDU plus any expected (#192)BlockAck frame response is less than the remaining TXNAV timer value.

NOTE 1—PIFS is used by a VHT STA to perform CCA in the secondary 20 MHz, 40 MHz, and 80 MHz channels before receiving RTS.(11ac)

NOTE 2—An RD responder can transmit multiple MPDUs as described in **Error! Reference source not found.**.(#241)

(32) After a valid response to the initial frame of a TXOP, if the Duration/ID field is set for multiple frame transmission and there is a subsequent transmission failure, the corresponding channel access function may transmit after the CS mechanism (see **Error! Reference source not found.**) indicates that the medium is idle at the TxPIFS slot boundary (defined in **Error! Reference source not found.**) provided that the duration of that transmission(Ed) plus the duration of any expected acknowledgment and applicable IFS is less than the remaining TXNAV timer value.(#251) At the expiry of the TXNAV timer, if the channel access function has not regained access to the medium, then the EDCAF shall invoke the backoff procedure that is described in EDCA backoff procedure. Transmission failure is defined in EDCA backoff procedure.

(33) All other channel access functions at the STA shall treat the medium as busy until the expiry of the TXNAV timer.

* In the following, I merged changes from CID 1292 into the insertion by .11ac. The changes from CID 1292 moved away from having “types of ack policy”, e.g. “Normal Ack policy” cited. Elsewhere the changes resulted in citing specific values of specific fields. Here the changes generalized the statement and removed references to specific “policies”.

(35) Note that, as for an EDCA TXOP, a multiple frame transmission is granted to an EDCAF, not to a STA, so that the multiple frame transmission is permitted only for the transmission of a frame of the same AC as the frame that was granted the EDCA TXOP, unless the EDCA TXOP obtained is used by an AP for a PSMP sequence or a VHT MU PPDU with TXVECTOR parameter NUM\_USERS > 1.(11ac)

(36) In the case of PSMP,(11ac) this AC transmission restriction does not apply to either the AP or the STAs participating in the PSMP sequence, but the specific restrictions on transmission during a PSMP sequence described in **Error! Reference source not found.** do apply.

(37) When permitted by the rules in Sharing an EDCA TXOP, traffic from secondary ACs may be transmitted in a VHT MU PPDU that has TXVECTOR parameter NUM\_USERS > 1 and that carries traffic for the primary AC.(11ac)

(38) If a TXOP is protected by an RTS or CTS frame carried in a non-HT or a non-HT duplicate PPDU, the TXOP holder shall set the TXVECTOR parameter CH\_BANDWIDTH of a PPDU as follows:(11ac)

* To be the same or narrower than RXVECTOR parameter CH\_BANDWIDTH\_IN\_NON\_HT of the last received CTS frame in the same TXOP, if the RTS frame with a bandwidth signaling TA and TXVECTOR parameter DYN\_BANDWIDTH\_IN\_NON\_HT set to Dynamic has been sent by the TXOP holder in the last RTS/CTS exchange.
* Otherwise, to be the same or narrower than the TXVECTOR parameter CH\_BANDWIDTH of the RTS frame that has been sent by the TXOP holder in the last RTS/CTS exchange(Ed) in the same TXOP.

(39) If there is no RTS/CTS exchange in non-HT duplicate format in a TXOP and there is at least one non-HT duplicate frame exchange in a TXOP, the TXOP holder shall set the CH\_BANDWIDTH parameter in TXVECTOR of a PPDU sent after the first non-HT duplicate frame to be the same or narrower than the CH\_BANDWIDTH parameter in TXVECTOR of the initial frame in the first non-HT duplicate frame exchange in the same TXOP.(11ac)

(40) If there is no non-HT duplicate frame exchange in a TXOP, the TXOP holder shall set the TXVECTOR parameter CH\_BANDWIDTH of a non-initial PPDU to be the same or narrower than the TXVECTOR parameter CH\_BANDWIDTH of the preceding PPDU that it has transmitted in the same TXOP.(11ac)

(41) If a TXOP is protected by a CTS-to-self frame carried in a non-HT or non-HT duplicate PPDU, the TXOP holder shall set the TXVECTOR parameter CH\_BANDWIDTH of a PPDU to be the same or narrower than the TXVECTOR parameter CH\_BANDWIDTH of the CTS-to-self in the same TXOP.(11ac)

NOTE—The bandwidth of a PS-Poll frame does not constrain the bandwidth of an immediate data response to that PS-Poll frame.(11ac)

(15) Note that(#1288) when transmitting multiple frames in a TXOP using acknowledgment mechanisms other than Normal Ack, a protective mechanism should be used (such as RTS/CTS or the protection mechanism described in **Error! Reference source not found.**). A QoS AP or a mesh STA may send group addressed frames without using any protection mechanism. In a QoS IBSS, group addressed frames shall be sent one at a time, and backoff shall be performed after the transmission of each of the group addressed frames. In an MBSS, a mesh STA may send multiple group addressed frames in a TXOP, bounded by the TXOP limit, without performing backoff after the TXOP is obtained.

9.21.2.x TXOP Limits

(11) A STA obtaining a TXOP (the TXOP holder) shall, subject to the exceptions below, ensure that the duration of a TXOP does not exceed the TXOP Limit, when non-zero. The duration of a TXOP is the time the TXOP holder maintains uninterrupted control of the medium, and it includes the time required to transmit frames sent as an immediate response to TXOP holder transmissions.

(8) The TXOP limit duration values are advertised by the AP in the EDCA Parameter Set element in Beacon and Probe Response frames transmitted by the AP.

* Changes from CID 1616 merged with changes from .11ac in list item a) resulting in new a)4) below.

(9) A TXOP limit value of 0 indicates that the TXOP holder may transmit or cause to be transmitted (as responses) the following within the current TXOP:

* One of the following(11ac) at any rate, subject to the rules in **Error! Reference source not found.**
* SU PPDUs carrying fragments of a single MSDU or MMPDU(11ac)
* An SU PPDU or a VHT MU PPDU carrying a single MSDU, a single MMPDU, a single A-MSDU, or a single A-MPDU(11ac)
* A VHT MU PPDU carrying A-MPDUs to different users(11ac)
* A QoS Null frame(#1616) or PS-Poll frame(#Ed)
* Any required acknowledgments
* Any frames required for protection, including one of the following:
* An RTS/CTS exchange
* CTS to itself
* Dual CTS as specified in **Error! Reference source not found.**
* Any frames required for beamforming as specified in **Error! Reference source not found.** and in **Error! Reference source not found.**(11ac)
* Any frames required for link adaptation as specified in **Error! Reference source not found.**
* Any number of BlockAckReq frames

NOTE 1—This is a rule for the TXOP holder. A TXOP responder need not be aware of the TXOP limit nor of when the TXOP was started.

NOTE 2—This rule prevents the use of RD when the TXOP limit is 0.

(10) When dot11OCBActivated is true, TXOP limits shall be 0 for each AC.

(12) The TXOP holder may exceed the TXOP Limit only if it does not transmit more than one Data or Management (Ed)frame in the TXOP, and only for:(#2408)

* Retransmission of an MPDU, not in an A-MPDU consisting of more than one MPDU
* Initial transmission of an MSDU under a Block Ack agreement, where the MSDU is not in an A-MPDU consisting of more than one MPDU and the MSDU is not in an A-MSDU
* Transmission of a Control MPDU or a QoS Null MPDU, not in an A MPDU consisting of more than one MPDU
* Initial transmission of a fragment of an MSDU or(Ed) MMPDU, if a previous fragment of that MSDU or(Ed) MMPDU was retransmitted
* Transmission of a fragment of an MSDU or(Ed) MMPDU fragmented into 16 fragments
* Transmission of an A-MPDU consisting of the initial transmission of a single MPDU not containing an A MSDU and that is not an individually addressed Management (Ed)frame
* Transmission of a group addressed MPDU, not in an A-MPDU consisting of more than one MPDU
* Transmission of a Null Data Packet (NDP)
* Insertion of .11ac was into text that has been restructured. I think the following is the correct home for it. Reviewers please check carefully.
* Transmission of a VHT NDP Announcement frame and NDP or transmission of a Beamforming Report Poll frame that fit within the TXOP limit but the response and the immediately preceding SIFS cause the TXOP limit to be exceeded.

(13) Except as described above, a STA shall fragment an individually addressed MSDU or(Ed) MMPDU so that the initial transmission of the first fragment does not cause the TXOP Limit to be exceeded.(#2408)

NOTE—The TXOP Limit is not exceeded for:(#2408)

* Initial transmission of an MPDU containing an unfragmented though fragmentable (see **Error! Reference source not found.**) MSDU/MMPDU
* Initial transmission of the first fragment of a fragmented MSDU/MMPDU, except for an MSDU/MMPDU fragmented into 16 fragments
* Initial transmission of an A-MSDU
* Initial transmission of a fragment of a fragmented MSDU/MMPDU, if no previous fragment of that MSDU/MMPDU was retransmitted, except for an MSDU/MMPDU fragmented into 16 fragments
* Transmission of an A-MPDU consisting of a single MPDU containing an A MSDU or individually addressed Management (Ed)frame, unless this is a retransmission of that MPDU
* Transmission of an A-MPDU consisting of more than one MPDU, even if some or all of the MPDUs are retransmissions

(14) If the TXOP holder exceeds the TXOP Limit, it should use as high a PHY rate as possible to minimize the duration of the TXOP.(#2408)

NOTE—The rules in this subclause apply to priority-downgraded MSDUs and(Ed) A-MSDUs (see **Error! Reference source not found.**

* Truncation of TXOP

(68) When a STA gains access to the channel using EDCA and empties its transmission queue, it may transmit a CF-End frame provided that the remaining duration is long enough to transmit this frame. By transmitting the CF-End frame, the STA is explicitly indicating the completion of its TXOP. In a DMG BSS, the STA shall not send a CF-End frame(#2069) with a nonzero value in the Duration/ID field if the remaining duration is shorter than 2×TXTIME(CF-End) + 2×SIFS. (11ad)

(69) A TXOP holder that transmits a CF-End frame shall not initiate any further frame exchange sequences within the current TXOP.

(70) A non-AP STA that is not the TXOP holder shall not transmit a CF-End frame.

(71) In a non-DMG network, a(11ad) STA shall interpret the reception of a CF-End frame as a NAV reset, i.e., it resets its NAV timer to 0 at the end of the PPDU containing this frame. After receiving a CF-End frame with a matching BSSID(TA) without comparing Individual/Group bit,(11ac) an AP may respond by transmitting a CF-End frame after SIFS.

NOTE 1—The transmission of a single CF-End frame by the TXOP holder resets the NAV of STAs hearing the TXOP holder. There may be STAs that could hear the TXOP responder that had set their NAV that do not hear this NAV reset. Those STAs are prevented from contending for the medium until the original NAV reservation expires.

NOTE 2—A CF-End sent by a non-AP VHT STA that is a member of a VHT BSS can include the TXVECTOR parameter CH\_BANDWIDTH\_IN\_NON\_HT as defined in **Error! Reference source not found.** in case it elicits a CF-End response.(11ac)

(72) In a DMG BSS, a STA that is not in the listening mode(#2184) (**Error! Reference source not found.**) shall interpret the reception of a CF-End frame as a NAV reset, i.e., it resets its NAV timer to 0 at the end of the time interval indicated in the value of the Duration/ID field of the received frame. The interval starts at PHY-RXEND.indication of the frame reception. The STA shall not transmit during the interval if the RA field of the frame is not equal to the STA MAC address. The STA may transmit a CF-End frame if the RA field of the received frame is equal to the STA MAC address and the value of the Duration/ID field in the received frame is not equal to 0. (11ad)

(73) **Error! Reference source not found.** shows an example of TXOP truncation. In this example, the STA accesses the medium using EDCA channel access and then transmits a nav-set sequence (e.g., RTS/CTS for non-DMG STAs or RTS/DMG CTS for DMG STAs(11ad)) (using the terminology of Annex G). After a SIFS, it then transmits an initiator-sequence, which may involve the exchange of multiple PPDUs between the TXOP holder and a TXOP responder. At the end of the second sequence, the TXOP holder has no more data that it can(11ad) send that fits within the TXOP; therefore, it truncates the TXOP by transmitting a CF-End frame.

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| * Example of TXOP truncation |

(74) Non-DMG(11ad) STA that receive the CF-End frame reset their NAV and can start contending for the medium without further delay. A DMG STA that receives a CF-End frame can start contending for the medium at the end of the time interval equal to the value in Duration/ID field of the frame if none of its NAV timers has a nonzero value (**Error! Reference source not found.**).(11ad)(Ed)

(75) TXOP truncation shall not be used in combination with L-SIG TXOP protection when the HT Protection field of the HT Operation element is equal to nonmember protection mode or non-HT mixed mode.

* Retransmit procedures
* General(11aa)

(51) A QoS STA(#1289) shall maintain a short retry counter and a long retry counter for each MSDU, A‑MSDU, or MMPDU that belongs to a TC that requires acknowledgment. The initial value for the short and long retry counters shall be 0. QoS STAs also maintain a short retry counter and a long retry counter for each AC. They are defined as QSRC[AC] and QLRC[AC], respectively, and each is initialized to a value of 0. When dot11RobustAVStreamingImplemented is true, a QoS STA(#1289) shall maintain a short drop-eligible retry counter and a long drop-eligible retry counter for each AC. They are defined as QSDRC[AC] and QLDRC[AC], respectively, and each is initialized to a value of zero. APs with dot11RobustAVStreamingImplemented true and mesh STAs with dot11MeshGCRImplemented true, shall maintain an unsolicited retry counter.(11aa)(#1055)

(52) After an RTS frame is transmitted to protect an MSDU or MMPDU, a QoS STA performs the CTS procedure, as defined in **Error! Reference source not found.**. If a valid CTS frame is not received, the short retry counter for the MSDU or MMPDU and the QSRC[AC] for the corresponding AC shall be incremented. If a valid CTS frame is received, the QSRC[AC] for the corresponding AC shall be reset to 0.(motion\_29)

(53) (11aa)After transmitting a frame that requires an immediate acknowledgment, the STA shall perform either of the acknowledgment procedures, as appropriate, that are defined in **Error! Reference source not found.** and **Error! Reference source not found.**. The short retry count for an MSDU or A‑MSDU that is not part of a (#2353)block ack agreement or for an MMPDU shall be incremented every time transmission of a frame in a PSDU(#358) of length less than or equal to dot11RTSThreshold fails for that MSDU, A‑MSDU, or MMPDU. The unsolicited retry counter shall be incremented after the transmission of every A‑MSDU that is transmitted using the GCR unsolicited retry retransmission policy.(11aa)

(54) QSRC[AC] shall be incremented every time transmission of an A‑MPDU or frame in a PSDU(#358) of length less than or equal to dot11RTSThreshold fails, regardless of the presence or value of the DEI field. When dot11RobustAVStreamingImplemented is true, QSDRC[AC] shall be incremented every time transmission of an A‑MPDU or frame in which the HT variant(11ac) HT Control field is present, the DEI field is equal to 1 and the length of the PSDU(Ed) is less than or equal to dot11RTSThreshold fails.(11aa) This short retry count and the QoS STA QSRC[AC] shall be reset when an A‑MPDU or frame of length in a PSDU(#358) less than or equal to dot11RTSThreshold succeeds. When dot11RobustAVStreamingImplemented is true, the QSDRC[AC] shall be reset when an A‑MPDU or frame in a PSDU(Ed) of length less than or equal to dot11RTSThreshold succeeds, regardless of the presence or value of the DEI field.(11aa)

(55) The long retry count for an MSDU or A‑MSDU that is not part of a (#2353)block ack agreement or for an MMPDU shall be incremented every time transmission of a MAC frame in a PSDU(#358) of length greater than dot11RTSThreshold fails for that MSDU, A‑MSDU, or MMPDU.

(56) QLRC[AC] shall be incremented every time transmission of an A‑MPDU or frame in a PSDU(#358) of length greater than or equal to dot11RTSThreshold fails, regardless of the presence or value of the DEI field.(11aa) This long retry count and the QLRC[AC] shall be reset when an A‑MPDU or frame in a PSDU(#358) of length greater than dot11RTSThreshold succeeds. When dot11RobustAVStreamingImplemented is true, QLDRC[AC] shall be incremented every time transmission fails for an A‑MPDU or frame in a PSDU(Ed) of length greater than dot11RTSThreshold in which the HT variant(11ac) HT Control field is present and the DEI field is equal to 1. The QLDRC[AC] shall be reset when an A‑MPDU or frame in a PSDU(Ed) of length greater than dot11RTSThreshold succeeds, regardless of the presence or value of the DEI field.(11aa)

(57) All retransmission attempts for an MPDU that is not sent under a (#2353)block ack agreement and that has failed the acknowledgment procedure one or more times shall be made with the Retry field set to 1 in the data or (#100)Management frame.

(58) Retries for failed transmission attempts shall continue until one or more of the following conditions occurs:(11aa)

* The short retry count for the MSDU, A‑MSDU, or MMPDU is equal to MPDUdot11ShortRetryLimit.
* The long retry count for the MSDU, A‑MSDU, or MMPDU is equal to dot11LongRetryLimit.
* The short drop-eligible retry count for the MSDU, A‑MSDU, or MMPDU is equal to dot11ShortDEIRetryLimit.
* The long drop-eligible retry count for the MSDU, A‑MSDU, or MMPDU is equal to dot11LongDEIRetryLimit.
* The unsolicited retry count for the A‑MSDU is equal to dot11UnsolicitedRetryLimit.

(59) When any(11aa) of these limits is reached, retry attempts shall cease, and the MSDU, A‑MSDU, or MMPDU shall be discarded.

(60) For internal collisions occurring with the EDCA access method, the appropriate retry counters (short retry counter for MSDU, A‑MSDU, or MMPDU and QSRC[AC] or long retry counter for MSDU, A‑MSDU, or MMPDU and QLRC[AC]) are incremented. For internal collisions occurring with the EDCA access method where dot11RobustAVStreamingImplemented is true, the appropriate drop-eligible retry counters (QSDRC[AC], and QLDRC[AC]) are incremented when the collision occurs for an(Ed) MSDU, A‑MSDU, or MMPDU that has drop eligibility equal to 1.(11aa) For transmissions that use block ack(#2069), the rules in **Error! Reference source not found.** also apply. A STA(#1289) shall retry failed transmissions until the transmission is successful or until the relevant retry limit is reached.

(61) With the exception of a frame belonging to a TID for which block ack(#2069) is set up, a QoS STA shall not initiate the transmission of any management or (#100)Data frame to a specific RA while the transmission of another management or (#100)Data frame with the same RA and having been assigned its sequence number from the same sequence counter has not yet completed to the point of success, retry fail, or other MAC discard (e.g., lifetime expiry).

(62) A QoS STA(#1289) shall maintain a transmit MSDU timer for each MSDU passed to the MAC. dot11EDCATableMSDULifetime specifies the maximum amount of time allowed to transmit an MSDU for a given AC. The transmit MSDU timer shall be started when the MSDU is passed to the MAC. If the value of this timer exceeds the appropriate entry in dot11EDCATableMSDULifetime, then the MSDU, or any remaining, undelivered fragments of that MSDU, shall be discarded by the source STA without any further attempt to complete delivery of that MSDU.

(63) When A‑MSDU aggregation is used, the HT STA maintains a single timer for the whole A‑MSDU. The timer is restarted each time an MSDU is added to the A‑MSDU. The result of this procedure is that no MSDU in the A‑MSDU is discarded before a period of dot11EDCATableMSDULifetime has elapsed.

* Unsolicited retry procedure(11aa)

(64) When using the GCR unsolicited retry retransmission policy for a group address, an(Ed) AP or mesh STA may retransmit an MPDU to increase the probability of correct reception at the STAs that are listening to this group address (i.e., the group address is in their dot11GroupAddressesTable). The set of MPDUs that may be retransmitted is dependent upon whether (#2353)block ack agreements are active with the STAs that are listening to this group address and is defined in 10.24.16.3.6 (GCR unsolicited retry(11aa)). How an AP or a mesh STA chooses which MPDUs to retransmit is an implementation decision and beyond the scope of this standard.

(65) A protective mechanism (such as a mechanism described in **Error! Reference source not found.**) should be used to reduce the probability of other STAs transmitting during the GCR TXOP. When using a protection mechanism that requires a response from another STA, the AP should select a STA that is a member of the GCR group.

(66) The TXOP initiation rules defined in EDCA TXOPs and **Error! Reference source not found.** shall be used for initiating a GCR TXOP. The duration of a GCR TXOP shall be subject to the TXOP limits defined in EDCA TXOPs.

(67) When transmitting MPDUs using the GCR service with retransmission policy equal to GCR unsolicited retry, the following rules apply:

* Following a MAC protection exchange that includes a response frame, in all GCR unsolicited retry retransmissions, the STA shall either transmit the frames within a GCR TXOP separated by SIFS or invoke its backoff procedure as defined in EDCA backoff procedure. The STA shall not transmit an MPDU and a retransmission of the same MPDU within the same GCR TXOP. The final frame transmitted within a GCR TXOP shall follow the backoff procedure defined in EDCA backoff procedure
* Without MAC protection or with MAC protection that lacks a response frame, in all transmissions, the STA shall invoke the backoff procedure defined in EDCA backoff procedure, using a value of CWmin[AC] for CW, at the PHY-TXEND.confirm primitive that follows the transmission of each unsolicited retry GCR MPDU.
* All retransmissions of an MPDU shall have the Retry field in their Frame Control fields set to 1.
* During a GCR TXOP, frames may be transmitted within the GCR TXOP that do not use the GCR unsolicited retry retransmission policy.

***Modified text (the final proposed version). Renumber clauses appropriately.***

* HCF
* General

(1) Under HCF, the basic unit of allocation of the right to transmit onto the WM is the TXOP. Each TXOP is defined by a starting time and a defined maximum length. In a non-DMG network, (11ad) the TXOP may be obtained by a STA winning an instance of EDCA contention (see 9.21.2 (HCF (#2203)contention based channel access (EDCA))) during the CP or by a STA receiving a QoS (+)CF-Poll frame (see 9.21.3 (HCCA))) during the CP or CFP. The former is called *EDCA TXOP*, while the latter is called *HCCA TXOP* or *polled TXOP*..

(2) In a DMG BSS, the EDCAF operates only during CBAPs. Operation of the EDCAF is suspended at the end of a CBAP and is resumed at the beginning of the following CBAP. See 9.35.5 ((#2203)Contention based access period (CBAP) transmission rules(11ad)) and 9.35.6.3 ((#2203)Contention based access period (CBAP) allocation(11ad)) for additional rules regarding (#2203)contention based access in DMG BSSs. (11ad)

(3) HCCA is not used by DMG STAs.(11ad)

Throughout this sub-clause, a frame exchange sequence is as described in Annex G.

* HCF (#2203)contention based channel access (EDCA)
* Reference model

(4) The EDCA channel access protocol is derived from the DCF procedures described in 9.3 (DCF), by adding four independent enhanced distributed channel access functions (EDCAFs) to provide differentiated priorities to transmitted traffic, through the use of four different access categories (ACs).

(5) For the case in which dot11AlternateEDCAActivated is false or not present, a model of the reference implementation is shown in Figure 9-24 (Reference implementation model when dot11AlternateEDCAActivated is false or not present(11aa)), and for the case in which dot11AlternateEDCAActivated is true, a model is shown in Figure 9-25 (Reference implementation model when dot11AlternateEDCAActivated is true(11aa)). These figures illustrate(11aa) a mapping from frame type or UP to the (11aa) transmit queues and the four independent EDCAFs.(11aa) The mapping of UP to the transmit queue and the mapping to AC are(11aa) described in 9.2.4.2 (HCF (#2203)contention based channel access (EDCA)) and Table 9-1 (UP-to-AC mappings). The mapping of frame types to ACs is also described in 9.2.4.2 (HCF (#2203)contention based channel access (EDCA)).



(6) A DMG STA may implement a single AC. If the DMG(#DMG) STA implements a single AC, all UP and frame types shall be mapped to AC\_BE. (11ad)

NOTE—A DMG STA that implements a single AC has only one queue in Figure 9-24 (Reference implementation model when dot11AlternateEDCAActivated is false or not present(11aa)).. (11ad)

* EDCA backoff procedure

(42) Each EDCAF shall maintain a state variable CW[AC], which shall be initialized to the value of the parameter CWmin[AC], for that EDCAF’s AC.

(43) For the purposes of this subclause, transmission failure of an MPDU(11ac) is defined as follows:

* After transmitting an MPDU (even if(11ac) it is carried in an A‑MPDU or as part of a VHT MU PPDU that might have TXVECTOR parameter NUM\_USERS > 1)(11ac) that requires an immediate frame as a response, the STA shall wait for a timeout interval of duration of aSIFSTime + aSlotTime + aRxPHYStartDelay(#1486), starting at the PHY-TXEND.confirm primitive. If a PHY-RXSTART.indication primitive does not occur during the timeout interval, the STA concludes that the transmission of the MPDU has failed.
* If a PHY-RXSTART.indication primitive does occur during the timeout interval, the STA shall wait for the corresponding PHY-RXEND.indication primitive to recognize a valid response frame sent by the recipient of the MPDU requiring a response. The recognition of anything else, including any other valid frame, shall be interpreted as failure of the MPDU transmission.(11aa)
* The nonfinal (re)transmission of an MPDU that is delivered using the GCR unsolicited retry retransmission policy (Unsolicited retry procedure)) is defined to be a failure.(11aa)

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

* 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,(#1439) the medium is busy on the primary channel(11ac) as indicated by either physical or virtual CS, and the backoff timer has a value of 0 for that AC.
* The transmission of the MPDU in the final PPDU transmitted(11ac) by the TXOP holder during the TXOP for that AC has completed(#285) and the TXNAV timer has expired, and the AC was a primary AC.(11ac) (See 9.21.2.4 (Sharing an EDCA TXOP(11ac)))
* The expected immediate response to(11ac) the initial frame of a TXOP of that AC is not received and the AC was a primary AC.(11ac)
* The transmission attempt collides internally with another EDCAF of an AC that has higher priority, that is, two or more EDCAFs in the same STA are granted a TXOP at the same time.(11ac)
* The transmission attempt of a STA coordinated by an MM-SME collides internally with another STA coordinated by the same MM-SME (see 10.34 (MMSL cluster operation(11ad))), which is indicated to the first MAC entity with a (#2123)PHY-TXBUSY.indication (BUSY) as response to the PHY-TXSTART.request primitive. (11ad)

(45) In addition, the backoff procedure may be invoked for an EDCAF when the transmission of the MPDUs in a non-initial PPDU by the TXOP holder fails.(11ac)

NOTE 2(#1101)—A STA can perform a PIFS recovery, as described in 9.21.2.5 (Multiple frame transmission in an EDCA TXOP),, or perform a backoff, as described in the previous paragraph, as a response to transmission failure within a TXOP. How it chooses between these two is implementation dependent.

(46) A STA that performs a backoff within its existing TXOP shall not extend the TXNAV timer value (see 9.21.2.5 (Multiple frame transmission in an EDCA TXOP)).

NOTE 3(#1101)—In other words, the backoff is a continuation of the TXOP, not the start of a new TXOP.

(47) If the backoff procedure is invoked for reason a) above, the value of CW[AC] shall be left unchanged. If the backoff procedure is invoked because of reason b) above, the value of CW[AC] shall be reset to CWmin[AC].

NOTE 4—If condition b) or c) occurs for a secondary AC, the backoff for the associated EDCAF continues without change to the backoff counter or to the value of CW[AC].(11ac)

(48) If the backoff procedure is invoked because of a failure event [reason c), d), or e)(11ad) above or the transmission failure of a non-initial frame by the TXOP holder], the value of CW[AC] shall be updated as follows before invoking the backoff procedure:

* If the QSRC[AC] or the QLRC[AC] (#1056)has reached dot11ShortRetryLimit or dot11LongRetryLimit respectively, CW[AC] shall be reset to CWmin[AC].
* If dot11RobustAVStreamingImplemented is true and either(#1056) the QSDRC[AC] or the QLDRC[AC] has reached dot11ShortDEIRetryLimit or dot11LongDEIRetryLimit, respectively, CW[AC] shall be reset to CWmin[AC].(11aa)
* Otherwise,
* If CW[AC] is less than CWmax[AC], CW[AC] shall be set to the value (CW[AC] + 1)×2 – 1.
* If CW[AC] is equal to CWmax[AC], CW[AC] shall be left unchanged.
* EDCA TXOPs

(7) There are three(11ac) modes of EDCA TXOP defined:(Ed) initiation of an EDCA TXOP, sharing an EDCA TXOP,(11ac) and multiple frame transmission within an EDCA TXOP. Initiation of the TXOP occurs when the EDCA rules permit access to the medium. Sharing of the EDCA TXOP occurs within an AP that supports DL-MU-MIMO when an EDCAF has obtained access to the medium, making the corresponding AC the primary AC, and includes traffic from queues associated with other ACs in VHT MU PPDUs transmitted during the TXOP.(11ac) Multiple frame transmission within the TXOP occurs when an EDCAF retains the right to access the medium following the completion of a frame exchange sequence, such as on receipt of an (#1198)Ack frame.

* Obtaining an EDCA TXOP

(18) Each EDCAF shall maintain a backoff timer, which has a value measured in backoff slots as described below.

(49) When the backoff procedure is invoked, the backoff timer is set to an integer value chosen randomly with a uniform distribution taking values in the range [0,CW[AC]] inclusive.

(19) The duration AIFS[AC] is a duration derived from the value AIFSN[AC] by the relation

AIFS[AC] = AIFSN[AC] × aSlotTime + aSIFSTime.

(20) In an infrastructure BSS, AIFSN[AC] is advertised by an EDCA AP in the EDCA Parameter Set element in Beacon and Probe Response frames transmitted by the AP.Tthe value of AIFSN[AC] shall be greater than or equal to 2 for non-AP STAs.(#2437) The value of AIFSN[AC] shall be greater than or equal to 1 for APs. An EDCA TXOP is granted to an EDCAF when the EDCAF determines that it shall initiate the transmission of a frame exchange sequence. Transmission initiation shall be determined according to the following rules:

(22) EDCAF operations shall be performed at slot boundaries, defined as follows on the primary channel(11ac), for each EDCAF:

* Following AIFSN[AC] × aSlotTime – aRxTxTurnaroundTime of idle medium after SIFS (not necessarily idle medium during the SIFS(#156)) after the last busy medium on the antenna that was the result of a reception of a frame with a correct FCS.
* Following EIFS – DIFS + AIFSN[AC] × aSlotTime + aSIFSTime – aRxTxTurnaroundTime of idle medium after the last indicated busy medium as determined by the physical CS mechanism 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.
* When any other EDCAF at this STA transmitted a frame requiring acknowledgment, the earlier of
  + The end of the (#1627)ACKTimeout interval timed from the (#1601)PHY-TXEND.confirm primitive, followed by AIFSN[AC] (#1630)× aSlotTime + aSIFSTime – aRxTxTurnaroundTime of idle medium, and
* The end of the first AIFSN[AC] × aSlotTime – aRxTxTurnaroundTime of idle medium after SIFS (not necessarily medium idle during the SIFS(#156), the start of the SIFS(#156) implied by the length in the PHY(#61) header of the previous frame) when a PHY-RXEND.indication primitive occurs as specified in 9.3.2.9 ((#1198)Ack procedure).
* Following AIFSN[AC] × aSlotTime – aRxTxTurnaroundTime of idle medium after SIFS (not necessarily medium idle during the SIFS(#156)) 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.
* 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).
* Following aSlotTime of idle medium, which occurs immediately after any of these conditions, a) to f), is met for the EDCAF.

(21) On these specific slot boundaries, each EDCAF shall make a determination to perform one and only one of the following functions:

* Decrement the backoff timer for that access function.
* Initiate the transmission of a frame exchange sequence for that access function.
* Invoke the backoff procedure due to an internal collision.
* Do nothing.

NOTE—In the case that an EDCAF gains access to the channel and transmits MSDUs, A-MSDUs, or MMPDUs from a secondary AC, the EDCAF of the secondary AC is not affected by this operation. If the EDCAF of a secondary AC experiences an internal collision with the EDCAF that gained access to the channel, it performs the backoff procedure regardless of the transmission of any of its MSDUs, A-MSDUs, or MMPDUs.(11ac) (See 9.21.2.4 (Sharing an EDCA TXOP(11ac)))

(24) At each of the above-described specific slot boundaries, each EDCAF shall decrement the backoff timer if the backoff timer for that EDCAF has a nonzero value.

(23) At each of the above-described specific slot boundaries, each EDCAF shall initiate a transmission sequence if

* There is a frame available for transmission at that EDCAF, and
* The backoff timer for that EDCAF has a value of 0, and
* Initiation of a transmission sequence is not allowed to commence at this time for an EDCAF of higher UP.

(25) At each of the above-described specific slot boundaries, each EDCAF shall report an internal collision (which is handled in 9.21.2.6 (EDCA backoff procedure)) if

* There is a frame available for transmission at that EDCAF, and
* The backoff timer for that EDCAF has a value of 0, and
* Initiation of a transmission sequence is allowed to commence at this time for an EDCAF of higher UP.

(26) An example showing the relationship between AIFS, AIFSN, DIFS, and slot times immediately following a medium busy condition (and assuming that medium busy condition was not caused by a frame in error) is shown in Figure 9-26 (EDCA mechanism timing relationships(#1610)(#1609)). In this case, with AIFSN = 2, the EDCAF may decrement the backoff counter for the first time at 2 × aSlotTime following the (#1610)TxSIFS (where (#1610)TxSIFS is the time at which the MAC responds to the end of the medium busy condition if it is going to respond “after SIFS”). If, in this example, the backoff counter contained a value of 1 at the time the medium became idle, transmission would start as a result of an EDCA TXOP on-air at a time

aSIFSTime + 3 × aSlotTime

following the end of the medium busy condition.



(16) A STA shall save the TXOP holder address for the BSS in which it is associated, which is the MAC address from the Address 2 field of the frame that initiated a frame exchange sequence except when this is a CTS frame, in which case the TXOP holder address is the Address 1 field. If the TXOP holder address is obtained from a Control frame(Ed), a VHT STA shall save the non-bandwidth signaling TA value obtained from the Address 2 field. If a non-VHT STA receives(11ac) an RTS frame with the RA address matching the MAC address of the STA and the MAC address in the TA field in the RTS frame matches the saved TXOP holder address, then the STA shall send the CTS frame after SIFS, without regard for, and without resetting, its NAV. If a VHT STA receives an RTS frame with the RA address matching the MAC address of the STA and the non-bandwidth signaling TA value obtained from the Address 2 field in the RTS frame matches the saved TXOP holder address, then the STA shall send the CTS frame after SIFS, without regard for, and without resetting, its NAV.(11ac) When a STA receives a frame addressed to it that requires an immediate response, except for RTS, it shall transmit the response independent of its NAV. The saved TXOP holder address shall be cleared when the NAV is reset or when the NAV counts down to 0.

* EDCA channel access in a VHT BSS(11ac)

(76) If the MAC receives a PHY-CCA.indication primitive with the channel-list parameter present, the channels considered idle are defined in Table 9-10 (Channels indicated idle by the channel-list parameter(11ac)).

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| --- | --- |
| * Channels indicated idle by the channel-list parameter(11ac) | |
| PHY-CCA.indication channel-list element | Idle channels |
| primary | None |
| secondary | Primary 20 MHz channel |
| secondary40 | Primary 20 MHz channel and secondary 20 MHz channel |
| secondary80 | Primary 20 MHz channel, secondary 20 MHz channel, and secondary 40 MHz channel |

(17) When a STA and the BSS of which the STA is a member both support multiple channel widths, an EDCA TXOP is obtained based solely on activity of the primary channel. “Idle medium” in this subclause means “idle primary channel.” Likewise “busy medium” means “busy primary channel.” Once an EDCA TXOP has been obtained according to this subclause, further constraints defined in 10.16.9 (STA CCA sensing in a 20/40 MHz BSS) and 9.21.2.9 (EDCA channel access in a VHT BSS(11ac)) might limit the width of transmission during the TXOP or deny the channel access, based on the state of CCA on secondary channel, secondary 40 MHz channel, or secondary 80 MHz channel.(11ac)

(77) In the following description, the CCA is sampled according to the timing relationships defined in 9.3.7 (DCF timing relations). Slot boundaries are determined solely by activity on the primary channel. “Channel idle for an interval of PIFS” means that whenever CCA is sampled during the period of PIFS that ends at the start of transmission, the CCA for that channel was determined to be idle.

(78) If a STA is permitted to begin a TXOP (as defined in in 9.21.2.3 (Obtaining an EDCA TXOP) and the STA has at least one MSDU pending for transmission for the AC of the permitted TXOP, the STA shall perform exactly one of the following actions:

* The STA may transmit a 160 MHz or 80+80 MHz mask PPDU if, in addition to the primary channel being idle per the rules for obtaining a TXOP, the secondary channel, the secondary 40 MHz channel, and the secondary 80 MHz channel were all also idle during an interval of PIFS immediately preceding the start of the TXOP, or
* The STA may transmit an 80 MHz mask PPDU on the primary 80 MHz channel if, in addition to the primary channel being idle per the rules for obtaining a TXOP, both the secondary channel and the secondary 40 MHz channel were also idle during an interval of PIFS immediately preceding the start of the TXOP, or
* The STA may transmit a 40 MHz mask PPDU on the primary 40 MHz channel if, in addition to the primary channel being idle per the rules for obtaining a TXOP, the secondary channel was also idle during an interval of PIFS immediately preceding the start of the TXOP, or
* The STA may transmit a 20 MHz mask PPDU on the primary 20 MHz channel, or
* The STA may restart the channel access attempt by invoking the backoff procedure as specified in 9.21.2 (HCF (#2203)contention based channel access (EDCA)) as though the medium is busy on the primary channel as indicated by either physical or virtual CS and the backoff timer has a value of 0.

NOTE 1—In the case of rule e), the STA selects a new random number using the current value of CW[AC], and the retry counters are not updated (as described in 9.21.2.5 (Multiple frame transmission in an EDCA TXOP); backoff procedure invoked for event a)).

NOTE 2—For both an HT and a VHT STA, an EDCA TXOP is obtained based on activity on the primary channel (see 9.21.2.3 (Obtaining an EDCA TXOP)). The width of transmission is determined by the CCA status of the non-primary channels during the PIFS interval before transmission (see VHT description in 9.3.2 (Procedures common to both DCF and EDCAF)).

* Sharing an EDCA TXOP(11ac)

(27) This mode applies only to an AP that supports DL-MU-MIMO. The AC associated with the EDCAF that gains an EDCA TXOP becomes the primary AC. TXOP sharing is allowed when primary AC traffic is transmitted in a VHT MU PPDU and resources permit traffic from secondary ACs to be included, targeting up to four STAs. The inclusion of secondary AC traffic in a VHT MU PPDU shall not increase the duration of the VHT MU PPDU beyond that required to transport the primary AC traffic. If a destination is targeted by frames in the queues of both the primary AC and at least one secondary AC, the frames in the primary AC queue shall be transmitted to the destination first, among a series of downlink transmissions within a TXOP. The decision of which secondary ACs and destinations are selected for TXOP sharing, as well as the order of transmissions, are implementation specific and out of scope for this specification.

(28) When sharing, the TXOP limit that applies is the TXOP limit of the primary AC.

NOTE—An AP can protect the immediate response by preceding the VHT MU PPDU (which might have TXVECTOR parameter NUM\_USERS > 1) with an RTS/CTS exchange or a CTS-to-self transmission.

(29) An illustration of TXOP sharing is shown in Figure 9-27 (Illustration of TXOP sharing and PPDU construction(11ac)). In this figure, the AP has frames in queues of three of its ACs. It is assumed that the TXOP was obtained by AC\_VI and is shared by AC\_VO and AC\_BE. It is also assumed that these frames are targeting three STAs, STA-1 to STA-3.

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| * Illustration of TXOP sharing and PPDU construction(11ac) |

* Multiple frame transmission in an EDCA TXOP

(34)

(31) The TXNAV timer is a timer that is initialized with the duration from the Duration/ID field in the frame most recently successfully transmitted by the TXOP holder, except for PS-Poll frames. The TXNAV timer begins counting down from the end of the transmission of the PPDU containing that frame. An HT STA may retransmit unacknowledged MPDUs within the same TXOP or in a subsequent TXOP.

(30) Multiple frames may be transmitted in an EDCA TXOP that was acquired following the rules in 9.21.2.3 (Obtaining an EDCA TXOP) if there is more than one frame pending in the primary(11ac) AC for which the channel has been acquired. However, those frames that are pending in other ACs shall not be transmitted in this EDCA TXOP except when sent in a VHT MU PPDU with TXVECTOR parameter NUM\_USERS > 1 and if allowed by the rules in 9.21.2.4 (Sharing an EDCA TXOP(11ac)).(11ac) If a TXOP holder has in its transmit queue an additional frame of the primary(11ac) AC and the duration of transmission of that frame plus any expected acknowledgment for that frame is less than the remaining TXNAV timer value, then the TXOP holder(11ac) may commence transmission of that frame a SIFS (or RIFS, if the conditions defined in 9.3.2.3.2 (RIFS) are met(11ac)) after the completion of the immediately preceding frame exchange sequence, subject to the TXOP limit restriction as described in 9.21.2.2 (EDCA TXOPs). A STA shall not commence the transmission of an RTS with a bandwidth signaling TA until at least PIFS time after the immediately preceding frame exchange sequence.(11ac) An HT STA that is a TXOP holder may transmit multiple MPDUs of the same AC within an A‑MPDU as long as the duration of transmission of the A‑MPDU plus any expected (#192)BlockAck frame response is less than the remaining TXNAV timer value.

NOTE 1—PIFS is used by a VHT STA to perform CCA in the secondary 20 MHz, 40 MHz, and 80 MHz channels before receiving RTS.(11ac) (See 9.3.2 (Procedures common to both DCF and EDCAF).)

NOTE 2—An RD responder can transmit multiple MPDUs as described in 9.27.4 (Rules for RD responder).(#241)

(32) After a valid response to the initial frame of a TXOP, if the Duration/ID field is set for multiple frame transmission and there is a subsequent transmission failure, the corresponding channel access function may transmit after the 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)) provided that the duration of that transmission(Ed) plus the duration of any expected acknowledgment and applicable IFS is less than the remaining TXNAV timer value.(#251) At the expiry of the TXNAV timer, if the channel access function has not regained access to the medium, then the EDCAF shall invoke the backoff procedure that is described in 9.21.2.6 (EDCA backoff procedure). Transmission failure is defined in 9.21.2.6 (EDCA backoff procedure).

(33) All other channel access functions at the STA shall treat the medium as busy until the expiry of the TXNAV timer.

* In the following, I merged changes from CID 1292 into the insertion by .11ac. The changes from CID 1292 moved away from having “types of ack policy”, e.g. “Normal Ack policy” cited. Elsewhere the changes resulted in citing specific values of specific fields. Here the changes generalized the statement and removed references to specific “policies”.

(35) Note that, as for an EDCA TXOP, a multiple frame transmission is granted to an EDCAF, not to a STA, so that the multiple frame transmission is permitted only for the transmission of a frame of the same AC as the frame that was granted the EDCA TXOP, unless the EDCA TXOP obtained is used by an AP for a PSMP sequence or a VHT MU PPDU with TXVECTOR parameter NUM\_USERS > 1.(11ac)

(36) In the case of PSMP,(11ac) this AC transmission restriction does not apply to either the AP or the STAs participating in the PSMP sequence, but the specific restrictions on transmission during a PSMP sequence described in 9.28 (PSMP Operation) do apply.

(38) If a TXOP is protected by an RTS or CTS frame carried in a non-HT or a non-HT duplicate PPDU, the TXOP holder shall set the TXVECTOR parameter CH\_BANDWIDTH of a PPDU as follows:(11ac)

* To be the same or narrower than RXVECTOR parameter CH\_BANDWIDTH\_IN\_NON\_HT of the last received CTS frame in the same TXOP, if the RTS frame with a bandwidth signaling TA and TXVECTOR parameter DYN\_BANDWIDTH\_IN\_NON\_HT set to Dynamic has been sent by the TXOP holder in the last RTS/CTS exchange.
* Otherwise, to be the same or narrower than the TXVECTOR parameter CH\_BANDWIDTH of the RTS frame that has been sent by the TXOP holder in the last RTS/CTS exchange(Ed) in the same TXOP.

(39) If there is no RTS/CTS exchange in non-HT duplicate format in a TXOP and there is at least one non-HT duplicate frame exchange in a TXOP, the TXOP holder shall set the CH\_BANDWIDTH parameter in TXVECTOR of a PPDU sent after the first non-HT duplicate frame to be the same or narrower than the CH\_BANDWIDTH parameter in TXVECTOR of the initial frame in the first non-HT duplicate frame exchange in the same TXOP.(11ac)

(40) If there is no non-HT duplicate frame exchange in a TXOP, the TXOP holder shall set the TXVECTOR parameter CH\_BANDWIDTH of a non-initial PPDU to be the same or narrower than the TXVECTOR parameter CH\_BANDWIDTH of the preceding PPDU that it has transmitted in the same TXOP.(11ac)

(41) If a TXOP is protected by a CTS-to-self frame carried in a non-HT or non-HT duplicate PPDU, the TXOP holder shall set the TXVECTOR parameter CH\_BANDWIDTH of a PPDU to be the same or narrower than the TXVECTOR parameter CH\_BANDWIDTH of the CTS-to-self in the same TXOP.(11ac)

NOTE—The bandwidth of a PS-Poll frame does not constrain the bandwidth of an immediate data response to that PS-Poll frame.(11ac)

(15) Note that(#1288) when transmitting multiple frames in a TXOP using acknowledgment mechanisms other than Normal Ack, a protective mechanism should be used (such as RTS/CTS or the protection mechanism described in 9.25 (Protection mechanisms)). A QoS AP or a mesh STA may send group addressed frames without using any protection mechanism. In a QoS IBSS, group addressed frames shall be sent one at a time, and backoff shall be performed after the transmission of each of the group addressed frames. In an MBSS, a mesh STA may send multiple group addressed frames in a TXOP, bounded by the TXOP limit, without performing backoff after the TXOP is obtained.

9.21.2.x TXOP Limits

(11) The duration of a TXOP is the time the TXOP holder maintains uninterrupted control of the medium, and it includes the time required to transmit frames sent as an immediate response to TXOP holder transmissions. A STA obtaining a TXOP (the TXOP holder) shall, subject to the exceptions below, ensure that the duration of a TXOP does not exceed the TXOP limit, when non-zero.

(8) The TXOP limit duration values are advertised by the AP in the EDCA Parameter Set element in Beacon and Probe Response frames transmitted by the AP.

* Changes from CID 1616 merged with changes from .11ac in list item a) resulting in new a)4) below.

(9) A TXOP limit value of 0 indicates that the TXOP holder may transmit or cause to be transmitted (as responses) the following within the current TXOP:

* One of the following(11ac) at any rate, subject to the rules in 9.7 (Multirate support)
* SU PPDUs carrying fragments of a single MSDU or MMPDU(11ac)
* An SU PPDU or a VHT MU PPDU carrying a single MSDU, a single MMPDU, a single A-MSDU, or a single A-MPDU(11ac)
* A VHT MU PPDU carrying A-MPDUs to different users(11ac)
* A QoS Null frame(#1616) or PS-Poll frame(#Ed)
* Any required acknowledgments
* Any frames required for protection, including one of the following:
* An RTS/CTS exchange
* CTS to itself
* Dual CTS as specified in 9.3.2.8 (Dual CTS protection)
* Any frames required for beamforming as specified in 9.29 (Sounding PPDUs) and in 9.33.5 (VHT sounding protocol(11ac)) (11ac)
* Any frames required for link adaptation as specified in 9.30 (Link adaptation)
* Any number of BlockAckReq frames

NOTE 1—This is a rule for the TXOP holder. A TXOP responder need not be aware of the TXOP limit nor of when the TXOP was started.

NOTE 2—This rule prevents the use of RD when the TXOP limit is 0.

(10) When dot11OCBActivated is true, TXOP limits shall be 0 for each AC.

(12) The TXOP holder may exceed the TXOP Limit only if it does not transmit more than one Data or Management (Ed)frame in the TXOP, and only for:(#2408)

* Retransmission of an MPDU, not in an A-MPDU consisting of more than one MPDU
* Initial transmission of an MSDU under a Block Ack agreement, where the MSDU is not in an A-MPDU consisting of more than one MPDU and the MSDU is not in an A-MSDU
* Transmission of a Control MPDU or a QoS Null MPDU, not in an A MPDU consisting of more than one MPDU
* Initial transmission of a fragment of an MSDU or(Ed) MMPDU, if a previous fragment of that MSDU or(Ed) MMPDU was retransmitted
* Transmission of a fragment of an MSDU or(Ed) MMPDU fragmented into 16 fragments
* Transmission of an A-MPDU consisting of the initial transmission of a single MPDU not containing an A MSDU and that is not an individually addressed Management (Ed)frame
* Transmission of a group addressed MPDU, not in an A-MPDU consisting of more than one MPDU
* Transmission of a Null Data Packet (NDP)
* Insertion of .11ac was into text that has been restructured. I think the following is the correct home for it. Reviewers please check carefully.
* Transmission of a VHT NDP Announcement frame and NDP or transmission of a Beamforming Report Poll frame that fit within the TXOP limit but the response and the immediately preceding SIFS cause the TXOP limit to be exceeded.

(13) Except as described above, a STA shall fragment an individually addressed MSDU or(Ed) MMPDU so that the initial transmission of the first fragment does not cause the TXOP Limit to be exceeded.(#2408)

NOTE 3—The TXOP Limit is not exceeded for:(#2408)

* Initial transmission of an MPDU containing an unfragmented though fragmentable (see 9.2.7 (Fragmentation/defragmentation overview)) MSDU/MMPDU
* Initial transmission of the first fragment of a fragmented MSDU/MMPDU, except for an MSDU/MMPDU fragmented into 16 fragments
* Initial transmission of an A-MSDU
* Initial transmission of a fragment of a fragmented MSDU/MMPDU, if no previous fragment of that MSDU/MMPDU was retransmitted, except for an MSDU/MMPDU fragmented into 16 fragments
* Transmission of an A-MPDU consisting of a single MPDU containing an A MSDU or individually addressed Management (Ed)frame, unless this is a retransmission of that MPDU
* Transmission of an A-MPDU consisting of more than one MPDU, even if some or all of the MPDUs are retransmissions

(14) If the TXOP holder exceeds the TXOP Limit, it should use as high a PHY rate as possible to minimize the duration of the TXOP.(#2408)

NOTE 4—The rules in this subclause also apply to priority-downgraded MSDUs and(Ed) A-MSDUs (see (9.21.4.2 (#2203)Contention based admission control procedures)).

* Truncation of TXOP

(68) When a STA gains access to the channel using EDCA and empties its transmission queue, it may transmit a CF-End frame provided that the remaining duration is long enough to transmit this frame. By transmitting the CF-End frame, the STA is explicitly indicating the completion of its TXOP. In a DMG BSS, the STA shall not send a CF-End frame(#2069) with a nonzero value in the Duration/ID field if the remaining duration is shorter than 2×TXTIME(CF-End) + 2×SIFS. (11ad)

(69) A TXOP holder that transmits a CF-End frame shall not initiate any further frame exchange sequences within the current TXOP.

(70) A non-AP STA that is not the TXOP holder shall not transmit a CF-End frame.

(71) In a non-DMG network, a(11ad) STA shall interpret the reception of a CF-End frame as a NAV reset, i.e., it resets its NAV timer to 0 at the end of the PPDU containing this frame. After receiving a CF-End frame with a matching BSSID(TA) without comparing Individual/Group bit,(11ac) an AP may respond by transmitting a CF-End frame after SIFS.

NOTE 1—The transmission of a single CF-End frame by the TXOP holder resets the NAV of STAs hearing the TXOP holder. There may be STAs that could hear the TXOP responder that had set their NAV that do not hear this NAV reset. Those STAs are prevented from contending for the medium until the original NAV reservation expires.

NOTE 2—A CF-End sent by a non-AP VHT STA that is a member of a VHT BSS can include the TXVECTOR parameter CH\_BANDWIDTH\_IN\_NON\_HT as defined in 9.7.6.6 (Channel Width selection for (#100)Control frames) in case it elicits a CF-End response.(11ac)

(72) In a DMG BSS, a STA that is not in the listening mode(#2184) (9.35.6.6 (DMG protected period(#2184)(11ad))) shall interpret the reception of a CF-End frame as a NAV reset, i.e., it resets its NAV timer to 0 at the end of the time interval indicated in the value of the Duration/ID field of the received frame. The interval starts at PHY-RXEND.indication of the frame reception. The STA shall not transmit during the interval if the RA field of the frame is not equal to the STA MAC address. The STA may transmit a CF-End frame if the RA field of the received frame is equal to the STA MAC address and the value of the Duration/ID field in the received frame is not equal to 0. (11ad)

(73) Figure 9-28 (Example of TXOP truncation) shows an example of TXOP truncation. In this example, the STA accesses the medium using EDCA channel access and then transmits a nav-set sequence (e.g., RTS/CTS for non-DMG STAs or RTS/DMG CTS for DMG STAs(11ad)) (using the terminology of Annex G). After a SIFS, it then transmits an initiator-sequence, which may involve the exchange of multiple PPDUs between the TXOP holder and TXOP responders. At the end of the second sequence, the TXOP holder has no more data that it can(11ad) send that fits within the TXOP limit; therefore, it truncates the TXOP by transmitting a CF-End frame.

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| * Example of TXOP truncation |

(74) Non-DMG(11ad) STAs that receive the CF-End frame reset their NAV and can start contending for the medium without further delay. A DMG STA that receives a CF-End frame can start contending for the medium at the end of the time interval equal to the value in Duration/ID field of the frame if none of its NAV timers has a nonzero value (9.35.10 (Updating multiple NAV timers(11ad))).(11ad)(Ed)

(75) TXOP truncation shall not be used in combination with L-SIG TXOP protection when the HT Protection field of the HT Operation element is equal to nonmember protection mode or non-HT mixed mode.

* Retransmit procedures
* General(11aa)

(51) A QoS STA(#1289) shall maintain a short retry counter and a long retry counter for each MSDU, A‑MSDU, or MMPDU that belongs to a TC that requires acknowledgment. The initial value for the short and long retry counters shall be 0. QoS STAs also maintain a short retry counter and a long retry counter for each AC. They are defined as QSRC[AC] and QLRC[AC], respectively, and each is initialized to a value of 0. When dot11RobustAVStreamingImplemented is true, a QoS STA(#1289) shall maintain a short drop-eligible retry counter and a long drop-eligible retry counter for each AC. They are defined as QSDRC[AC] and QLDRC[AC], respectively, and each is initialized to a value of zero. APs with dot11RobustAVStreamingImplemented true and mesh STAs with dot11MeshGCRImplemented true, shall maintain an unsolicited retry counter.(11aa)(#1055)

(52) After an RTS frame is transmitted to protect an MSDU or MMPDU, a QoS STA performs the CTS procedure, as defined in 9.3.2.7 (CTS and DMG CTS(11ad) procedure). If a valid CTS frame is not received, the short retry counter for the MSDU or MMPDU and the QSRC[AC] for the corresponding AC shall be incremented. If a valid CTS frame is received, the QSRC[AC] for the corresponding AC shall be reset to 0.(motion\_29)

(53) (11aa)After transmitting a frame that requires an immediate acknowledgment, the STA shall perform either of the acknowledgment procedures, as appropriate, that are defined in 9.3.2.9 ((#1198)Ack procedure) and 9.23.3 (Data and acknowledgment transfer using immediate block ack(#2069) policy and delayed block ack(#2069) policy). The short retry count for an MSDU or A‑MSDU that is not part of a (#2353)block ack agreement or for an MMPDU shall be incremented every time transmission of a frame in a PSDU(#358) of length less than or equal to dot11RTSThreshold fails for that MSDU, A‑MSDU, or MMPDU. The unsolicited retry counter shall be incremented after the transmission of every A‑MSDU that is transmitted using the GCR unsolicited retry retransmission policy.(11aa)

(54) QSRC[AC] shall be incremented every time transmission of an A‑MPDU or frame in a PSDU(#358) of length less than or equal to dot11RTSThreshold fails, regardless of the presence or value of the DEI field. When dot11RobustAVStreamingImplemented is true, QSDRC[AC] shall be incremented every time transmission of an A‑MPDU or frame in which the HT variant(11ac) HT Control field is present, the DEI field is equal to 1 and the length of the PSDU(Ed) is less than or equal to dot11RTSThreshold fails.(11aa) This short retry count and the QoS STA QSRC[AC] shall be reset when an A‑MPDU or frame of length in a PSDU(#358) less than or equal to dot11RTSThreshold succeeds. When dot11RobustAVStreamingImplemented is true, the QSDRC[AC] shall be reset when an A‑MPDU or frame in a PSDU(Ed) of length less than or equal to dot11RTSThreshold succeeds, regardless of the presence or value of the DEI field.(11aa)

(55) The long retry count for an MSDU or A‑MSDU that is not part of a (#2353)block ack agreement or for an MMPDU shall be incremented every time transmission of a MAC frame in a PSDU(#358) of length greater than dot11RTSThreshold fails for that MSDU, A‑MSDU, or MMPDU.

(56) QLRC[AC] shall be incremented every time transmission of an A‑MPDU or frame in a PSDU(#358) of length greater than or equal to dot11RTSThreshold fails, regardless of the presence or value of the DEI field.(11aa) This long retry count and the QLRC[AC] shall be reset when an A‑MPDU or frame in a PSDU(#358) of length greater than dot11RTSThreshold succeeds. When dot11RobustAVStreamingImplemented is true, QLDRC[AC] shall be incremented every time transmission fails for an A‑MPDU or frame in a PSDU(Ed) of length greater than dot11RTSThreshold in which the HT variant(11ac) HT Control field is present and the DEI field is equal to 1. The QLDRC[AC] shall be reset when an A‑MPDU or frame in a PSDU(Ed) of length greater than dot11RTSThreshold succeeds, regardless of the presence or value of the DEI field.(11aa)

(57) All retransmission attempts for an MPDU that is not sent under a (#2353)block ack agreement and that has failed the acknowledgment procedure one or more times shall be made with the Retry field set to 1 in the data or (#100)Management frame.

(58) Retries for failed transmission attempts shall continue until one or more of the following conditions occurs:(11aa)

* The short retry count for the MSDU, A‑MSDU, or MMPDU is equal to MPDUdot11ShortRetryLimit.
* The long retry count for the MSDU, A‑MSDU, or MMPDU is equal to dot11LongRetryLimit.
* The short drop-eligible retry count for the MSDU, A‑MSDU, or MMPDU is equal to dot11ShortDEIRetryLimit.
* The long drop-eligible retry count for the MSDU, A‑MSDU, or MMPDU is equal to dot11LongDEIRetryLimit.
* The unsolicited retry count for the A‑MSDU is equal to dot11UnsolicitedRetryLimit.

(59) When any(11aa) of these limits is reached, retry attempts shall cease, and the MSDU, A‑MSDU, or MMPDU shall be discarded.

(60) For internal collisions occurring with the EDCA access method, the appropriate retry counters (short retry counter for MSDU, A‑MSDU, or MMPDU and QSRC[AC] or long retry counter for MSDU, A‑MSDU, or MMPDU and QLRC[AC]) are incremented. For internal collisions occurring with the EDCA access method where dot11RobustAVStreamingImplemented is true, the appropriate drop-eligible retry counters (QSDRC[AC], and QLDRC[AC]) are incremented when the collision occurs for an(Ed) MSDU, A‑MSDU, or MMPDU that has drop eligibility equal to 1.(11aa) For transmissions that use block ack(#2069), the rules in 9.23.3 (Data and acknowledgment transfer using immediate block ack(#2069) policy and delayed block ack(#2069) policy) also apply. A STA(#1289) shall retry failed transmissions until the transmission is successful or until the relevant retry limit is reached.

(61) With the exception of a frame belonging to a TID for which block ack(#2069) is set up, a QoS STA shall not initiate the transmission of any management or (#100)Data frame to a specific RA while the transmission of another management or (#100)Data frame with the same RA and having been assigned its sequence number from the same sequence counter has not yet completed to the point of success, retry fail, or other MAC discard (e.g., lifetime expiry).

(62) A QoS STA(#1289) shall maintain a transmit MSDU timer for each MSDU passed to the MAC. dot11EDCATableMSDULifetime specifies the maximum amount of time allowed to transmit an MSDU for a given AC. The transmit MSDU timer shall be started when the MSDU is passed to the MAC. If the value of this timer exceeds the appropriate entry in dot11EDCATableMSDULifetime, then the MSDU, or any remaining, undelivered fragments of that MSDU, shall be discarded by the source STA without any further attempt to complete delivery of that MSDU.

(63) When A‑MSDU aggregation is used, the HT STA maintains a single timer for the whole A‑MSDU. The timer is restarted each time an MSDU is added to the A‑MSDU. The result of this procedure is that no MSDU in the A‑MSDU is discarded before a period of dot11EDCATableMSDULifetime has elapsed.

* Unsolicited retry procedure(11aa)

(64) When using the GCR unsolicited retry retransmission policy for a group address, an(Ed) AP or mesh STA may retransmit an MPDU to increase the probability of correct reception at the STAs that are listening to this group address (i.e., the group address is in their dot11GroupAddressesTable). The set of MPDUs that may be retransmitted is dependent upon whether (#2353)block ack agreements are active with the STAs that are listening to this group address and is defined in 10.24.16.3.6 (GCR unsolicited retry(11aa)). How an AP or a mesh STA chooses which MPDUs to retransmit is an implementation decision and beyond the scope of this standard.

(65) A protective mechanism (such as a mechanism described in 9.25 (Protection mechanisms)) should be used to reduce the probability of other STAs transmitting during the GCR TXOP. When using a protection mechanism that requires a response from another STA, the AP should select a STA that is a member of the GCR group.

(66) The TXOP initiation rules defined in 9.21.2.2 (EDCA TXOPs) and 9.21.3.3 (TXOP structure and timing) shall be used for initiating a GCR TXOP. The duration of a GCR TXOP shall be subject to the TXOP limits defined in 9.21.2.2 (EDCA TXOPs).

(67) When transmitting MPDUs using the GCR service with retransmission policy equal to GCR unsolicited retry, the following rules apply:

* Following a MAC protection exchange that includes a response frame, in all GCR unsolicited retry retransmissions, the STA shall either transmit the frames within a GCR TXOP separated by SIFS or invoke its backoff procedure as defined in 9.21.2.6 (EDCA backoff procedure). The STA shall not transmit an MPDU and a retransmission of the same MPDU within the same GCR TXOP. The final frame transmitted within a GCR TXOP shall follow the backoff procedure defined in 9.21.2.6 (EDCA backoff procedure)
* Without MAC protection or with MAC protection that lacks a response frame, in all transmissions, the STA shall invoke the backoff procedure defined in 9.21.2.6 (EDCA backoff procedure), using a value of CWmin[AC] for CW, at the PHY-TXEND.confirm primitive that follows the transmission of each unsolicited retry GCR MPDU.
* All retransmissions of an MPDU shall have the Retry field in their Frame Control fields set to 1.
* During a GCR TXOP, frames may be transmitted within the GCR TXOP that do not use the GCR unsolicited retry retransmission policy.

***Make the indicated changes to sub-clause 9.21.3.2.3***

**9.21.3.2.3 CAP generation**

When the HC needs access to the WM to start a CFP or a TXOP in CP, the HC shall sense the WM. When the WM is determined to be idle at the (#1610)TxPIFS slot boundary as defined in 9.3.7 (DCF timing relations), the HC shall transmit the first frame of any permitted frame exchange sequence, with the duration value set to cover the CFP or the TXOP. An HCCA TXOP shall not extend across a TBTT.(#63) The occurrence of a TBTT implies the end of the HCCA TXOP, after which the regular channel access procedure (EDCA or HCCA) is resumed. It is possible that no frame was transmitted during the TXOP. The shortened termination of the HCCA TXOP does not imply an error condition.  The first permitted frame in a CFP after a TBTT is the Beacon frame. CAPs along with the CFPs and the CPs are illustrated in Figure 9-26 (CAP/CFP/CP periods).

***Insert a new paragraph after the 5th paragraph of 9.35.5, as shown:***

A STA shall not extend a transmission frame exchange sequence that started during a CBAP beyond the end

of that CBAP. A STA that initiates a sequence shall check that the frame exchange sequence, including any

control frame responses, completes before the end of the CBAP.

Operation of the EDCAF is suspended at the end of a CBAP and is resumed at the beginning of the following CBAP. When the EDCAF is being suspended, the values of the backoff and NAV timers shall remain unchanged until the start of the following CBAP. A TXOP may be obtained only within a CBAP. A TXOP may be obtained by a DMG STA winning an instance of EDCA contention (see 9.21.2 (HCF (#2203)contention based channel access (EDCA))) or by a DMG STA receiving a Grant frame with the AllocationType field equal to 1. S***Original text (from D2.6) – with paragraph numbers added***

* HCF
* General

(1) Under HCF, the basic unit of allocation of the right to transmit onto the WM is the TXOP. Each TXOP is defined by a starting time and a defined maximum length. In a non-DMG network, (11ad) the TXOP may be obtained by a STA winning an instance of EDCA contention (see HCF ) during the CP or by a STA receiving a QoS (+)CF-Poll frame (see **Error! Reference source not found.**) during the CP or CFP. The former is called *EDCA TXOP*, while the latter is called *HCCA TXOP* or *polled TXOP*. An HCCA TXOP shall not extend across a TBTT.(#63) The occurrence of a TBTT implies the end of the HCCA TXOP, after which the regular channel access procedure (EDCA or HCCA) is resumed. It is possible that no frame was transmitted during the TXOP. The shortened termination of the HCCA TXOP does not imply an error condition.

(2) In a DMG BSS, the EDCAF operates only during CBAPs. Operation of the EDCAF is suspended at the end of a CBAP and is resumed at the beginning of the following CBAP. When the EDCAF is being suspended, the values of the backoff and NAV timers shall remain unchanged until the start of the following CBAP. A TXOP may be obtained only within a CBAP. A TXOP may be obtained by a DMG STA winning an instance of EDCA contention (see HCF ) or by a DMG STA receiving a Grant frame with the AllocationType field equal to 1. See **Error! Reference source not found.** and **Error! Reference source not found.** for additional rules regarding (#2203)contention based access in DMG BSSs. (11ad)

(3) HCCA is not used by DMG STAs.(11ad)

* HCF (#2203)contention based channel access (EDCA)
* Reference implementation

(4) The channel access protocol is derived from the DCF procedures described in **Error! Reference source not found.**.

(5) A model of the reference implementation is shown in **Error! Reference source not found.** for the case in which dot11AlternateEDCAActivated is false or not present and in **Error! Reference source not found.** for the case in which dot11AlternateEDCAActivated is true. These figures illustrate(11aa) a mapping from frame type or UP to the (11aa) transmit queues and the four independent EDCAFs.(11aa) The mapping of UP to the transmit queue and the mapping to AC are(11aa) described in **Error! Reference source not found.** and **Error! Reference source not found.**. The mapping of frame types to ACs is described in **Error! Reference source not found.**.



(6) A DMG STA may implement a single AC. If the DMG(#DMG) STA implements a single AC, all UP and frame types shall be mapped to AC\_BE. (11ad)

NOTE—A DMG STA that implements a single AC has only one queue in **Error! Reference source not found.**. (11ad)

* EDCA TXOPs

(7) There are three(11ac) modes of EDCA TXOP defined:(Ed) initiation of an EDCA TXOP, sharing an EDCA TXOP,(11ac) and multiple frame transmission within an EDCA TXOP. Initiation of the TXOP occurs when the EDCA rules permit access to the medium. Sharing of the EDCA TXOP occurs when an EDCAF has obtained access to the medium, making the corresponding AC the primary AC, and includes traffic from queues associated with other ACs in VHT MU PPDUs transmitted during the TXOP.(11ac) Multiple frame transmission within the TXOP occurs when an EDCAF retains the right to access the medium following the completion of a frame exchange sequence, such as on receipt of an (#1198)Ack frame.

(8) The TXOP limit duration values are advertised by the AP in the EDCA Parameter Set element in Beacon and Probe Response frames transmitted by the AP.

* Changes from CID 1616 merged with changes from .11ac in list item a) resulting in new a)4) below.

(9) A TXOP limit value of 0 indicates that the TXOP holder may transmit or cause to be transmitted (as responses) the following within the current TXOP:

* One of the following(11ac) at any rate, subject to the rules in **Error! Reference source not found.**
* SU PPDUs carrying fragments of a single MSDU or MMPDU(11ac)
* An SU PPDU or a VHT MU PPDU carrying a single MSDU, a single MMPDU, a single A-MSDU, or a single A-MPDU(11ac)
* A VHT MU PPDU carrying A-MPDUs to different users(11ac)
* A QoS Null frame(#1616) or PS-Poll frame(#Ed)
* Any required acknowledgments
* Any frames required for protection, including one of the following:
* An RTS/CTS exchange
* CTS to itself
* Dual CTS as specified in **Error! Reference source not found.**
* Any frames required for beamforming as specified in **Error! Reference source not found.** and in **Error! Reference source not found.**(11ac)
* Any frames required for link adaptation as specified in **Error! Reference source not found.**
* Any number of BlockAckReq frames

NOTE 1—This is a rule for the TXOP holder. A TXOP responder need not be aware of the TXOP limit nor of when the TXOP was started.

NOTE 2—This rule prevents the use of RD when the TXOP limit is 0.

(10) When dot11OCBActivated is true, TXOP limits shall be 0 for each AC.

(11) A STA obtaining a TXOP (the TXOP holder) shall, subject to the exceptions below, ensure that the duration of a TXOP does not exceed the TXOP Limit, when non-zero. The duration of a TXOP is the time the TXOP holder maintains uninterrupted control of the medium, and it includes the time required to transmit frames sent as an immediate response to TXOP holder transmissions.

(12) The TXOP holder may exceed the TXOP Limit only if it does not transmit more than one Data or Management (Ed)frame in the TXOP, and only for:(#2408)

* Retransmission of an MPDU, not in an A-MPDU consisting of more than one MPDU
* Initial transmission of an MSDU under a Block Ack agreement, where the MSDU is not in an A-MPDU consisting of more than one MPDU and the MSDU is not in an A-MSDU
* Transmission of a Control MPDU or a QoS Null MPDU, not in an A MPDU consisting of more than one MPDU
* Initial transmission of a fragment of an MSDU or(Ed) MMPDU, if a previous fragment of that MSDU or(Ed) MMPDU was retransmitted
* Transmission of a fragment of an MSDU or(Ed) MMPDU fragmented into 16 fragments
* Transmission of an A-MPDU consisting of the initial transmission of a single MPDU not containing an A MSDU and that is not an individually addressed Management (Ed)frame
* Transmission of a group addressed MPDU, not in an A-MPDU consisting of more than one MPDU
* Transmission of a Null Data Packet (NDP)
* Insertion of .11ac was into text that has been restructured. I think the following is the correct home for it. Reviewers please check carefully.
* Transmission of a VHT NDP Announcement frame and NDP or transmission of a Beamforming Report Poll frame that fit within the TXOP limit but the response and the immediately preceding SIFS cause the TXOP limit to be exceeded.

(13) Except as described above, a STA shall fragment an individually addressed MSDU or(Ed) MMPDU so that the initial transmission of the first fragment does not cause the TXOP Limit to be exceeded.(#2408)

NOTE—The TXOP Limit is not exceeded for:(#2408)

* Initial transmission of an MPDU containing an unfragmented though fragmentable (see **Error! Reference source not found.**) MSDU/MMPDU
* Initial transmission of the first fragment of a fragmented MSDU/MMPDU, except for an MSDU/MMPDU fragmented into 16 fragments
* Initial transmission of an A-MSDU
* Initial transmission of a fragment of a fragmented MSDU/MMPDU, if no previous fragment of that MSDU/MMPDU was retransmitted, except for an MSDU/MMPDU fragmented into 16 fragments
* Transmission of an A-MPDU consisting of a single MPDU containing an A MSDU or individually addressed Management (Ed)frame, unless this is a retransmission of that MPDU
* Transmission of an A-MPDU consisting of more than one MPDU, even if some or all of the MPDUs are retransmissions

(14) If the TXOP holder exceeds the TXOP Limit, it should use as high a PHY rate as possible to minimize the duration of the TXOP.(#2408)

NOTE—The rules in this subclause apply to priority-downgraded MSDUs and(Ed) A-MSDUs (see **Error! Reference source not found.**

(15) Note that(#1288) when transmitting multiple frames in a TXOP using acknowledgment mechanisms other than Normal Ack, a protective mechanism should be used (such as RTS/CTS or the protection mechanism described in **Error! Reference source not found.**). A QoS AP or a mesh STA may send group addressed frames without using any protection mechanism. In a QoS IBSS, group addressed frames shall be sent one at a time, and backoff shall be performed after the transmission of each of the group addressed frames. In an MBSS, a mesh STA may send multiple group addressed frames in a TXOP, bounded by the TXOP limit, without performing backoff after the TXOP is obtained.

(16) A STA shall save the TXOP holder address for the BSS in which it is associated, which is the MAC address from the Address 2 field of the frame that initiated a frame exchange sequence except when this is a CTS frame, in which case the TXOP holder address is the Address 1 field. If the TXOP holder address is obtained from a Control frame(Ed), a VHT STA shall save the non-bandwidth signaling TA value obtained from the Address 2 field. If a non-VHT STA receives(11ac) an RTS frame with the RA address matching the MAC address of the STA and the MAC address in the TA field in the RTS frame matches the saved TXOP holder address, then the STA shall send the CTS frame after SIFS, without regard for, and without resetting, its NAV. If a VHT STA receives an RTS frame with the RA address matching the MAC address of the STA and the non-bandwidth signaling TA value obtained from the Address 2 field in the RTS frame matches the saved TXOP holder address, then the STA shall send the CTS frame after SIFS, without regard for, and without resetting, its NAV.(11ac) When a STA receives a frame addressed to it that requires an immediate response, except for RTS, it shall transmit the response independent of its NAV. The saved TXOP holder address shall be cleared when the NAV is reset or when the NAV counts down to 0.

* Obtaining an EDCA TXOP

(17) When a STA and the BSS, of which the STA is a member, both support multiple channel widths, an EDCA TXOP is obtained based solely on activity of the primary channel. “Idle medium” in this subclause means “idle primary channel.” Likewise “busy medium” means “busy primary channel.” Once an EDCA TXOP has been obtained according to this subclause, further constraints defined in 10.16.9 (STA CCA sensing in a 20/40 MHz BSS) and **Error! Reference source not found.** might limit the width of transmission during the TXOP or deny the channel access, based on the state of CCA on secondary channel, secondary 40 MHz channel, or secondary 80 MHz channel.(11ac)

(18) Each channel access timer shall maintain a backoff function (timer), which has a value measured in backoff slots.

(19) The duration AIFS[AC] is a duration derived from the value AIFSN[AC] by the relation

AIFS[AC] = AIFSN[AC] × aSlotTime + aSIFSTime.

(20) In EDCA, the value of AIFSN[AC] shall be greater than or equal to 2 for non-AP STAs.(#2437) In an infrastructure BSS, AIFSN[AC] is advertised by the AP in the EDCA Parameter Set element in Beacon and Probe Response frames transmitted by the AP. The value of AIFSN[AC] shall be greater than or equal to 1 for APs. An EDCA TXOP is granted to an EDCAF when the EDCAF determines that it shall initiate the transmission of a frame exchange sequence. Transmission initiation shall be determined according to the following rules:

(21) On specific slot boundaries as determined on the primary channel,(11ac) each EDCAF shall make a determination to perform one and only one of the following functions:

* Initiate the transmission of a frame exchange sequence for that access function.
* Decrement the backoff timer for that access function.
* Invoke the backoff procedure due to an internal collision.
* Do nothing for that access function.

NOTE—In the case that an EDCAF gains access to the channel and transmits MSDUs, A-MSDUs, or MMPDUs from a secondary AC, the EDCAF of the secondary AC is not affected by this operation. If the EDCAF of a secondary AC experiences an internal collision with the EDCAF that gained access to the channel, it performs the backoff procedure regardless of the transmission of any of its MSDUs, A-MSDUs, or MMPDUs.(11ac)

(22) The specific slot boundaries at which exactly one of these operations shall be performed are defined as follows, for each EDCAF:

* Following AIFSN[AC] × aSlotTime – aRxTxTurnaroundTime of idle medium after SIFS (not necessarily idle medium during the SIFS(#156)) after the last busy medium on the antenna that was the result of a reception of a frame with a correct FCS.
* Following EIFS – DIFS + AIFSN[AC] × aSlotTime + aSIFSTime – aRxTxTurnaroundTime of idle medium after the last indicated busy medium as determined by the physical CS mechanism 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.
* When any other EDCAF at this STA transmitted a frame requiring acknowledgment, the earlier of
  + The end of the (#1627)ACKTimeout interval timed from the (#1601)PHY-TXEND.confirm primitive, followed by AIFSN[AC] (#1630)× aSlotTime + aSIFSTime – aRxTxTurnaroundTime of idle medium, and
* The end of the first AIFSN[AC] × aSlotTime – aRxTxTurnaroundTime of idle medium after SIFS (not necessarily medium idle during the SIFS(#156), the start of the SIFS(#156) implied by the length in the PHY(#61) header of the previous frame) when a PHY-RXEND.indication primitive occurs as specified in **Error! Reference source not found.**.
* Following AIFSN[AC] × aSlotTime – aRxTxTurnaroundTime of idle medium after SIFS (not necessarily medium idle during the SIFS(#156)) 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.
* 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).
* Following aSlotTime of idle medium, which occurs immediately after any of these conditions, a) to f), is met for the EDCAF.

(23) At each of the above-described specific slot boundaries, each EDCAF shall initiate a transmission sequence if

* There is a frame available for transmission at that EDCAF, and
* The backoff timer for that EDCAF has a value of 0, and
* Initiation of a transmission sequence is not allowed to commence at this time for an EDCAF of higher UP.

(24) At each of the above-described specific slot boundaries, each EDCAF shall decrement the backoff timer if the backoff timer for that EDCAF has a nonzero value.

(25) At each of the above-described specific slot boundaries, each EDCAF shall report an internal collision (which is handled in EDCA backoff procedure) if

* There is a frame available for transmission at that EDCAF, and
* The backoff timer for that EDCAF has a value of 0, and
* Initiation of a transmission sequence is allowed to commence at this time for an EDCAF of higher UP.

(26) An example showing the relationship between AIFS, AIFSN, DIFS, and slot times immediately following a medium busy condition (and assuming that medium busy condition was not caused by a frame in error) is shown in **Error! Reference source not found.**. In this case, with AIFSN = 2, the EDCAF may decrement the backoff counter for the first time at 2 × aSlotTime following the (#1610)TxSIFS (where (#1610)TxSIFS is the time at which the MAC responds to the end of the medium busy condition if it is going to respond “after SIFS”). If, in this example, the backoff counter contained a value of 1 at the time the medium became idle, transmission would start as a result of an EDCA TXOP on-air at a time

aSIFSTime + 3 × aSlotTime

following the end of the medium busy condition.



* Sharing an EDCA TXOP(11ac)

(27) This mode applies only to an AP that supports DL-MU-MIMO. The AC associated with the EDCAF that gains an EDCA TXOP becomes the primary AC. TXOP sharing is allowed when primary AC traffic is transmitted in a VHT MU PPDU and resources permit traffic from secondary ACs to be included, targeting up to four STAs. The inclusion of secondary AC traffic in a VHT MU PPDU shall not increase the duration of the VHT MU PPDU beyond that required to transport the primary AC traffic. If a destination is targeted by frames in the queues of both the primary AC and at least one secondary AC, the frames in the primary AC queue shall be transmitted to the destination first, among a series of downlink transmissions within a TXOP. The decision of which secondary ACs and destinations are selected for TXOP sharing, as well as the order of transmissions, are implementation specific and out of scope for this specification.

(28) When sharing, the TXOP duration that applies is the TXOP limit of the primary AC.

NOTE—An AP can protect the immediate response by preceding the VHT MU PPDU (which might have TXVECTOR parameter NUM\_USERS > 1) with an RTS/CTS exchange or a CTS-to-self transmission.

(29) An illustration of TXOP sharing is shown in Illustration of TXOP sharing and PPDU construction. In this figure, the AP has frames in queues of three of its ACs. It is assumed that the TXOP was obtained by AC\_VI and is shared by AC\_VO and AC\_BE. It is also assumed that these frames are targeting three STAs, STA-1 to STA-3.

|  |
| --- |
|  |
| * Illustration of TXOP sharing and PPDU construction(11ac) |

* Multiple frame transmission in an EDCA TXOP

(30) Multiple frames may be transmitted in an EDCA TXOP that was acquired following the rules in Obtaining an EDCA TXOP if there is more than one frame pending in the primary(11ac) AC for which the channel has been acquired. However, those frames that are pending in other ACs shall not be transmitted in this EDCA TXOP except when sent in a VHT MU PPDU with TXVECTOR parameter NUM\_USERS > 1 and if allowed by the rules in Sharing an EDCA TXOP.(11ac) If a TXOP holder has in its transmit queue an additional frame of the primary(11ac) AC and the duration of transmission of that frame plus any expected acknowledgment for that frame is less than the remaining TXNAV timer value, then the TXOP holder(11ac) may commence transmission of that frame a SIFS (or RIFS, if the conditions defined in **Error! Reference source not found.** are met(11ac)) after the completion of the immediately preceding frame exchange sequence, subject to the TXOP limit restriction as described in EDCA TXOPs. A STA shall not commence the transmission of an RTS with a bandwidth signaling TA until at least PIFS time after the immediately preceding frame exchange sequence.(11ac) An HT STA that is a TXOP holder may transmit multiple MPDUs of the same AC within an A‑MPDU as long as the duration of transmission of the A‑MPDU plus any expected (#192)BlockAck frame response is less than the remaining TXNAV timer value.

NOTE 1—PIFS is used by a VHT STA to perform CCA in the secondary 20 MHz, 40 MHz, and 80 MHz channels before receiving RTS.(11ac)

NOTE 2—An RD responder can transmit multiple MPDUs as described in **Error! Reference source not found.**.(#241)

(31) The TXNAV timer is a timer that is initialized with the duration from the Duration/ID field in the frame most recently successfully transmitted by the TXOP holder. The TXNAV timer begins counting down from the end of the transmission of the PPDU containing that frame. Following the (#192)BlockAck frame response, the HT STA may start transmission of another MPDU or A‑MPDU a SIFS after the completion of the immediately preceding frame exchange sequence. The HT STA may retransmit unacknowledged MPDUs within the same TXOP or in a subsequent TXOP.

(32) After a valid response to the initial frame of a TXOP, if the Duration/ID field is set for multiple frame transmission and there is a subsequent transmission failure, the corresponding channel access function may transmit after the CS mechanism (see **Error! Reference source not found.**) indicates that the medium is idle at the TxPIFS slot boundary (defined in **Error! Reference source not found.**) provided that the duration of that transmission(Ed) plus the duration of any expected acknowledgment and applicable IFS is less than the remaining TXNAV timer value.(#251) At the expiry of the TXNAV timer, if the channel access function has not regained access to the medium, then the EDCAF shall invoke the backoff procedure that is described in EDCA backoff procedure. Transmission failure is defined in EDCA backoff procedure.

(33) All other channel access functions at the STA shall treat the medium as busy until the expiry of the TXNAV timer.

* In the following, I merged changes from CID 1292 into the insertion by .11ac. The changes from CID 1292 moved away from having “types of ack policy”, e.g. “Normal Ack policy” cited. Elsewhere the changes resulted in citing specific values of specific fields. Here the changes generalized the statement and removed references to specific “policies”.

(34) A frame exchange may be one of the following:(11ac)

* A frame not requiring immediate acknowledgment (such as a group addressed frame or a frame transmitted with an acknowledgement policy that does not require immediate acknowledgement) or an A-MPDU containing only such frames
* A frame requiring acknowledgment (such as an individually addressed frame transmitted with an acknowledgement policy that requires immediate acknowledgement) or an A-MPDU containing at least one such frame, followed after SIFS by a corresponding acknowledgment frame
* Either
* a VHT NDP Announcement frame followed after SIFS by a VHT NDP, or
* a Beamforming Report Poll frame

followed after SIFS by a PPDU containing one or more VHT Compressed Beamforming frames

(35) Note that, as for an EDCA TXOP, a multiple frame transmission is granted to an EDCAF, not to a STA, so that the multiple frame transmission is permitted only for the transmission of a frame of the same AC as the frame that was granted the EDCA TXOP, unless the EDCA TXOP obtained is used by an AP for a PSMP sequence or a VHT MU PPDU with TXVECTOR parameter NUM\_USERS > 1.(11ac)

(36) In the case of PSMP,(11ac) this AC transmission restriction does not apply to either the AP or the STAs participating in the PSMP sequence, but the specific restrictions on transmission during a PSMP sequence described in **Error! Reference source not found.** do apply.

(37) When permitted by the rules in Sharing an EDCA TXOP, traffic from secondary ACs may be transmitted in a VHT MU PPDU that has TXVECTOR parameter NUM\_USERS > 1 and that carries traffic for the primary AC.(11ac)

(38) If a TXOP is protected by an RTS or CTS frame carried in a non-HT or a non-HT duplicate PPDU, the TXOP holder shall set the TXVECTOR parameter CH\_BANDWIDTH of a PPDU as follows:(11ac)

* To be the same or narrower than RXVECTOR parameter CH\_BANDWIDTH\_IN\_NON\_HT of the last received CTS frame in the same TXOP, if the RTS frame with a bandwidth signaling TA and TXVECTOR parameter DYN\_BANDWIDTH\_IN\_NON\_HT set to Dynamic has been sent by the TXOP holder in the last RTS/CTS exchange.
* Otherwise, to be the same or narrower than the TXVECTOR parameter CH\_BANDWIDTH of the RTS frame that has been sent by the TXOP holder in the last RTS/CTS exchange(Ed) in the same TXOP.

(39) If there is no RTS/CTS exchange in non-HT duplicate format in a TXOP and there is at least one non-HT duplicate frame exchange in a TXOP, the TXOP holder shall set the CH\_BANDWIDTH parameter in TXVECTOR of a PPDU sent after the first non-HT duplicate frame to be the same or narrower than the CH\_BANDWIDTH parameter in TXVECTOR of the initial frame in the first non-HT duplicate frame exchange in the same TXOP.(11ac)

(40) If there is no non-HT duplicate frame exchange in a TXOP, the TXOP holder shall set the TXVECTOR parameter CH\_BANDWIDTH of a non-initial PPDU to be the same or narrower than the TXVECTOR parameter CH\_BANDWIDTH of the preceding PPDU that it has transmitted in the same TXOP.(11ac)

(41) If a TXOP is protected by a CTS-to-self frame carried in a non-HT or non-HT duplicate PPDU, the TXOP holder shall set the TXVECTOR parameter CH\_BANDWIDTH of a PPDU to be the same or narrower than the TXVECTOR parameter CH\_BANDWIDTH of the CTS-to-self in the same TXOP.(11ac)

NOTE—The bandwidth of a PS-Poll frame does not constrain the bandwidth of an immediate data response to that PS-Poll frame.(11ac)

* EDCA backoff procedure

(42) Each EDCAF shall maintain a state variable CW[AC], which shall be initialized to the value of the parameter CWmin[AC].

(43) For the purposes of this subclause, successful transmission and transmission failure of an MPDU(11ac) are defined as follows:

* After transmitting an MPDU (even if(11ac) it is carried in an A‑MPDU or as part of a VHT MU PPDU that might have TXVECTOR parameter NUM\_USERS > 1)(11ac) that requires an immediate frame as a response, the STA shall wait for a timeout interval of duration of aSIFSTime + aSlotTime + aRxPHYStartDelay(#1486), starting at the PHY-TXEND.confirm primitive. If a PHY-RXSTART.indication primitive does not occur during the timeout interval, the STA concludes that the transmission of the MPDU has failed.
* If a PHY-RXSTART.indication primitive does occur during the timeout interval, the STA shall wait for the corresponding PHY-RXEND.indication primitive to determine whether the MPDU transmission was successful. The recognition of a valid response frame sent by the recipient of the MPDU requiring a response, corresponding to this PHY-RXEND.indication primitive, shall be interpreted as a successful response.
* (11aa)The recognition of a valid (#100)Data frame sent by the recipient of a PS-Poll frame shall also be accepted as successful acknowledgment of the PS-Poll frame.
* The transmission of an MPDU(11ac) that does not require an immediate frame as a response is defined as a successful transmission, unless it is one of the nonfinal (re)transmissions of an MPDU that is delivered using the GCR unsolicited retry retransmission policy (Unsolicited retry procedure).(11aa)
* The nonfinal (re)transmission of an MPDU that is delivered using the GCR unsolicited retry retransmission policy (Unsolicited retry procedure)) is defined to be a failure.(11aa)
* The final (re)transmission of an MPDU that is delivered using the GCR unsolicited retry retransmission policy (Unsolicited retry procedure) is defined as a successful transmission.(11aa)
* The recognition of anything else, including any other valid frame, shall be interpreted as failure of the MPDU transmission.(11aa)

(44) The backoff procedure shall be invoked for an EDCAF when any of the following events occurs:

* 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,(#1439) the medium is busy on the primary channel(11ac) as indicated by either physical or virtual CS, and the backoff timer has a value of 0 for that AC.
* In the following, .11ac changed “successful” to “successful as defined in this subclause”. Comment 285 chaned “succesful” to “completed”. The .11ac change has been ignored.
* The transmission of the MPDU in the final PPDU transmitted(11ac) by the TXOP holder during the TXOP for that AC has completed(#285) and the TXNAV timer has expired, and the AC was a primary AC.(11ac)
* The expected immediate response to(11ac) the initial frame of a TXOP of that AC is not received and the AC was a primary AC.(11ac)
* The transmission attempt collides internally with another EDCAF of an AC that has higher priority, that is, two or more EDCAFs in the same STA are granted a TXOP at the same time.(11ac)
* The transmission attempt of a STA coordinated by an MM-SME collides internally with another STA coordinated by the same MM-SME (see 10.34 (MMSL cluster operation(11ad))), which is indicated to the first MAC entity with a (#2123)PHY-TXBUSY.indication (BUSY) as response to the PHY-TXSTART.request primitive. (11ad)
* Is the following necessary. See previous Editor Note. There may be no need to define “successful”.

NOTE 1—For the purpose of this subclause, reception of a valid immediate response to any of the MPDUs in this PPDU determines that transmission of all MPDUs in the PPDU was successful.

(45) In addition, the backoff procedure may be invoked for an EDCAF when the transmission of the MPDUs in a non-initial PPDU by the TXOP holder fails.(11ac)

NOTE 2(#1101)—A STA can perform a PIFS recovery, as described in Multiple frame transmission in an EDCA TXOP, or perform a backoff, as described in the previous paragraph, as a response to transmission failure within a TXOP. How it chooses between these two is implementation dependent.

(46) A STA that performs a backoff within its existing TXOP shall not extend the TXNAV timer value.

NOTE 3(#1101)—In other words, the backoff is a continuation of the TXOP, not the start of a new TXOP.

(47) If the backoff procedure is invoked for reason a) above, the value of CW[AC] shall be left unchanged. If the backoff procedure is invoked because of reason b) above, the value of CW[AC] shall be reset to CWmin[AC].

NOTE 4—If condition b) or c) occurs for a secondary AC, the backoff for the associated EDCAF continues without change to the backoff counter or to the value of CW[AC].(11ac)

(48) If the backoff procedure is invoked because of a failure event [reason c), d), or e)(11ad) above or the transmission failure of a non-initial frame by the TXOP holder], the value of CW[AC] shall be updated as follows before invoking the backoff procedure:

* If the QSRC[AC] or the QLRC[AC] (#1056)has reached dot11ShortRetryLimit or dot11LongRetryLimit respectively, CW[AC] shall be reset to CWmin[AC].
* If dot11RobustAVStreamingImplemented is true and either(#1056) the QSDRC[AC] or the QLDRC[AC] has reached dot11ShortDEIRetryLimit or dot11LongDEIRetryLimit, respectively, CW[AC] shall be reset to CWmin[AC].(11aa)
* Otherwise,
* If CW[AC] is less than CWmax[AC], CW[AC] shall be set to the value (CW[AC] + 1)×2 – 1.
* If CW[AC] is equal to CWmax[AC], CW[AC] shall remain unchanged for the remainder of any retries.

(49) The backoff timer is set to an integer value chosen randomly with a uniform distribution taking values in the range [0,CW[AC]] inclusive.

(50) All backoff slots occur following an AIFS[AC] period during which the medium is determined to be idle on the primary channel(11ac) for the duration of the AIFS[AC] period, or following an EIFS – DIFS + AIFS[AC] period during which the medium is determined to be idle on the primary channel(11ac) for the duration of the EIFS – DIFS + AIFS[AC] period, as appropriate (see **Error! Reference source not found.**), except as defined in Obtaining an EDCA TXOP, which allows the medium to be busy during the initial aSIFSTime of this period under certain conditions.(11ac)

* Retransmit procedures
* General(11aa)

(51) A QoS STA(#1289) shall maintain a short retry counter and a long retry counter for each MSDU, A‑MSDU, or MMPDU that belongs to a TC that requires acknowledgment. The initial value for the short and long retry counters shall be 0. QoS STAs also maintain a short retry counter and a long retry counter for each AC. They are defined as QSRC[AC] and QLRC[AC], respectively, and each is initialized to a value of 0. When dot11RobustAVStreamingImplemented is true, a QoS STA(#1289) shall maintain a short drop-eligible retry counter and a long drop-eligible retry counter for each AC. They are defined as QSDRC[AC] and QLDRC[AC], respectively, and each is initialized to a value of zero. APs with dot11RobustAVStreamingImplemented true and mesh STAs with dot11MeshGCRImplemented true, shall maintain an unsolicited retry counter.(11aa)(#1055)

(52) After an RTS frame is transmitted to protect an MSDU or MMPDU, a QoS STA performs the CTS procedure, as defined in **Error! Reference source not found.**. If a valid CTS frame is not received, the short retry counter for the MSDU or MMPDU and the QSRC[AC] for the corresponding AC shall be incremented. If a valid CTS frame is received, the QSRC[AC] for the corresponding AC shall be reset to 0.(motion\_29)

(53) (11aa)After transmitting a frame that requires an immediate acknowledgment, the STA shall perform either of the acknowledgment procedures, as appropriate, that are defined in **Error! Reference source not found.** and **Error! Reference source not found.**. The short retry count for an MSDU or A‑MSDU that is not part of a (#2353)block ack agreement or for an MMPDU shall be incremented every time transmission of a frame in a PSDU(#358) of length less than or equal to dot11RTSThreshold fails for that MSDU, A‑MSDU, or MMPDU. The unsolicited retry counter shall be incremented after the transmission of every A‑MSDU that is transmitted using the GCR unsolicited retry retransmission policy.(11aa)

(54) QSRC[AC] shall be incremented every time transmission of an A‑MPDU or frame in a PSDU(#358) of length less than or equal to dot11RTSThreshold fails, regardless of the presence or value of the DEI field. When dot11RobustAVStreamingImplemented is true, QSDRC[AC] shall be incremented every time transmission of an A‑MPDU or frame in which the HT variant(11ac) HT Control field is present, the DEI field is equal to 1 and the length of the PSDU(Ed) is less than or equal to dot11RTSThreshold fails.(11aa) This short retry count and the QoS STA QSRC[AC] shall be reset when an A‑MPDU or frame of length in a PSDU(#358) less than or equal to dot11RTSThreshold succeeds. When dot11RobustAVStreamingImplemented is true, the QSDRC[AC] shall be reset when an A‑MPDU or frame in a PSDU(Ed) of length less than or equal to dot11RTSThreshold succeeds, regardless of the presence or value of the DEI field.(11aa)

(55) The long retry count for an MSDU or A‑MSDU that is not part of a (#2353)block ack agreement or for an MMPDU shall be incremented every time transmission of a MAC frame in a PSDU(#358) of length greater than dot11RTSThreshold fails for that MSDU, A‑MSDU, or MMPDU.

(56) QLRC[AC] shall be incremented every time transmission of an A‑MPDU or frame in a PSDU(#358) of length greater than or equal to dot11RTSThreshold fails, regardless of the presence or value of the DEI field.(11aa) This long retry count and the QLRC[AC] shall be reset when an A‑MPDU or frame in a PSDU(#358) of length greater than dot11RTSThreshold succeeds. When dot11RobustAVStreamingImplemented is true, QLDRC[AC] shall be incremented every time transmission fails for an A‑MPDU or frame in a PSDU(Ed) of length greater than dot11RTSThreshold in which the HT variant(11ac) HT Control field is present and the DEI field is equal to 1. The QLDRC[AC] shall be reset when an A‑MPDU or frame in a PSDU(Ed) of length greater than dot11RTSThreshold succeeds, regardless of the presence or value of the DEI field.(11aa)

(57) All retransmission attempts for an MPDU that is not sent under a (#2353)block ack agreement and that has failed the acknowledgment procedure one or more times shall be made with the Retry field set to 1 in the data or (#100)Management frame.

(58) Retries for failed transmission attempts shall continue until one or more of the following conditions occurs:(11aa)

* The short retry count for the MSDU, A‑MSDU, or MMPDU is equal to MPDUdot11ShortRetryLimit.
* The long retry count for the MSDU, A‑MSDU, or MMPDU is equal to dot11LongRetryLimit.
* The short drop-eligible retry count for the MSDU, A‑MSDU, or MMPDU is equal to dot11ShortDEIRetryLimit.
* The long drop-eligible retry count for the MSDU, A‑MSDU, or MMPDU is equal to dot11LongDEIRetryLimit.
* The unsolicited retry count for the A‑MSDU is equal to dot11UnsolicitedRetryLimit.

(59) When any(11aa) of these limits is reached, retry attempts shall cease, and the MSDU, A‑MSDU, or MMPDU shall be discarded.

(60) For internal collisions occurring with the EDCA access method, the appropriate retry counters (short retry counter for MSDU, A‑MSDU, or MMPDU and QSRC[AC] or long retry counter for MSDU, A‑MSDU, or MMPDU and QLRC[AC]) are incremented. For internal collisions occurring with the EDCA access method where dot11RobustAVStreamingImplemented is true, the appropriate drop-eligible retry counters (QSDRC[AC], and QLDRC[AC]) are incremented when the collision occurs for an(Ed) MSDU, A‑MSDU, or MMPDU that has drop eligibility equal to 1.(11aa) For transmissions that use block ack(#2069), the rules in **Error! Reference source not found.** also apply. A STA(#1289) shall retry failed transmissions until the transmission is successful or until the relevant retry limit is reached.

(61) With the exception of a frame belonging to a TID for which block ack(#2069) is set up, a QoS STA shall not initiate the transmission of any management or (#100)Data frame to a specific RA while the transmission of another management or (#100)Data frame with the same RA and having been assigned its sequence number from the same sequence counter has not yet completed to the point of success, retry fail, or other MAC discard (e.g., lifetime expiry).

(62) A QoS STA(#1289) shall maintain a transmit MSDU timer for each MSDU passed to the MAC. dot11EDCATableMSDULifetime specifies the maximum amount of time allowed to transmit an MSDU for a given AC. The transmit MSDU timer shall be started when the MSDU is passed to the MAC. If the value of this timer exceeds the appropriate entry in dot11EDCATableMSDULifetime, then the MSDU, or any remaining, undelivered fragments of that MSDU, shall be discarded by the source STA without any further attempt to complete delivery of that MSDU.

(63) When A‑MSDU aggregation is used, the HT STA maintains a single timer for the whole A‑MSDU. The timer is restarted each time an MSDU is added to the A‑MSDU. The result of this procedure is that no MSDU in the A‑MSDU is discarded before a period of dot11EDCATableMSDULifetime has elapsed.

* Unsolicited retry procedure(11aa)

(64) When using the GCR unsolicited retry retransmission policy for a group address, an(Ed) AP or mesh STA may retransmit an MPDU to increase the probability of correct reception at the STAs that are listening to this group address (i.e., the group address is in their dot11GroupAddressesTable). The set of MPDUs that may be retransmitted is dependent upon whether (#2353)block ack agreements are active with the STAs that are listening to this group address and is defined in 10.24.16.3.6 (GCR unsolicited retry(11aa)). How an AP or a mesh STA chooses which MPDUs to retransmit is an implementation decision and beyond the scope of this standard.

(65) A protective mechanism (such as a mechanism described in **Error! Reference source not found.**) should be used to reduce the probability of other STAs transmitting during the GCR TXOP. When using a protection mechanism that requires a response from another STA, the AP should select a STA that is a member of the GCR group.

(66) The TXOP initiation rules defined in EDCA TXOPs and **Error! Reference source not found.** shall be used for initiating a GCR TXOP. The duration of a GCR TXOP shall be subject to the TXOP limits defined in EDCA TXOPs.

(67) When transmitting MPDUs using the GCR service with retransmission policy equal to GCR unsolicited retry, the following rules apply:

* Following a MAC protection exchange that includes a response frame, in all GCR unsolicited retry retransmissions, the STA shall either transmit the frames within a GCR TXOP separated by SIFS or invoke its backoff procedure as defined in EDCA backoff procedure. The STA shall not transmit an MPDU and a retransmission of the same MPDU within the same GCR TXOP. The final frame transmitted within a GCR TXOP shall follow the backoff procedure defined in EDCA backoff procedure
* Without MAC protection or with MAC protection that lacks a response frame, in all transmissions, the STA shall invoke the backoff procedure defined in EDCA backoff procedure, using a value of CWmin[AC] for CW, at the PHY-TXEND.confirm primitive that follows the transmission of each unsolicited retry GCR MPDU.
* All retransmissions of an MPDU shall have the Retry field in their Frame Control fields set to 1.
* During a GCR TXOP, frames may be transmitted within the GCR TXOP that do not use the GCR unsolicited retry retransmission policy.
* Truncation of TXOP

(68) When a STA gains access to the channel using EDCA and empties its transmission queue, it may transmit a CF-End frame provided that the remaining duration is long enough to transmit this frame. By transmitting the CF-End frame, the STA is explicitly indicating the completion of its TXOP. In a DMG BSS, the STA shall not send a CF-End frame(#2069) with a nonzero value in the Duration/ID field if the remaining duration is shorter than 2×TXTIME(CF-End) + 2×SIFS. (11ad)

(69) A TXOP holder that transmits a CF-End frame shall not initiate any further frame exchange sequences within the current TXOP.

(70) A non-AP STA that is not the TXOP holder shall not transmit a CF-End frame.

(71) In a non-DMG network, a(11ad) STA shall interpret the reception of a CF-End frame as a NAV reset, i.e., it resets its NAV timer to 0 at the end of the PPDU containing this frame. After receiving a CF-End frame with a matching BSSID(TA) without comparing Individual/Group bit,(11ac) an AP may respond by transmitting a CF-End frame after SIFS.

NOTE 1—The transmission of a single CF-End frame by the TXOP holder resets the NAV of STAs hearing the TXOP holder. There may be STAs that could hear the TXOP responder that had set their NAV that do not hear this NAV reset. Those STAs are prevented from contending for the medium until the original NAV reservation expires.

NOTE 2—A CF-End sent by a non-AP VHT STA that is a member of a VHT BSS can include the TXVECTOR parameter CH\_BANDWIDTH\_IN\_NON\_HT as defined in **Error! Reference source not found.** in case it elicits a CF-End response.(11ac)

(72) In a DMG BSS, a STA that is not in the listening mode(#2184) (**Error! Reference source not found.**) shall interpret the reception of a CF-End frame as a NAV reset, i.e., it resets its NAV timer to 0 at the end of the time interval indicated in the value of the Duration/ID field of the received frame. The interval starts at PHY-RXEND.indication of the frame reception. The STA shall not transmit during the interval if the RA field of the frame is not equal to the STA MAC address. The STA may transmit a CF-End frame if the RA field of the received frame is equal to the STA MAC address and the value of the Duration/ID field in the received frame is not equal to 0. (11ad)

(73) **Error! Reference source not found.** shows an example of TXOP truncation. In this example, the STA accesses the medium using EDCA channel access and then transmits a nav-set sequence (e.g., RTS/CTS for non-DMG STAs or RTS/DMG CTS for DMG STAs(11ad)) (using the terminology of Annex G). After a SIFS, it then transmits an initiator-sequence, which may involve the exchange of multiple PPDUs between the TXOP holder and a TXOP responder. At the end of the second sequence, the TXOP holder has no more data that it can(11ad) send that fits within the TXOP; therefore, it truncates the TXOP by transmitting a CF-End frame.

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| * Example of TXOP truncation |

(74) Non-DMG(11ad) STA that receive the CF-End frame reset their NAV and can start contending for the medium without further delay. A DMG STA that receives a CF-End frame can start contending for the medium at the end of the time interval equal to the value in Duration/ID field of the frame if none of its NAV timers has a nonzero value (**Error! Reference source not found.**).(11ad)(Ed)

(75) TXOP truncation shall not be used in combination with L-SIG TXOP protection when the HT Protection field of the HT Operation element is equal to nonmember protection mode or non-HT mixed mode.

* EDCA channel access in a VHT BSS(11ac)

(76) If the MAC receives a PHY-CCA.indication primitive with the channel-list parameter present, the channels considered idle are defined in Channels indicated idle by the channel-list parameter.

|  |  |
| --- | --- |
| * Channels indicated idle by the channel-list parameter(11ac) | |
| PHY-CCA.indication channel-list element | Idle channels |
| primary | None |
| secondary | Primary 20 MHz channel |
| secondary40 | Primary 20 MHz channel and secondary 20 MHz channel |
| secondary80 | Primary 20 MHz channel, secondary 20 MHz channel, and secondary 40 MHz channel |

(77) In the following description, the CCA is sampled according to the timing relationships defined in **Error! Reference source not found.**. Slot boundaries are determined solely by activity on the primary channel. “Channel idle for an interval of PIFS” means that whenever CCA is sampled during the period of PIFS that ends at the start of transmission, the CCA for that channel was determined to be idle.

(78) If a STA is permitted to begin a TXOP (as defined in Obtaining an EDCA TXOP) and the STA has at least one MSDU pending for transmission for the AC of the permitted TXOP, the STA shall perform exactly one of the following steps:

* Transmit a 160 MHz or 80+80 MHz mask PPDU if the secondary channel, the secondary 40 MHz channel, and the secondary 80 MHz channel were idle during an interval of PIFS immediately preceding the start of the TXOP.
* Transmit an 80 MHz mask PPDU on the primary 80 MHz channel if both the secondary channel and the secondary 40 MHz channel were idle during an interval of PIFS immediately preceding the start of the TXOP.
* Transmit a 40 MHz mask PPDU on the primary 40 MHz channel if the secondary channel was idle during an interval of PIFS immediately preceding the start of the TXOP.
* Transmit a 20 MHz mask PPDU on the primary 20 MHz channel.
* Restart the channel access attempt by invoking the backoff procedure as specified in HCF as though the medium is busy on the primary channel as indicated by either physical or virtual CS and the backoff timer has a value of 0.

NOTE 1—In the case of rule e), the STA selects a new random number using the current value of CW[AC], and the retry counters are not updated (as described in Multiple frame transmission in an EDCA TXOP; backoff procedure invoked for event a)).

NOTE 2—For both an HT and a VHT STA, an EDCA TXOP is obtained based on activity on the primary channel (see Obtaining an EDCA TXOP). The width of transmission is determined by the CCA status of the non-primary channels during the PIFS interval before transmission (see Multiple frame transmission in an EDCA TXOP).