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Wireless LANs

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| “Proposal for New Annex G Frame Exchange Sequence Descriptions”  |
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Abstract

This proposal seeks to introduce the reader to an alternative version of Annex G for describing frame exchange sequence examples, their temporal boundaries, and recommended practice based on frame exchange sequences that are specified in the P802.11-REVme/D2.1 document.

# Background

The Architecture Standing Committee has extensively debated the disposition of Annex G for many meetings. In the course of those discussions, the group has requested a proposed revision to Annex G that explains to the novice reader of the 802.11 standard, using informative text, the concept of frame exchange sequences, as the term is consistently used throughout the standard in various contexts. To this end, proposed text for Annex G is presented below for discussion. We may want to consider as part of the discussion the prospect of moving the informative text in clause O.3 (Example of RD frame exchanges) to Annex G, as it appears to be out of place in its current location.

# Normative Text related to the definition of a frame exchange sequence

## Clause 3.1

“**wireless medium (WM):** The medium used to implement the transfer of protocol data units (PDUs) between peer physical layer (PHY) entities of a wireless local area network (LAN).”

“**channel:** An instance of use of the wireless medium (WM) for the purpose of passing physical layer (PHY) protocol data units (PDUs) between two or more stations (STAs).”

“**network allocation vector (NAV):** An indicator, maintained by each station (STA), of time periods whentransmission onto the wireless medium (WM) is not initiated by the STA regardless of whether the STA’s clear channel assessment (CCA) function senses that the WM is busy.”

This normative text definition suggests that the NAV does not control the WM, since CCA can indicate the medium is busy or idle during the NAV period. Rather, the NAV controls the behavior of the STA by inhibiting the initiation of a transmission. This may seem to be a distinction without a difference, until we appreciate that there can be extended periods when the CCA senses the WM is idle because no peer STA is transmitting. This can allow other non-peer STAs to transmit in the channel of the peer STAs during the NAV. This can happen, for example, when multiple WLANs partially overlap in the same geographic space and share the same frequency.

## Clause 3.1Clause 10.2.3.2Clause 10.23.3.3

“**transmission opportunity (TXOP):** An interval of time during which a particular quality-of-service (QoS)station (STA) has the right to initiate frame exchange sequences onto the wireless medium (WM).”

“During an EDCA TXOP won by an EDCAF a STA may initiate multiple frame exchange sequences to transmit MMPDUs and/or MSDUs within the same AC.”

“Within a polled TXOP, a STA may initiate the transmission of one or more frame exchange sequences, with all such sequences nominally separated by a SIFS.”

This normative text suggests that a TXOP does not define the start time and end time of a singular frame exchange sequence. Even a frame exchange that reserves a TXOP (such as a transmitted RTS, MU-RTS Trigger, or CTS frame) for the purpose of controlling the wireless medium for an interval of time, does not indicate the beginning of a single frame exchange sequence. Rather, a TXOP is simply a time period during which any QSTA has the ***right*** to send one or more frame exchange sequences. Thus, the definition of a TXOP does not make clear the definition of a frame exchange sequence.

In addition, there could be arbitrary-length time gaps between frame exchange sequences initiated by any QSTA during a TXOP. Note, the normative text says the “CSMA/CA distributed algorithm mandates that a gap of a minimum specified duration exists between frame exchange sequnences. A transmitting STA shall verify the medium is idle for this required duration before attempting to transmit.” §10.2.2, p. 2002, l. 38. These time gaps allow for non-peer STAs to take control of the WM, unless peer QSTAs always initiate the next frame exchange sequence after the minimum IFS (which is not a requirement for all TXOPs, only polled TXOPs).

Thus, the normative text does not support the notion that a TXOP holder is guaranteed to control the wireless medium for an uninterrupted exchange of frames spanning the entire duration of the TXOP.

# Perspectives on the frame exchange sequence time interval

For any given frame exchange sequence (FES), there can be different understandings among the peer STAs about when the FES terminates. Nonetheless, this is not a problem. For example,

Persepctive #1: The STA that initiates the FES (STA #1) identifies the end of the FES as the end of a PIFS interval following the last transmission during the FES. This last transmission during the FES is either pre-determined by the particular FES (e.g., RTS / CTS) or is scheduled by STA #1 (BAR frame).

Perspective #2: The peer STA to STA #1 (STA #2) identifies the end of the FES as the end of a PIFS interval following the last transmission during the FES from its perspective. This understanding may differ from STA #1. For example, if STA #1 transmits PPDUs to STA #2 through STA #5 on the same channel, and STA #2’s CCA function indicates the medium idle when the BlockAcks from STA #3 through #5 are transnmitted, then STA #2 will declare the end of the frame exchange sequence a PIFS interval after its BlockAck transmission. Note, however, that the NAV protection signaled by STA #1 still prevents STA #2 from initiating any transmission until STA #5 has transmitted, regardless of CCA sensing. If STA #2’s CCA function indicates the medium is busy when the BlockAcks from STA #3 through #5 are transmitted, then STA #2 will immediately terminate its FES with STA #1 if it can decode the PPDU, per the normative text. See §11.2.6:

“The STA can determine the end of the frame exchange sequence through any of the following:

* It receives an individually addressed frame addressed to another STA.
* It receives a frame with a TA that differs from the TA of the frame that started the TXOP.

. . .

* The CS mechanism (see 10.3.2.1 (CS mechanism) indicates that the medium is idle at the TxPIFS slot boundary (defined in 10.3.7 (DCF timing relations)).”

This nuance is not currently captured in the normative text, and should be explained to the reader in Annex G where appropriate.

**Annex G (revised)**

(informative)

## Example uses of Frame Exchange Sequences

Frame exchange sequences are described in a variety of contexts throughout this standard, though the rules governing frame exchange sequences are mostly contained in the QoS facility. Descriptions of frame exchange sequences are generally included in the normative text of multiple PHY clauses (i.e., Clauses 26 through 28 (each describing a different peer PHY entity). It is entirely possible for STAs to operate in a heterogenous environment, where there can be different peer PHY entities operating in accordance with different PHY clauses in the same geographic area.

Often, these descriptions are tailored to the specific requirements context of the clause in which they appear. For some PHY scenarios, there is only one wireless channel instance, for other PHY scenarios, there may be several channel instances of the wireless medium, due to sectorization, beamforming, and MU-MIMO that can impact single wireless channel PHYs. At times there has been some confusion surrounding the temporal boundaries of frame exchange sequences on the wireless medium, and the resulting implications of those boundaries to the operation of STAs. This is particularly important when understanding their impact on mechanisms and procedures that are triggered and/or terminated by frame exchange sequence boundaries, such as scanning, synchronization, BSS initialization, and power save mechanisms (which cannot be initiated until the current frame exchange sequence is completed), and power management indications (which cannot be modified until the current frame exchange sequence is completed). In addition, other mechanisms that maintain overlapping control with frame exchange sequences of the wireless medium are impacted by these boundaries.

The purpose of this annex is to help clarify the purpose and limitations of frame exchange sequences through examples that depict their usage throughout the various clauses of this standard, in a unified manner. The examples cover the use of frame exchange sequences in the following scenarios:

1. Distributed Coordination Function (DCF). This example is one in which a minimum specified duration exists between basic frame exchange sequences.
2. HCF controlled channel access (HCCA). This example is one in which HCF frame exchange sequences are implemented as part of the handling rules defined by the HCF.
3. MCF controlled channel access (MCCA). This example is one in which the efficiency of frame exchange sequences is optimized in a mesh BSS.
4. Transmission opportunity (TXOP). This example is one in which frame exchange sequences may be initiated by one or more QoS STAs or an AP in an MU cascading sequence. In this case, a TXOP responder may or may not transmit its frame within the time window of the TXOP, given the estimated time required for transmission of the response frame may be inexact.
5. Groupcast with Retries (GCR) TXOP. This example is one in which frame exchange sequences may be initiated by one or more APs and/or mesh stations to support the GCR service.
6. Multiple frame exchange sequences in an EDCA TXOP or HCCA TXOP. This example is one in which other mechanisms have overlapping control of the wireless medium with frame exchange sequences.
7. Association of a GLK STA with a GLK AP. This example is one of many in which frame exchange sequences may occur outside the context of an HCF, MCCA or TXOP. Service Period, Announcement Transmission Interval (ATI) and Data Transfer Interval (DTI) are other examples.
8. Peer-to-peer application. This example is one in which a peer-to-peer application can identify individual frame exchange sequences between HE STAs.
9. Block Ack for VHT PHYs. This example is one in which a single frame exchange sequence includes multiple block acknowledgments, each from a different STA, and each preceded by either a BAR or a VHT MU PPDU transmitted by an AP STA.
10. Restricted Access Window (RAW). This example is one in which a frame exchange sequence shall not exceed the allocated RAW slot boundary.
11. GCR MU-BAR. This example is one in which a frame exchange sequence includes two types of Block Acks for the GCR group members.
12. RD frame exchanges. This example is shown in the informative text of clause O.3.
13. Implicit transmit beamforming. This example is one in which a transmit beamforming frame exchange sequence is initiated by an unsteered PPDU that includes a training request.
14. SU-MIMO and MU-MIMO channel access. This example is one in which frame exchange sequences use MIMO channel access to exchange frames.
15. TXOP-based sectorization operation. This example is one in which spatially orthogonal frame exchange sequences are transmitted until the expiry of the SO timer without resetting the NAV.
16. Sector training. This example is one in which an AP transmits NDP CTS frames, followed by sector ID feedback.
17. Power management in an MBSS. This example shows the unique endings of the frame exchange sequence.

Some of the affected indications include:

1. Power Management subfield
2. Mesh Power Save Level subfield
3. Block Ack Timeout Value field
4. Nominal Minimum TWT Wake Duration field